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Standard Practices for Preserving and Transporting Rock Core Samples¹

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1. Scope

1.1 These practices cover the preservation, transportation, storage, cataloging, retrieval, and post-test disposition of rock core samples obtained for testing purposes and geologic study.

1.2 These practices apply to both hard and soft rock, but exclude ice and permafrost.

1.3 These practices do not apply to those situations in which changes in volatile gas components, contamination of the pore fluids, or mechanical stress relaxation affect the intended use for the core.

1.4 *This standard does not purport to address the safety problems 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:

D 420 Practice for Investigating and Sampling Soil and Rock for Engineering Purposes²

D 2113 Practice for Diamond Core Drilling for Site Investigation²

D 4220 Practice for Preserving and Transporting Soil Samples²

2.2 API Standard:

API RP-40 Recommended Practice for Core Analysis Procedure³

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *critical care*—samples which are fragile or fluid or temperature sensitive. This protection level includes the requirements prescribed for routine and special care.

3.1.2 *routine care*—non-sensitive, non-fragile samples for which only general visual identification is necessary, and samples which will not change or deteriorate before laboratory testing.

3.1.3 *soil-like care*—materials which are so poorly consoli-

dated that soil sampling procedures must be employed to obtain intact pieces of core.

3.1.4 *special care*—fluid sensitive samples and those which must later be subjected to testing. Requirements for this level of protection include those prescribed for routine care.

4. Significance and Use

4.1 The geologic characteristics and the intended use of the rock core samples determine the extent and type of preservation required. If engineering properties are to be determined for the core, it must be handled and preserved in such a way that the measured properties are not significantly influenced by mechanical damage, changes in chemistry, and environmental conditions of moisture and temperature, from the time that the core is recovered from the core drill until testing is performed. Drill core is also the sample record for the subsurface geology at the borehole location, and as such must be preserved for some period of time, in some cases indefinitely, for future geologic study.

4.2 These practices present a selection of curatorial requirements which apply to the majority of projects. The requirements are given for a variety of rock types and project types ranging from small to large and from noncritical to critical. Noncritical projects are those in which failure of an element or the structure would result in negligible risk of injury and property loss, while there is great risk to property and life after failure of critical structures and projects. Guidance is given for the selection of those specific requirements which should be followed for a given project.

5. Guide for Implementation

5.1 A qualified person shall be assigned to have curatorial management responsibility for a given project. This person shall be technically competent in the management of rock core samples and shall have a knowledge of the various end uses for the cores and their associated preservation requirements. This responsible person shall have the authority to implement the requirements selected from these practices. In some cases, he or she may also have to decide between competing uses for the same core.

5.2 The responsible person shall select from Sections 6-11 those requirements and procedures that should be applied for the core from a particular project. The curatorial manager shall then see that these procedures are implemented, and also see that the records specified in Section 12 are kept.

¹ These practices are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.12 on Rock Mechanics.

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

³ Available from American Petroleum Institute, 1220 L Street, Washington, DC 20005.

5.3 The following factors should be considered when selecting the curatorial requirements from Sections 6-11:

5.3.1 Project requirements for use of the core range from simple ones, in which the only need is to identify and locate the various lithologic units, to complex and critical ones in which detailed property testing of the core is required for engineering design. Priorities for multiple uses or different types of tests must sometimes be established when available core lengths are limited and when one use or test precludes another. For example, splitting a core for detailed geologic study prevents later strength testing, which requires an intact core.

5.3.2 Mechanical property tests for structural design purposes should be performed on a core in its natural moisture state, particularly if the rocks are argillaceous. Irreversible changes occur when such rocks are allowed to dry out, often resulting in invalid design data. The initial moisture content of such a core should therefore be preserved.

5.3.3 Freezing of pore water in the core may reduce the strength of the rock. The high temperature associated with unventilated storage sheds in summer, and temperatures alternating between hot and cold, may cause moisture migration from the core and weakening of the rock due to differential thermal expansion and contraction between grains. Such temperature extremes should therefore be avoided, particularly for weak sedimentary rock types.

5.3.4 A weak rock core may be broken or further weakened by careless handling, such as dropping a core box, or by mechanical vibration and shock during transportation. Breaking of the core reduces sample lengths available for testing. Weakening caused by such mechanical stressing may lower measured strength parameters and may affect other properties.

5.3.5 The required preservation time may vary from as short as three months to several years, and sometimes core may need to be stored indefinitely. A core taken simply to identify the bedrock lithology beneath a small structure may be needed for a few months only. For large and critical structures, it may be necessary to retain the core for many years as re-examination and testing may be required at some later time for additional geologic study or re-evaluation of property data. Some states have regulations governing the disposition and storage of core obtained within the state.

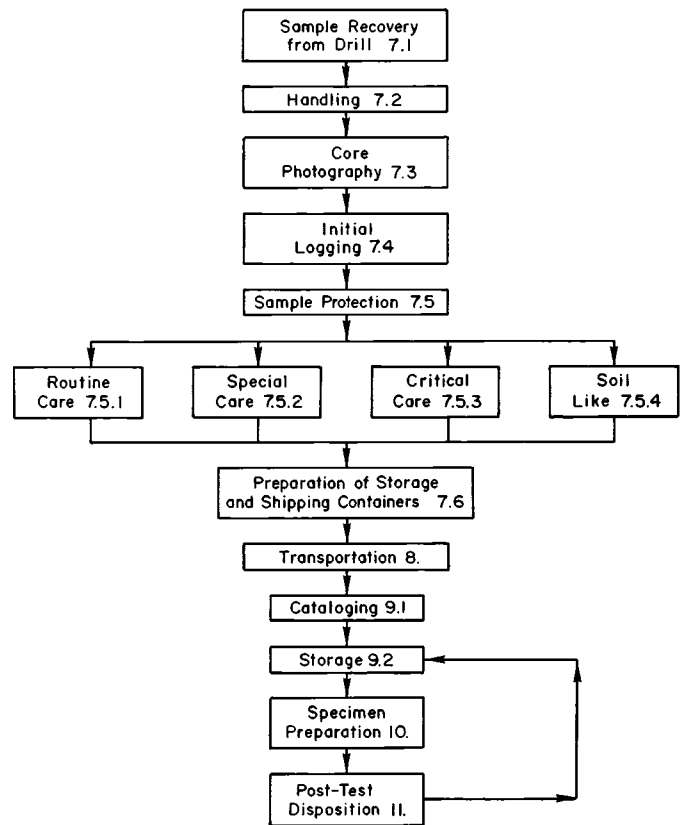
5.4 Fig. 1 is a flow chart that shows the various core handling, use, and storage activities and the corresponding section numbers in these practices. Note that four care or protection levels are defined in Section 3 to account for the great variety of rock sensitivities and core uses encountered in practice.

5.5 The person assigned curatorial management responsibility should study the flow chart in Fig. 1 as it relates to the designated Sections 6-11 in these practices. Note in particular, that a selection of the required protection must be made in 7.5, where four levels of protection are specified, namely routine care, special care, critical care, and soil-like care.

5.6 Special attention is also directed to records requirements in Section 12, that document the history of the core handling, preservation, and storage.

6. Apparatus

6.1 *Camera*, for taking photographs of cores for logging.



NOTE 1—Numbers refer to corresponding sections of this practice.
FIG. 1 Flow Chart for Core Handling, Use, and Storage Activities

6.2 *Controlled Humidity Room.*

6.3 *Core Boxes*—See 7.6.1.

6.4 *Vinylidene Chloride Plastic Film, Aluminum Foil, Plastic Microcrystalline Wax*, for sealing in moisture content of cores.

6.5 *Polyethylene Layflat Plastic Tubing.*

6.6 *Poly(vinyl chloride) Tubing.*

6.7 *Sawdust, Rubber, Polystyrene*, or material of similar resiliency to cushion the core.

6.8 *Miscellaneous Equipment*, such as adhesive tape and waterproof felt-tip markers.

7. Requirements and Procedures at the Drilling Site

7.1 *Sample Recovery:*

7.1.1 Accomplish sample recovery in accordance with Practice D 2113 or API RP-40.

7.1.2 Whichever approved drilling method is used, remove the samples from the core barrel with a minimum of disturbance.

7.2 *Handling:*

7.2.1 Each borehole shall be given full-time attention by a qualified inspector constantly available for observing, directing, photographing, and field logging. The inspector shall not perform simultaneously the same duties for more than one boring unless the borings are close enough to each other so that the entire inspection process can be done for each boring.

7.2.2 For relatively solid pieces of core that will not be adversely affected, the inspector shall use a marker, such as a

felt-tip, to orient each piece so that later users will always be able to distinguish top from bottom. Acceptable formats are a continuous line with arrows or parallel solid and dashed lines with the dashed line always on the same side of the solid line. The direction convention shall be recorded in the log book. Locations of known depths should be marked directly on the core when the orientation marks are drawn.

7.3 Core Photography:

7.3.1 Perform core photography on all core samples with a camera of 35 mm (minimum) format using color film to record permanently the unaltered appearance of the rock. The film selected should be color balanced for the available lighting (daylight, flash, incandescent, or florescent), or an appropriate filter should be placed on the camera to compensate for the difference. The core should be cleaned prior to any photography.

7.3.2 A commercially available color strip chart should be included in the photo frame to serve as a reference to check the accuracy of the photographic reproduction of the rock core colors.

7.3.3 For rock placed in core boxes, take one photo of each box once it is filled to capacity. Include the inside of the box lid with appropriate identification data and a clearly visible length scale laid along one edge of the box so that it also shows in the photo.

7.3.4 Where very long, intact cores are being preserved in single plastic tubes, make detail-revealing close-ups of each core interval in addition to a single photo showing the complete core.

7.3.5 Take photographs before the core is obscured by protective sealants and wraps, and before any deterioration begins in particularly fragile or sensitive rock types.

7.3.6 For a boxed core that is not particularly sensitive and for which maintenance of in-situ moisture content is not important, two photos should be made: one with the core in a surface dry condition and one with the core in a wet condition to bring out optical properties that would not otherwise be apparent.

7.3.7 This procedure may require photography both in the field and then later in the storage facility, but it must be completed before any test core removal and before damage from mishandling has a chance to occur.

7.3.8 Where it is impossible for a photo to show identification data marked directly on the sample or its container, then mount appropriately marked placards so as to be included in the frame.

7.3.9 Organize the photographs and mount in a folder for easy access and preservation.

7.4 Initial Logging:

7.4.1 The boring inspector must complete at least a preliminary field log of the core before it is packed away to be transported. Suggested procedures for logging are given in the literature.^{4, 5, 6, 7} The preliminary log must include all identification data for the borehole and personnel and equipment involved, notations of coring run depths, recovery percentages,

lithologic contact depths, types and locations of protection applied to samples, and any facts that would otherwise be unknown to whomever may complete a more detailed log at a later time. It is desirable that detailed logs be completed by the same inspector who does the field logging. It is advisable for the inspector immediately to make notations on the depths at which, in his judgment, any core losses occurred. Sometimes it is possible later to fill in gaps in the initial log by interpretations from wireline logs.

7.4.2 The inspector is to complete a detailed log on the drill site (see the literature^{4, 5, 6, 7}) in cases where the core is likely to deteriorate or otherwise change before being examined again.

7.4.3 For fragile core that must be immediately protected by wrapping and sealing, preliminary logging should take place in the field, but application of protective measures are to take precedence over time-consuming detailed logging.

NOTE 1—It is permissible later to make changes in detailed logs when laboratory analysis indicates original misidentification of rock type or other geologic features.

7.5 *Sample Protection*—Four levels of sample protection are covered (see Section 3): routine care, special care, critical care, and soil-like care. The level of protection chosen will depend on the geologic character of the rock and the intended use for the core.

7.5.1 Routine care (see Fig. 2):

7.5.1.1 For rock cored in 5 to 10-ft. runs, samples are sufficiently protected if placed in structurally sound core boxes. Enclosing the core in a loose-fitting polyethylene sleeve (layflat tubing) prior to placing the core in the core box is recommended.

7.5.1.2 Where very long solid cores have been recovered and need to be preserved intact, place each core in a reasonably stiff tube (poly(vinyl chloride) (PVC) tubing is recommended) of equal or slightly greater length and secure both ends to prevent slippage. The inside diameter of the tube should be slightly greater than the core diameter; the wall thickness of the tube must be sufficient to provide the rigidity to prevent core breakage due to bending.

7.5.2 Special Care:

7.5.2.1 The moisture state of some rocks, and even the moisture-state history of rocks such as shales, affects their properties. If tests are to be performed on the core, and if it is possible that a change in the moisture state may influence the test results, then the core must be sealed to prevent changes in the moisture state until the time of testing. This same procedure also applies to other samples where it is important to maintain fluids other than water (for example, hydrocarbons).

7.5.2.2 Seal samples requiring special care. Such sealing shall consist of a tightly fitting wrapping of a plastic film, such

⁵ Deere, D. U., Dunn, J. R., Fickies, R. H., and Proctor, R. J., "Geologic Logging and Sampling of Rock Core for Engineering Purposes (Tentative)," Association of Professional Geological Scientists, 1977.

⁶ The Geological Society, Engineering Group Working Party, "The Logging of Rock Core for Engineering Purposes," *Quarterly Journal of Engineering Geology*, Vol 3, 1970, pp. 1-24.

⁷ International Society for Rock Mechanics, "Basic Geotechnical Description of Rock Masses," *International Journal of Rock Mechanics and Mining Sciences and Geomechanics Abstracts*, Vol 18, 1980, pp. 85-110.

⁴ Association of Engineering Geologist, Core Logging Committee, South Africa Section, "A Guide to Core Logging for Rock Engineering," *Bulletin of the Association of Engineering Geologist*, Vol 15, No. 3, 1978, pp. 295-328.



FIG. 2 Typical Wooden Core Box Showing Core Placement, Labeling, and Polyethylene Layflat Tubing Placed Over Core as Suggested for Routine Care (as in 7.5.1)

as vinylidene chloride (for example, saran or similar material). Over this, place another tight wrapping of aluminum foil (Note 2). Apply both of these wrappings so that as little air as possible is trapped beneath the wrappings. Overlap the ends of the wrappings over the ends of the sample and fold over so as to seal the ends of the sample. Finally, apply a few coats of a plastic microcrystalline wax (Note 3), preferably with a paint brush, although rapid dipping in molten wax is also acceptable. Apply a minimum of $\frac{1}{8}$ in. (3 mm) of this plastic microcrystalline wax over the entire surface of the sample. This thickness of wax shall consist of at least two coatings of wax and preferably more. For long periods of storage, apply a minimum of $\frac{1}{4}$ in. (6 mm) of wax.

NOTE 2—In some instances where the aluminum foil wrapping chemically reacts with either the rock or its fluids, it should be replaced with some other metal foil which is nonreactive. A less preferable method is to delete the metal foil and increase the thickness of the sealing wax. If the metal foil is not used, the thickness of the sealing wax should be increased to $\frac{1}{4}$ in. (6 mm) when the required storage time is short (one week to a few months). For longer period, a thickness of $\frac{3}{8}$ in. (9 mm) may be adequate.

NOTE 3—It is important that plastic microcrystalline wax be utilized, as it does not become brittle. Regular microcrystalline waxes are brittle and susceptible to cracking, which then severely limits their use as sealants.

7.5.2.3 Polyethylene layflat tubing is a much less effective moisture barrier than the wax-metal foil seal described in 7.5.2.2, and particular attention must be paid to the manner in which the ends of the tubing are sealed. This method of sealing may be used only if the person having testing management responsibility can prove that moisture loss can be tolerated without significantly affecting the pertinent mechanical and physical properties of the samples. The thickness of the polyethylene plastic tubing shall be at least 0.005 in. (0.13 mm). Tightly seal the ends of the tubing, for example, by doubling the ends over at least twice and securing with adhesive tape. Make a check for seal quality; an acceptable

method is to squeeze the sealed tube and observe if the air escapes easily. The effectiveness of this barrier can be improved by tightly wrapping the core with plastic film, such as vinylidene chloride, before it is placed in the polyethylene tubing. Even with the addition of this extra plastic film, the moisture barrier is still not nearly as effective as the wax-metal foil seal described in 7.5.2.2.

7.5.3 Critical Care:

7.5.3.1 If shock and vibration or variations in temperature, or both, may subject samples to unacceptable conditions during transport, place samples in suitable core boxes that provide cushioning or thermal insulation, or both.

7.5.3.2 Protect fragile samples from mechanical disturbance, such as vibration and shock. Completely encase each sample in the cushioning material (sawdust, rubber, polystyrene, urethane foam, or material of similar resiliency). The cushioning between the samples and walls of the core boxes should have a minimum thickness of 1 in. (25 mm). Provide a minimum thickness of 2 in. (50 mm) on the core box floor and lid. Samples must fit snugly into their assigned space.

7.5.3.3 Thermally insulate samples that are temperature sensitive. Thermal insulation is best provided by placing the core container (box or tube) inside another container that is designed specifically to provide thermal insulation. Such insulating containers are generally constructed of double or triple layers of an insulating material. Additionally, such containers are usually relatively airtight.

7.5.3.4 Seal samples that are sensitive to mechanical disturbance, fluid content, and temperature in accordance with 7.5.2.2.

7.5.4 Soil-Like Care—Such materials should be treated as indicated in Practices D 4220.

7.5.5 Handling of sensitive samples between borehole and transport vehicle should take place within a covered space that

either provides shade against intense sunlight or can be heated to keep temperatures above freezing.

7.6 *Preparation of Storage and Shipping Containers:*

7.6.1 Core boxes must be constructed rigidly enough to prevent flexing of the core when the box is picked up by its ends. Wood is the desired construction material, and it should be $\frac{1}{2}$ to $\frac{3}{4}$ in. (13 to 19 mm) thick. Partitions between core lengths shall be firmly nailed in place to increase the stiffness of the box. The lid should have sturdy hinges and a strong hasp or screw closure. Do not drive nails in the lid.

7.6.2 Packing material should be placed in the core box to support the core and prevent it from rolling around in the box.

7.6.3 Gently place the core in the core box starting with the shallowest depth at the upper left corner (nearest the hinge, if the lid is hinged) and progressing downward, as in reading a book, to the deepest depth at the lower right corner as shown in Fig. 2.

7.6.4 Core blocks should be placed at the ends of each core run.

7.6.5 Where a run of less than 100 % recovery yields a core that is too short to fill its assigned trough, the recovered core should be held secure and prevented from scattering by placement of spacer block such as a piece of wood or cardboard tube cut to the length of the missing core.

7.6.6 Unnecessary breaking of the core to fit the core box should be avoided as it may reduce the number of available test specimens. Any intentional breaks shall be recorded on the log.

7.6.7 Mark depths of the top and bottom of the core length in the box with a waterproof marker near the core ends and corresponding box corners. Intermediate depths that are accurately known should also be similarly marked.

7.6.8 Mark both the top and one edge of the core box with the following information before transportation:

7.6.8.1 Company or project name, or both,

7.6.8.2 Drill hole number or location,

7.6.8.3 Core box number in sequence down the hole, and

7.6.8.4 Depths from a specified hole datum to top and bottom of core length in box marked on appropriate corners of box.

7.6.9 The following additional information may be required to be written on the core box for specific projects:

7.6.9.1 Percent core recovery, and

7.6.9.2 Rock quality designation,

7.6.10 Mark or label tubes with the same information as core boxes. Such tubes shall have sufficient flexural rigidity to prevent core breakage due to bending. A core that requires protection from mechanical shock should have shock absorbing material packed concentrically around the core.

8. Transportation Requirements and Procedures

8.1 Damage may occur to the core if certain precautions are not taken during transportation. The mode of transportation, distance, terrain, and handling at each end are important factors. The following requirements and procedures should be considered when transporting a core from one location to another:

8.1.1 Remove the core from the drill site before it has a chance to freeze or heat up or be damaged by activities at the drill site.

8.1.2 Handling during loading and unloading should be done gently. Never drop core boxes or tubes, but rather slide gently into position. If a box is accidentally dropped, record this fact.

8.1.2.1 A record of mishandling by commercial carriers is often difficult, if not impossible, to obtain. The use of company or agency vehicles is recommended, with someone assigned to supervise handling and storage along the transport route.

8.1.3 Provide transportation by a suitable vehicle to prevent damage by mechanical vibration, shock, freezing, and high temperatures along the entire transport route.

8.1.3.1 Rough terrain near the drill site may require the use of four-wheel drive vehicles for transport. In such cases, protect a core in the critical care category (7.5.3) by vibration insulators around the sides, bottom, and top of the core containers.

8.1.3.2 Highway transportation by passenger car, rather than van or truck, may be required for a fragile core.

8.1.4 Thermally insulate temperature sensitive cores. Thermally insulated containers are the preferred method (7.5.3.3). Such containers will maintain a thermal environment suitable for core preservation during the period of transport.

9. Cataloging and Storage Requirements and Procedures

9.1 *Cataloging*—Assign unique identification numbers to each core sample in the inventory. The identification numbers shall be easily traceable to the borehole number and depth interval from which the core was recovered. An acceptable method in many cases is to use the borehole number and depth interval as the identification numbers. It may be helpful to include the run numbers and core box numbers in the cataloging system, as well as other important subgroupings on large projects.

9.1.1 *Specimen Identification*—Core samples may be removed from inventory for a variety of tests and analyses. Preparation of specimens for these tests typically requires that the original sample be sawed and sometimes recorded. Assign core material removed for testing and analysis unique identification numbers which are easily traceable to the borehole number and depth, or which may actually be the borehole number and depth. The depth shall be taken as the depth to the midpoint of the specimen, or the depths to the top and bottom of the specimen, as required for the test program. It is often convenient to further identify the specimen with letters or numbers signifying the type of test or analysis to be performed. End pieces remaining after cutting shall be returned to their respective locations in the original core box. To hold the end pieces in their proper locations in the core box, a spacer should be placed in the location from which a test specimen has been removed.

9.2 *Storage*—Store the core so that it can be easily retrieved and in an environment that does not alter properties that are of interest.

9.2.1 *Storage Racks*—Place core boxes on racks that provide support over the entire length of the box. To reduce damage due to handling of core in the critical-care and soil-like categories, do not place more than a single layer of core boxes on a shelf. The lowest shelf in the rack should be a few inches above floor level to allow air circulation for temperature

control and as a precaution against water damage.

9.2.2 *Temperature Control*—Prevent from freezing core samples that contain significant amounts of water. Also, temperature extremes may need to be limited to prevent undesirable chemical changes, such as dewatering of certain minerals. More stringent temperature control is required to prevent large temperature variations which could pump fluid from the sample.

10. Laboratory Specimen Preparation Requirements and Procedures

10.1 Samples removed from the inventory for testing and analysis in the laboratory must be handled carefully to preserve fluid content and integrity.

10.1.1 *Specimen Preparation*—Preparation techniques must be selected carefully to prevent sample alteration. Give special attention to the choice of cutting fluids that are used in machining operations such as sawing, coring, and grinding. For example, water will dissolve halite and will cause some shales to swell or slake. Specimens of water-sensitive material may be prepared with air cooling if the material is soft enough that there are no hot spots during the operation. Cutting oils, if used, should be removed from the sample using a solvent because the oil may affect certain properties of some rock types. Specimens that are moisture sensitive should be sealed between various steps of preparation if the time between steps is more than 30 min. A controlled-humidity room or chamber may be necessary for preparation of some rock types. Samples that were sealed in the inventory should be sealed after preparation until tested, unless testing occurs within 30 min after preparation.

11. Post-Test Disposition Requirements and Procedures

11.1 The requirements and procedures for disposition of test specimens vary with the nature of the project and the length of time for which there is a need to preserve the test material. The need for future re-examination may arise in the verification of engineering design or litigation.

11.2 The tests performed may be destructive or nondestructive. Reassemble and tape major fragments from destructive tests and place in a plastic bag with the fine material. Identify the bag with the specimen identification (borehole number and depth). Also place specimens from nondestructive tests in plastic bags and label.

11.3 If the specimen material is not moisture sensitive, and if easy access to the test specimens is desired, the specimens in the labeled bags may be placed in a box labeled as follows:

- 11.3.1 Company or project name, or both,
- 11.3.2 Borehole number or location,
- 11.3.3 Types of tests performed on specimens,
- 11.3.4 Name of person responsible for disposition, and

11.3.5 Date of disposition.

11.4 For moisture sensitive test specimens for which easy access is desired, the requirements of 11.3 apply except that the specimen shall be suitably sealed from the atmosphere. The sealing procedure shall be as stringent for post-test disposition as it was for the initial core preservation, as given in 7.5.

11.5 Storage requirements for boxes in 11.3 and 11.4 are the same as for the original core as given in 9.2.

11.6 If easy access to all of the test specimens is not required, return the tested specimens to their original locations in the core boxes or PVC tubes, and reseal as appropriate.

12. Records

12.1 A permanent, legible record shall be maintained by a technically qualified person for the core from each borehole. The following information shall be recorded:

- 12.1.1 Company and project names,
- 12.1.2 Drill hole number and location,
- 12.1.3 Orientation of borehole,
- 12.1.4 Elevation of hole collar, Kelly bushing, or some other datum,
- 12.1.5 Date(s) of coring,
- 12.1.6 Core box or PVC tube numbers and core depth interval contained in each,
- 12.1.7 Date and name of person doing initial logging,
- 12.1.8 Geologic log or reference to its location, and
- 12.1.9 Photographs of core or reference to their location.

NOTE 4—A permanent historical record needs to be maintained so that it is accessible for later use in identifying the core, ascertaining what geologic study and testing has been performed on the core, and its storage location of other disposition.

12.2 Desirable records which may also be required for some projects are as follows:

- 12.2.1 Each date of transportation, from where to where, mode of transportation, and name of responsible person,
- 12.2.2 Storage locations and source of temperature and relative humidity data,
- 12.2.3 Date and person removing test samples from storage, including a list of sample lengths removed and their depths,
- 12.2.4 Name and location of testing laboratory, nature of testing, if known, and name of responsible person,
- 12.2.5 Post-test disposition including date, name of responsible person, and location of tested specimens if not returned to original core boxes or PVC tubes, and
- 12.2.6 Date and nature of any other activity involving the core such as handling, and additional inspection and testing.

13. Keywords

13.1 identification; microcrystalline wax; sampling; transportation

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