Project documents pertaining to soil testing for pipeline construction often do not reflect the latest version of the American Society for Testing and Materials (ASTM) standards (or others). This may cause conflict with regulatory agencies, third-party inspection forces, testing agencies, and the contractor’s understanding of how the specification documents apply to the project. Some of the more common outdated references to ASTM standards involve soil classification, soil plasticity, Proctor compaction tests and the nuclear density gauge.

In addition to project documents, the latest version of soil testing standards should be referenced in trade association and manufacturer’s manuals, guides and instructions.

Soil classification
The Unified Soil Classification System (USCS) is the most common soil classification method used in civil construction projects. The ASTM standards for the USCS are:
• D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)
• D 2488 Description and Identification of Soils (Visual-Manual Procedure)

In 1982 significant revisions were made to these two standards. However, many specifications and project documents still have not incorporated these changes that were made more than 30 years ago.

The 1982 changes include using precise numbers from laboratory tests, requiring the presence of 30 percent or more sand or gravel before adding the descriptive term sandy or gravelly, and re-defining organic clay and organic silt. Additionally, the names for the soil groups were formalized; for example, there is a specific definition for what silty clay means.

Some very plastic soils are difficult to compact, and may shrink and swell when dried or when water is added. Many specifications limit soils suitable for construction to those with a plasticity index (PI) of 40 or less. The PI is the difference between the liquid limit and the plastic limit of the soil and is a convenient representation of its plasticity characteristics. The percent compaction required for embankments (i.e. 98 percent or 95 percent Proctor) is sometimes based on the PI of the soil. In other cases, the liquid limit is used as a criterion.

ASTM D 4318 Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils first appeared in 1983. This standard replaced D 423 Method of Test for Liquid Limit of Soils and D 424 Method of Test for Plastic Limit. These latter two standards were withdrawn in 1982, yet are still inappropriately referred in some project documents.

One of the significant changes made in 1983 was the emphasis on wet preparation of the soils for testing. Wet preparation refers to a test protocol that maintains the soil at its natural moisture content. Dry preparation allows letting the soil air-dry for testing. The soil is dried to facilitate screening the soil. The tests are performed on soil passing the No. 40 sieve.

ASTM Designations
ASTM publishes procedures for testing soils yearly. The standards are revised frequently and are required to be re-approved every five years. If your project documents reference ASTM standards, the applicable standards are those that were in effect the year your specifications were issued. An exception would be specifications that refer to ASTM standards with year designations. Each standard has a date; for example, ASTM Designation D 9999 – 02 (2007). The first date reference 02 indicates the current standard was last revised in 2002. The second date (2007) means the 2002 version of the standard was re-approved in 2007.

The liquid and plastic limits of some soils that have been allowed to dry before testing may be considerably different from values obtained on non-dried samples. The liquid and plastic limits of soils are often used to correlate or estimate the engineering behavior of soils in their natural moist state. In these cases, soils should not be permitted to dry before testing. This is particularly true for soils suspected of having enough organic matter to affect the engineering properties.

You should be aware that D 4318 states, unless specifically requested, the tests shall be performed using the wet preparation method. However, the wet method is more expensive than the dry method and,
for most construction projects, is not warranted. Accordingly, the project documents, when referring to D 4318, should state that the dry preparation method is to be used.

**D 698 Method D**

The percent compaction (e.g. percent Proctor) is based on comparing the in-place density of a soil to its maximum density determined in a standard laboratory test. To be representative, the percent compaction should be determined using soil with the same characteristics. Since gravel size particles may significantly affect compaction, the gravel content is key for the comparison. The laboratory compaction tests use cylinders that are restricted in size and are, thus, limited to a maximum particle size that should be tested. To ensure that the percent compaction comparison is characteristic of the soil, gravel can mathematically either be added to, or subtracted from, the soil. This is sometimes referred as a rock correction.

Early versions of ASTM D 698, Laboratory Compaction Characteristics of Soil Using Standard Effort, had a method D, in which the gravel fraction is physically replaced with a finer fraction and the test performed to get a maximum density. Method D was eliminated almost 40 years ago. The last standard containing Method D was the 1978 version. The current ASTM D 698 still warns that Method D is inappropriate to determine the maximum density of soils containing oversize fractions. The same method D was also included in ASTM D 1557 (modified Proctor) and the prohibition is repeated in the current versions of D 1558. However, some current specifications still incorrectly list Method D as an accepted method.

The proper methods for incorporating a rock correction are detailed in ASTM Manual 70, Quality Control of Soil Compaction.

Up until 2007, there were two separate ASTM standards for using a nuclear gauge density to determine the in-place density and moisture content of soils:

- D 2922 Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)
- D 3017 Water Content of Soil and Rock In Place by Nuclear Methods (Shallow Depth)

These two standards have been replaced by D 6938 In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

In addition to combining the two standards, D 6938 contains significant revisions for using a nuclear gauge to measure in-place density and water content. Specifications and contract documents should now be referring to this standard to ensure that the project construction control program is consistent with the latest procedures.

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**Summary**

The ASTM standards pertaining to soil classification, soil plasticity, Proctor tests and nuclear density gauges have been revised. The current versions should be referenced in the project documents for earthwork.

For most pipeline projects, the project documents should state that the dry preparation method is to be used when referring to ASTM D 4318 (Atterberg limits).

**REFERENCES**

ASTM Manual 70 (2011) Quality Control of Soil Compaction
Howard, Amster (2015) Pipeline Installation 2.0

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