I. Call to Order and Opening Remarks - Curt Turgeon called the meeting to order at 10:17 am.
   A. Brief summary of activities (to ensure all attendees up to speed)

II. Roll Call

III. Approval of Technical Section Minutes (attachment #1): 1) AL, 2) VA, minutes are approved.

IV. Old Business
   A. SOM Ballot Items
      1. Outstanding items from Mid-Year Meeting - None
   B. TS Ballots (attachment #2)
      1. Determining Constant Mass 14 Affirmative, 3 Negative and 8 No vote.
         a. Comments regarding display of equations
         b. Illinois – not needed, plus comments – vote to find this negative non-persuasive: 1) ME, 2) MT, motion carries.
         c. Florida – Formula did not display correctly (hieroglyphics)
         d. Connecticut – Multiple changes throughout Standard. (#3)
         Discussion: WAQTC has reconciled CT’s concerns about wording. The formula issue has also been resolved.
         TS voted to move this standard to COMP ballot with changes: 1) ME, 2) FL, motion carries
   2. Dielectric Profiling System 17 Affirmative, 8 no vote
      a. Upon discussion, will require motion to move to full Ballot
         TS voted to move this standard to COMP ballot: 1) ME, 2) CT: motion carries
   3. File Format of Intelligent Construction Data 17 Affirmative, 8 no vote
      a. Upon discussion, will require motion to move to full Ballot
         Discussion: Why are we introducing another standard when this is already covered in intelligent compaction provisional specification? The idea is that the redundancies would be removed from intelligent compaction and have all data placed at on place in the software package.
         TS voted to move this standard to COMP ballot: 1) ME, 2) AL: motion carries
   4. Changes to R25 as recommended by the WAQTC 18 Affirmative, 7 No vote (attachment #4)
      a. Upon discussion, will require motion to move to full Ballot
         No negative. This is about technician training specification to evaluate which one to keep or remove.
         TS voted to move this standard to COMP ballot: 1) FL, 2) ME: motion carries
   C. Task Force Reports – No active task forces.
      Discussion: Question raised as to what is going on with Dennis Dvorak’s Task Force, but he is no longer able to attend the meetings. Curt will reach out to Dennis to see what the status was.
V. New Business
   A. Research Proposals
      1. Performance Specifications Implementation Guide (attachment #5)
         Discussion: none
         Presented by Maine - The focus of this research is to guide the state agency on how to use this technology and how it can fit into the state QA program.
         Discussion:
         Is 24 months long enough? Since there is no lab or field testing, 24 months might be enough, but it might need to go a little longer. Once approved, the timeframe can be adjusted.
         Are there provisions in there for NDT of steel and related certification requirements, experience, accreditation, etc.? Yes. This should look at all aspects of this activity.
         Is the NCHRP study on risk analysis going to factored into this? That might be the next round of studies once this is out there. Is this for acceptance, QA or verification test?
         Are you going to look at the cost/benefit analysis of performing the tests? Should we be performing the tests at all in some cases? Is the study going to help us determine which one to use? This is a risk-based study and it will give us enough information to help us make the decision.
   B. AASHTO Re:source/CCRL - Observations from Assessments? - None
   C. NCHRP Issues - None
   D. Correspondence, calls, meetings
   E. Presentation by Industry/Academia
      i. PRESENTATION: Dr. George Chang, Transtec ” Building Information Modeling (BIM) for Pavements (attachment #7)
         Discussion:
         How far down into the pavements are you talking? From the ground up.
         Does BIM support the file format? Yes. This helps all the different software talk to each other.
         This is moving toward open-source, public domain development.
         Is this going to also incorporate testing from the materials acceptance programs? It could be referenced to the lab testing. Everything will be georeferenced, tagged, etc.
         Do you see challenges when you are talking about long road with lot of data and GPS coordinates? No.
         Will you have roughness and maintenance data? There will be post-construction data such as roughness. This will have potential for life-cycle cost management.
         What kind of software do you envision the DOTs will be using? Similar to Veta. Software will be developed.
         How are you going to separate different parts of pavements, locations, and times? BIM tracks everything.
         Pooled fund study?
   F. Proposed New Standards - None
   G. Proposed New Task Forces
      i. FHWA ETG on Pavement Sustainability Update
         Environmental Product Declarations are coming faster in some places than others. FHWA is working on a benchmarking tool that can be used to calculate impacts of pavements to help move agencies toward life-cycle thinking. Heather Dylla is the contact (heather.dylla@dot.gov and 202-366-0120). CA is interested in this and has already successfully taken steps in this direction. MNDOT had two meeting: one with MNDOT staff and 2nd with MNDOT and Industry. Curt informed the group that he will share update about MNDOT progress.
H. Standards Requiring Reconfirmation
   i. Handled directly by AASHTO staff
      The chair would like to cover reconfirmations during the midyear meetings.
I. SOM Ballot Items (including any ASTM changes/ equivalencies) - None

VI. Open Discussion: none

VII. Adjournment at 11:11 am
### TS 5c 2018 Annual Meeting Summary

**Meeting Date:** 8/9/2018

**Items approved by the TS for Committee and or Technical Subcommittee Ballot:**

<table>
<thead>
<tr>
<th>Standard Designation</th>
<th>Page Numbers/Section Titles for Proposed Changes in Minutes</th>
<th>Technical Subcommittee and/or Committee?</th>
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<td>TXXX</td>
<td>New standard on determining constant mass</td>
<td>Committee</td>
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<td>TXXX</td>
<td>new standard on Dielectric profiling system standard</td>
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<td>Txxx</td>
<td>new standard on File format of intelligent construction data</td>
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<tr>
<td>R 25</td>
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**New Task Forces Formed:**

<table>
<thead>
<tr>
<th>Task Force Name</th>
<th>Summary of Task</th>
<th>Names of TF Members</th>
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**Other Action Items:**

Curt is going to reach out to Dennis Dvorak to see what happened with his old task force.
Standard Practice for

Technician Training and Qualification-Certification Programs

AASHTO Designation: R 25-00 (2013)18
Tech Section: 5c, Quality Assurance and Environmental
Release: Group 1 (April)

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001
Standard Practice for

Technician Training and Certification Qualification Programs

AASHTO Designation: R 25-00 (2013) 18
Tech Section: 5c, Quality Assurance and Environmental
Release: Group 1 (April)

1. SCOPE AND LIMITATION

1.1. This document provides a guideline for establishing evaluation and qualification procedures for personnel engaged in sampling and testing of soils, aggregates, hot mix-asphalt mixture, and portland cement concrete in accordance with AASHTO test methods. The guideline is intended for use by organizations providing qualification of sampling and testing technicians at the basic testing level for acceptance of materials and independent assurance testing.

1.2. The terms used in this standard regarding “technician” or “qualification/certification” are meant to be generic descriptions. The term “qualification” is equivalent to “certification” within this standard. Each state will need to use appropriate terminology consistent with state law and practices.

1.3. This guideline does not purport to address all possible events and procedures inherent in the administration and use of a technician qualification/certification program (TQP/TCP).

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards and Publications:
- R 47, Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size
- R 60, Sampling Freshly Mixed Concrete
- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling of Aggregates
- T 11, Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing
- T 19M/T 19, Bulk Density (“Unit Weight”) and Voids in Aggregate
- T 21, Organic Impurities in Fine Aggregate for Concrete
- T 22, Compressive Strength of Cylindrical Concrete Specimens
- T 23, Making and Curing Concrete Test Specimens in the Field
- T 27, Sieve Analysis of Fine and Coarse Aggregates
- T 44, Solubility of Bituminous Materials
- T 71, Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate
T 89, Determining the Liquid Limit of Soils
T 90, Determining the Plastic Limit and Plasticity Index of Soils
T 99, Moisture–Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
T 100, Specific Gravity of Soils
T 119M/T 119, Slump of Hydraulic Cement Concrete
T 121, Density (Unit Weight), Yiel d, and Air Content (G ravimetric) of Concrete
T 152, Air Content of Freshly Mixed Concrete by the Pressure Method
T 164, Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
T 168, Sampling Bituminous Paving Mixtures
T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
T 180, Moisture–Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
T 194, Determination of Organic Matter in Soils by Wet Combustion
T 209, Theoretical Maximum Specific Gravity (G mm) and Density of Hot Mix Asphalt (HMA)
T 255, Total Evaporable Moisture Content of Aggregate by Drying
T 267, Determination of Organic Content in Soils by Loss on Ignition
T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
T 287, Asphalt Binder Content of Asphalt Mixtures by the Nuclear Method
T 308, Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
T 309, Temperature of Freshly Mixed Portland Cement Concrete
T 310, In-Place Density and Moisture Content of Soil and Soil–Aggregate by Nuclear Methods (Shallow Depth)
T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
T 329, Moisture Content of Asphalt Mixtures by Oven Method
T 335, Determining the Percentage of Fracture in Coarse Aggregate
T 355, In-Place Density of Asphalt Mixtures by Nuclear Methods

2.2. ASTM Standards:
- C1064/C1064M, Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
- D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

This guideline is provided to:
- Help individual states, and where desired, combinations of states and other public agencies develop a TQP-TCP for use in conjunction with quality assurance (QA) specifications as described in the Implementation Manual for Quality Assurance and the Quality Assurance Guide Specification.
Describe the activities and organizational needs for the development and operation of a program that provides a flexible and effective means for ensuring qualified personnel perform sampling and testing.

- Identify coverage for Level I tests, the commonly used basic tests performed to identify material or product characteristics, for acceptance and/or payment under project contracts incorporating soils, aggregates, portland cement concrete (PCC), and hot mix asphalt mixture. Examples of these basic tests that could be included under Level I are shown in Appendix A.

6.1.3. Development of an agreement at the program inception, and prior to major changes, is recommended as the best means for gaining the needed understanding and support for the program.

6.1.4. Consideration of reciprocal agreements between states, and where feasible, regions, regarding materials technician certification/qualification acceptance is a means of addressing economy and business process efficiencies and should be an integral part of all TQP/TCPs.

6.2. Background:

6.2.1. Historic roles and responsibilities of industry and agencies have changed for sampling and testing activities under QA specifications. QA specifications allow the use of contractor test results in making acceptance decisions, and the use of consultants in independent assurance and verification sampling and testing programs, for materials and construction quality control.

6.2.2. Certification Qualification programs and associated training have been shown to be an effective tool for improving the quality of highways and bridges by verifying that essential knowledge and skills are possessed by agency or industry personnel who monitor, inspect, and control construction operations. Certification Qualification programs for personnel have proven to be useful, common for measuring expertise and performance among public transportation agencies, private construction contractors, and independent materials laboratories.

6.2.3. As the use of QC/QA specifications increases, the need for TQP/TCPs as an equitable means for test result comparison and credibility between contract parties has become apparent. Each state using QC/QA specifications should have provisions requiring the use of certified qualified technicians involved in construction project testing and inspection activities.

7. PROGRAM ORGANIZATIONAL STRUCTURE AND MANAGEMENT

7.1.1. Joint Sponsorship. Key to Success—A successful TQP/TCP works best with the full support and commitment from all parties (i.e., agency and industry) that have a vested interest in technician training and qualification/certification. Developing a partnership agreement at program inception, and prior to major changes, is recommended as the best means for gaining needed understanding and support for a TQP/TCP. Using a team approach helps provide an understanding of the multiple perspectives of the team members, and helps develop policies and procedures that will be supported by their organizations.

7.2.1. TQP/TCP Oversight Committee—State laws and state highway agency’s (SHA/DOT’s) policies may dictate a state or regional TQP/TCP structure, and restrictions on the language of the program charter and operation. Therefore, each state DOT should coordinate with its attorney general’s legal staff when developing their charter and bylaws for TQP/TCP governance and organizational structure.
It is recommended that a TCP should have an oversight committee to provide TCP governance. Several alternatives are recommended for establishing an oversight committee:

- Establish a joint venture between public and private industry;
- Have the state DOT take the lead; or
- Have an educational institution or industry group take the lead.

Oversight committee members typically include representatives from the following areas (e.g., state DOT, SHA personnel, contractors, suppliers, producers, independent laboratories, academia, private consultants, and the Federal Highway Administration (FHWA)). Because these programs will impact contract requirements, an agency manager should chair the oversight committee. Program oversight should be a joint effort among the entities represented on the oversight committee.

If the organization is a joint venture between agency and industry or between states, it may be incorporated as a nonprofit organization in order to receive and disburse funds on a regular basis.

The oversight committee should identify a TCP manager as a single contact point. The TCP manager may coordinate all the following activities: course development and curriculum; instructors and hands-on trainers; test development and qualification certification; training locations; manual development; class and provision of supplies.

It is advisable to have a centralized administration at a regional or state level. It is possible to have a regional program without having a centralized qualification and training location. Qualifications Certification and training may also be done at the local level to better meet the customers’ needs.

Start-up funds will be needed immediately for a variety of start-up tasks (e.g., to facilitate meetings, travel, printing, and other organizational functions). Possible start-up and developmental funding sources may include the following:

- State;
- Industry contributions;
- State Planning and Research (SP&R) Funds;
- Federal Highway Administration;
- Contributed time, facilities or equipment from industry, consultants, and academia; or
- Other innovative funding mechanisms (e.g., such as loans paid back from generated income for courses).

Multi-state or regional involvement may result in additional funding sources and a decrease in costs to the individual participants.

Course fees should be reasonable, but adequate, to enable the program to become self-sufficient. It is necessary to make a long-term commitment and conduct the program as if it were a business,
knowing that the program may lose money initially but should become self-sufficient after several years of operation. Areas where operational support may be available include the following:

- Manuals that are developed for certification/qualification and training may be sold publicly provided copyright laws are followed;
- Continued financial support from the agency and industry;
- Continued use of contributed items (e.g., facilities, equipment, etc.) from the agency and industry.

7.5. Organizational Task Groups—Task groups should be formed as soon as possible to simultaneously address the many TQP start-up issues. Each task group should be made up of four to six members with its chairman coming from the oversight committee. Other participating members may or may not be on the oversight committee. All members of the task group should have a working relationship and experience with the function of the particular task group. The task groups should be established and used to develop programs, plans, and policies for presentation and approval from the oversight committee. Recommended areas where task groups should be formed initially include the following:

- To develop requirements for training and certification/qualification programs;
- To establish experience and hands-on performance requirements;
- To establish course outlines; and
- To establish examinations criteria.

7.6. Development of Options for TCP—Options for leading the development, administration, and implementation of TQP certification/qualification programs have been developed and implemented through cooperative partnerships among public agencies, private sector organizations, and educational institutions. Options should be considered when determining who will be asked to lead the development, administration, and implementation of a state or regional TQP.

7.6.1. Agency In-House—Agency in-house TQP/CPs usually assign responsibilities for developing, administering, and implementing a TQP/CP into technical services, personnel/human resources, or product quality management areas.

7.6.1.1. The main advantages of an in-house TQP/CP are:

- Lower costs to contractors;
- No cost to DOT employees;
- Trainers knowledgeable of subject matter and familiar with specifications;
- Control of material being instructed; and
- In-house knowledge of TQP/CP requirements for technician’s skills, experience, certification or qualifications, re-certification/recertification, and decertification/dequalification.

7.6.1.2. The main disadvantages of the program are:

- Turnover of instructors;
- Fewer employees available to be instructors; and
- Fiscal and manpower costs to the SHA/state DOT.

7.6.2. Consultants—Using a third-party consultant to develop, administer, and implement a state or regional TQP/CP is similar to outsourcing other non-core tasks within an agency. The third-party consultant may be designated as a program director responsible for the day-to-day operations reporting directly to the oversight committee. The program director, ideally, would have no relationship with either the state or industry in order to eliminate potential appearance of a conflict of interest. Advantages of a third-party consultant include the availability of time and commitment to organizational needs, independence from interested parties, and facilitating and
overseeing the development of various programs to provide consistency among programs. A third-party consultant may also bring expertise and focus to the organization and provide the necessary staffing to expedite the product delivery schedule.

7.6.3.4.7.3. University/College—The advantages of using a university or college to develop, administer, and implement a state or regional TQP TCP are:

- Access to the diverse expertise found at a university or college; and
- Support facilities and services, e.g., mail, guest housing, meals, printing, janitorial, accounting, classrooms, laboratories, computers, fleet vehicles, student workers, and administration support staff.

7.6.4.4.7.4. Public/Private—State and regional certification qualification programs have been developed and implemented through cooperative partnerships among public agencies, private sector organizations, and educational institutions. These types of programs foster a cooperative relationship between industry groups and state agencies that will be very beneficial to everyone involved in this field. The partners can contribute their expertise to people from industry and agencies. This training to mixed groups will assure greater understanding and cooperation when constructing the project.

4.7.5. Private National Engineering and Technical Organizations—Several national engineering and technical organizations have created more generic certification qualification programs that are available to personnel from both agencies and industry.

7.6.5.4.7.6. Conflict of Interest—The TCP Oversight committee, TCP Manager, and program director should avoid the appearance of a conflict of interest.

8.5. TRAINING AND QUALIFICATION CERTIFICATION POLICIES

8.1-5.1. In developing state and regional TQPTCPs, the following guiding principles should be followed:

- Develop the TQPTCP using AASHTO sampling and testing procedures whenever possible. A state may require an additional endorsement to the TQPTCP to cover unique or additional procedures in their state;
- Address soils, aggregates, hot mix asphalt (HMA), asphalt mixture, and portland cement concrete (PCC) as the primary certification qualification topics; and
- Address a technician certification qualification Level-level I that involves involving basic sampling procedures and test methods initially, with additional certification qualification levels developed as the scope of the TQPTCP progresses.

8.2-5.2. Focus—In order to support the overall objective of improving highway construction the quality of the construction of highways through the improved work performance of those involved with the construction project, the TQPTCP must be directly work-related. The scope and content of all certification qualification-testing must be based on realistic and practical work needs. Because the TQPTCP focuses on work performance, everyone involved—managers, supervisors, program administrators, and participants—should treat qualification activities as natural extensions of their work duties and responsibilities.

5.3. Leveraging and Aligning Activities and Programs between States and Regions—There is a wide variation in the development and implementation of TQPTCPs between states and regions. There is an opportunity and a challenge for states and regions considering, or just beginning, TCP initiatives. No single “best way” to implement a TQPTCP has emerged, but there is much to be learned from states and regions with established TCPs. The following regional technician certification programs have been developed to promote certification reciprocity among member states:
8.2.1. Consideration should be given to developing state technician certification qualification requirements by participating in a regional TQP. Participating in a regional program has the positive benefit of pooling and leveraging state resources and also of allowing qualified technicians to work across state boundaries without having to retrain and requalify. Gaining these benefits will lower the states’ and contractors’ cost of doing business while still ensuring that high-quality testing is performed.

8.2.2. To facilitate reciprocity and efficiency, consideration should be given to developing qualification policies based on AASHTO standard test procedures. If an AASHTO test procedure is not available, then a state or region should adopt ASTM procedures or another agreed-upon method.

8.2.4. Once policies and procedures for developing a TQP are established, the next challenge is implementation. Given the experiences of states and regions that have already implemented TQPs, it is recommended that program elements be tested using a pilot process before fully implementing them as an integrated program. Well-designed pilots will maximize feedback and learning and help gain the support of those in government and industry who will be affected by the changes.

8.3. Consideration of Prerequisites—In addition to the required training, work experience may be used as an integral part of the certification qualification process to ensure technicians have the required knowledge, skills, and abilities. This assurance may be accomplished by establishing prequalification relevant work experience or education requirements, establishing work experience criteria prerequisites for participation in advanced certification qualification levels, or requiring relevant work experience to maintain and validate the requalification process.

8.3.1. The TQP should consider whether prerequisites are necessary for entry-level training. Demographics and the characteristics of the labor pool available to the state may need to be considered as a starting point. Minimum requirements in reading level and math skill capabilities may need to be identified as an entry-submittal gateway. If there is a problem noted with applicants’ reading and math skills that would hinder their performance, establishment of training to correct these deficiencies for the applicants may be advisable.

9. TRAINING

9.1. A well-planned and supportive training program is the basis for a successful certification qualification program. A good training program will ensure qualified technicians and testers will be performing inspection, sampling, and testing on construction projects. The training program should be offered to all individuals, including those from SHA, state DOT, local agencies, contractors, producers, or consultants. The program should be administered in the same way for all individuals similarly for everyone.

9.1.1. Training should be structured to fit the certification qualification test criteria. Since the program is toward highway construction, AASHTO test procedures should be used to the maximum extent.
The program administration requires the following resources:

- Funding and fees;
- Staffing (e.g., instructors, coordinators, proctors, etc.);
- Training facilities;
- Materials (e.g., manuals and equipment);
- Record keeping;
- Governing board/advisory committee; and
- Organizational task groups.

The above resources need to be considered when choosing who will handle the development and maintenance of the program.

Training materials may be developed solely for the TQP state or developed with another state/region. There are also existing training manuals and aides available for use.

Training may include lecture, hands-on training, or self-study methods. Inclusion of hands-on training will help to ensure that the technician is competent and should raise his or her comfort level in performing materials sampling and testing.

Qualified Certified technicians will need to be kept aware of test procedures, specification, equipment, or administration changes in the training program. This need may be satisfied by recertification, requalification training, update courses, or special training efforts.

Trainers need to have the technical knowledge and presentation skills necessary to instruct the courses. Competence and conduct criteria for the instructors, examiners, and proctors need to be defined and enforced.

EXAMINATION AND METHODS

A successful certification qualification program must have documented policies and procedures for examination methods to ensure consistent and fair administration by all examiners and proctors.

The program oversight committee should empower and formally task an individual (e.g., such as a TQP manager), to direct and coordinate all certification qualification examination activities (e.g., Typical duties of this individual are scheduling of examinations; registration of applicants; maintaining and ensuring the security of examination materials; notifying participants of their success or failure in their examination; and maintaining the completed examination materials).

Written and performance examinations should be given to determine if the applicants possess the knowledge and skills necessary to satisfy the established certification qualification requirements. “Grandfathering” technicians and testers, or a waiver of training and testing in lieu of certification qualification examination, should not be permitted.

If actually performing the test, a licensed professional engineer should demonstrate competence, follow the same written and performance examination requirements as other applicants, according to the TQP.
10.2.7.2. **Examination Controls and Integrity**—To avoid conflicts of interest, the examiner should not be the immediate supervisor of those being qualified certified. Examination procedures should be documented and included in the policy and procedures manual. The documentation should include procedures to:

- Develop and revise certification qualification exams;
- Establish examination pass-fail criteria;
- Determine examination duration;
- Determine disciplinary action for cheating;
- Document examination security procedures;
- Develop the detailed plan for conducting examinations;
- Develop retesting policy and procedures;
- Design a process to notify individuals of examination times and results;
- Develop procedures to ensure the confidentiality of score reporting;
- Establish requirements for examiners and proctors; and
- Establish a procedure to update or change tests when there is a change in a test method or specification.

10.3.7.3. **Examination Methods**—Written and performance examinations should be given to ensure that applicants have a complete understanding of the materials and calculations as well as the ability to perform test procedures. Care and good judgment are needed in developing fair and impartial written and performance examinations.

Prior to the examinations, the proctors should thoroughly explain to the applicants:

- The examination process and rules;
- What the exams will be comprised of;
Minimum scores necessary to pass; and

The retesting policy.

10.3.2  Performance Examination—Performance examinations measure the applicants’ ability to properly perform the prescribed test methodology. All proctors and examiners should evaluate each applicant’s proficiency by using standardized checklists that identify specific test method steps or tasks. The degree of detail of the performance checklists will be influenced by whether the performance examination is open- or closed-book. Inspection checklists developed by AMRL and CCRL are excellent references for the evaluation of AASHTO and ASTM test methods. Time limits can be set for the complete performance of each test method. The examinee may be asked to explain various steps of the procedure to reduce the full test time.

10.4  Re-Examination Policy—Written/Performance—Whenever a participant fails a written/performance certification qualification examination, some allowance should be provided for retesting. A policy should be established to address the following areas:
- Maximum number of retests allowed;
- When retesting will be permitted;
- Maximum time limit for retaking the written/performance examination; and
- Guidelines if the applicant fails the retest.

10.5  Notification of Results—Notification of an applicant’s successful or unsuccessful completion of the certification qualification requirements should be mailed to the applicant promptly after completion of the examination. If the applicant is unsuccessful, the procedure for re-examination should be explained.

10.6  Confidentiality of Records—Personal information and records of the examination are generally considered to be confidential and not to be released publicly. Confidential information includes:
- Personal and professional information provided by the participants applying for testing and certification qualification; and
- Specific test results and scores for participants.

10.7  Examination Materials Security—The certification qualification-training program should provide specific procedures and precautions for establishing and maintaining the security of examination materials at all times. Violation of security compromises the integrity and validity of the certification qualification process. Applicants should not retain a copy of the written examination. After the performance test, examiners and proctors may inform the applicants of their weaknesses, incorrect procedures and the details of correct proper procedures.
10.8.7.8. **Examiner and Proctor Qualifications**—Examiners and proctors should complete an orientation or training session. Examiners for the performance examination must be qualified in that examination area. Examiners may be employees of agencies, contractors, or industry associations.

10.8.7.9. **Examination Appeals**—An applicant wishing to register a complaint or protest regarding an examination or examiner must do so in writing to the TQP manager within a specified period of time. The written complaint must specify the examination date, the examiner, and the nature of the complaint or protest.

7.9.1. Complaints and protests should be reviewed and a recommendation made to the oversight committee. All complaints and protests should be promptly answered in writing.

10.9.1. **Continuous Improvement**—Course evaluations should be used to identify improvements that can be made in the TCP. Audits of certification training and examinations can be used to ensure that procedures are being followed.

11.8. **QUALIFICATION CERTIFICATION**

11.1.1. Each qualifying agency that issues, through their TQP TCP, the status of qualification or certification must maintain a written policy for administration of their TCP.

11.2.2. Each agency must maintain a registry of trained technicians who have successfully completed a training program. The registry should include:

- Name, Social Security number or certification identification number, and address;
- Courses, and dates completed; and
- Course content: Test methods included; Lecture or laboratory; Written examination; and Performance examination.

11.3.3. The qualifying agency shall provide the qualified technician with documentation of the certification. This documentation may be in the form of a registration card, email, or listing on accessible database, or letter. The document should include any appropriate expiration dates.

11.3.4. The qualifying agency may require the registered technician to maintain a current address on file as a condition of registration.

11.4.4. Establishing a registration policy is the TCP manager’s responsibility of the TQP manager. A registration application should include:

- Program administration and information contact(s);
- Listing of certification training courses and examinations and fee schedule;
- Refund policy;
- Payment policy;
- Enrollment and lodging information;
- Participant and employer information; and
- Resume application.
Enrolling and scheduling course participants and collecting fees can become a tedious and cumbersome task. It is highly recommended that developing a database software package or website be used to expedite the registration and record-keeping process.

The qualifying agency must adopt a policy to protect the privacy of all qualified technician’s records.

The TQP should establish a time period for which the qualification remains valid.

The TQP should include a recertification requalification policy. The recertification requalification process may include refresher courses, observations, and/or retaking written examinations, and performance examinations.

Note 3—A number of states use independent assurance sampling and testing to replace the performance examination requirement as part of recertification. The independent assurance program should evaluate testers by observation and the results of testing split samples or proficiency samples, when used as part of recertification, and be performed within 12 months of the recertification.

The TQP should include a written policy regarding the removal of certification status or disciplinary measures regarding technician performance. Progressive levels of discipline that lead up to decertification may be provided.

Each state or region should develop a set of test methods to support a Level I TQP. This level depends, to some extent, upon the specifications and materials requirements. It is hoped that a Level I TQP will be the starting point for reciprocity between the SHAs. The list of tests shown in Appendix A-X1 was developed as an example during the November 1996 Technician Certification Program Workshop and represents some of the tests commonly used by each state when selecting tests to include in their TQPs.

Training and certification programs can result in significant improvements in the quality of the American transportation system. TQPs can improve the abilities of technicians and help ensure validity of their testing, thereby resulting in fewer claims, legal disputes, and less adversarial relationships between the parties. Improved worker skills reduce the risks to both the owner/agency and contractor/producer and better identify the quality of each component and the final product. Training will improve the quality standards of highway workers, giving them more confidence and pride in their job performance. TQPs can be used to establish a career path for SHA, state DOT and industry employees, providing promotional opportunities based on merit. Improved worker performance should lead to longer-lasting roads and a more effective use of taxpayer dollars, while providing an improved infrastructure for the traveling public.

Technician certification; technician qualification; technician training.

11.5.8.5
12.1.9.1
13.10.1
14.11.1
APPENDIXES

(Nonmandatory Information)

X1. QUALIFYING TESTS—SOILS AND AGGREGATES

X1.1. Recommended Test and Corresponding AASHTO Test or Other Test:

X1.1.1. Gradation:

- T 27, Sieve Analysis of Fine and Coarse Aggregates
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate
- T 100, Specific Gravity of Soils
- T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

X1.1.2. Liquid Limit, Plastic Limit, and Plasticity Index:

- T 89, Determining the Liquid Limit of Soils
- T 90, Determining the Plastic Limit and Plasticity Index of Soils

X1.1.3. Compaction/Density:

- T 99, Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
- T 180, Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- T 310, In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

X1.1.4. Moisture Content:

- T 255, Total Evaporable Moisture Content of Aggregate by Drying

X1.1.5. Sampling and Splitting:

- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling of Aggregates

X1.1.6. Deleterious Materials:

- T 113, Lightweight Pieces in Aggregate

X1.1.13. Dry Rodded Unit Weight:

- T 19M/T 19, Bulk Density ("Unit Weight") and Voids in Aggregate

X1.1.14. Soil Preparation:

- R 58, Dry Preparation of Disturbed Soil and Soil-Aggregate Samples for Test
X2. QUALIFYING TESTS—PORTLAND CEMENT CONCRETE (PCC)

X2.1. Recommended AASHTO or Other Test Designations:

X2.1.1. Sampling:
- R 60, Sampling Freshly Mixed Concrete

X2.1.2. Aggregate Gradations:
- T 27, Sieve Analysis of Fine and Coarse Aggregates

X2.1.3. Moisture Content of Coarse and Fine Aggregate:
- T 121M/T 121, Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- T 255, Total Evaporable Moisture Content of Aggregate by Drying

X2.1.4. Aggregate Specific Gravity:
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate

X2.1.5. Air Content by Pressure Method:
- T 152, Air Content of Freshly Mixed Concrete by the Pressure Method

X2.1.6. Air Content by Volume Method:
- T 196M/T 196, Air Content of Freshly Mixed Concrete by the Volumetric Method

X2.1.7. Slump and Temperature:
- T 119M/T 119, Slump of Hydraulic Cement Concrete

X2.1.8. Fabrication and Curing of Compressive Strength Specimens (Cylinders and Beams):
- T 23, Making and Curing Concrete Test Specimens in the Field

X2.1.9. Capping and Testing Cylinders:
- T 22, Compressive Strength of Cylindrical Concrete Specimens

X3. QUALIFYING TESTS—HOT MIX ASPHALT MIXTURE (HMA)

X3.1. Recommended AASHTO or Other Test Designation:

X3.1.1. Aggregate Gradation:
- T 27, Sieve Analysis of Fine and Coarse Aggregates

X3.1.2. Asphalt Content (Ignition, Solvent, Nuclear):
X3.1.3. **Bulk Specific Gravity of Compacted Specimens:**
- T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens

X3.1.4. **Sampling Methods and Techniques:**
- R 47, Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size
- T 168, Sampling Bituminous Paving Mixtures

X3.1.5. **Voids and VMA:**
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures

X3.1.6. **Maximum Theoretical Specific Gravity:**
- T 209, Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA)

X3.1.7. **Specific Gravity of Aggregates:**
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate

X3.1.8. **Percent Passing 75-µm (No. 200) Sieve:**
- T 11, Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing

X3.1.9. **Moisture Content:**
- T 255, Total Evaporable Moisture Content of Aggregate by Drying
- T 329, Moisture Content of Asphalt Mixtures by Oven Method

X3.1.10. **Sand Equivalent:**
- T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- T 312, Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the Superpave Gyratory Compactor
- ASTM D1556, Standard Test Methods for Resistance to Deformation and Cohesion of Asphalt Mixtures
- ASTM D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

X3.1.12. **Coarse Aggregate Angularity:**
- ASTM D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
- ASTM D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

Commented [JB28]: Likewise, consistency? to italicize or not to

Commented [JB29]: above, we have Gmm in italics ... consistency?
X3.1.14, X3.1.13. **Moisture Susceptibility**:

- T 283, Resistance of Compacted Hot Mix Asphalt Mixtures (HMA) to Moisture-Induced Damage

X3.1.14. **Density**:

- T 355, In-Place Density of Asphalt Mixtures by Nuclear Methods
Standard Recommended Practice for

Determining Constant Mass

AASHTO Designation: PP XX-17
Standard Recommended Practice for

Determination of Constant Mass

AASHTO Designation: PP XX-17

1. SCOPE

1.1. This practice contains general criteria and guidelines for standard methods of determining constant mass when drying samples or container for testing equipment. This practice is intended for use with test methods that do not contain all the specific requirements for determining constant mass.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:
   - T 255, Total Evaporable Moisture Content of Aggregate by Drying
   - T 265, Laboratory Determination of Moisture Content of Soils

3. TERMINOLOGY

3.1. Constant mass—the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

4. SIGNIFICANCE AND USE

4.1.1. A consistent method of defining and determining constant mass of a sample or testing equipment is required to reduce variations in test results. The test method may define the allowable temperature, time interval, and allowable percent change in mass. When a test method does not address any or all of these, consider the following should be considered:

4.1.2. Related test methods—Test methods for comparable material type, where a procedure for constant mass or its components are defined should be considered.

4.1.3. Temperature—Test methods differ in specifying temperatures.

   4.1.3.1. When a heat source that are not thermostatically controlled, effort should be made to distribute the heat evenly throughout the sample. This can be accomplished by stirring, managing the distance from the heat source or output from the heat source, such as a heat lamp or open flame; reducing the heat output; or in the case of a microwave, reducing the time duration of each interval. Regardless of the heat source and method, the same procedure should be used for each cycle in the constant mass determination procedure.

4.1.4. Time interval—All samples are dried for an initial time and subsequent drying intervals. Initial and subsequent drying times may be dependent on the size of the sample, sample container and testing equipment.
equipment, or heat source, or any combination thereof. Appendix X1 should be reviewed before adjusting any of these parameters.

4.1.5. Allowable percent change of mass—Test measurement repeatability and its influence on results should be addressed.

Note 1—T 255 and T 265 allow define a maximum percent change as a change of less than 0.1 percent.

5. PROCEDURE

5.1. Determine constant mass of a sample:

5.1.1. Determine and record container mass.

Note 2—Units and accuracy are defined by the standard test method resultant.

5.1.2. Place sample in the container.

5.1.3. Determine and record initial sample and container mass if evaporable moisture content is desired.

Dry the sample until it appears moisture free.

5.1.5. Remove the sample and container from the heat source, immediately determine and record the mass.

Note 3—Use a cooling rack, oven mitt or other separation device between the hot container and balance to protect the balance and electronics equipment.

5.1.7. Remove the sample and container to the heat source for the additional time interval.

5.1.7. Remove the sample and container and immediately determine and record the mass.

\[
\% \text{ Change} = \frac{(M_p - M_n)}{M_p - M_c} \times 100
\]

Where:

- \( M_p \) = previous mass determination
- \( M_n \) = new mass determination
- \( M_c \) = container mass

5.1.9. The sample is at constant mass if the percent change is less than or equal to the allowed variation.

5.1.10. Repeat the drying cycles, step 5.1.5 through 5.1.9, if the percent change exceeds the allowable variation until the percent change is less than or equal to the allowable variation.

5.1.9. Cool the sample and container and determine and record the final dry mass, if required.

Note 4—Depending on the sample size, covering the container may be necessary so that is not absorbed while cooling.

5.2. Determine constant mass of a testing equipment (such as a container, bottle, or vessel):

5.2.1. Bring the container-testing equipment to the temperature of the heat source.
5.2.2. Remove the testing equipment container from the heat source, immediately determine and record (Refer to Note 3.)

Note 3—Use a cooling rack, oven mitt or other separation device between the hot container and balance to protect the balance and electronics.

5.2.4. Remove the testing equipment container and determine and immediately record the mass.

5.2.5. Calculate the percent change by subtracting the new mass from the previous mass and divide by the previous mass. Multiply this by 100.

\[
\text{\% Change} = \frac{M_p - M_n}{M_p} \times 100
\]

Where:

- \( M_p \) = previous mass determination
- \( M_n \) = new mass determination

5.2.6. The testing equipment container is at constant mass if the percent change is less than or equal to the allowed variation.

5.2.7. Repeat the drying cycles, step 5.2.2 through 5.2.6, if the percent change exceeds the allowable variation until the percent change is less than or equal to the allowable variation.

6. REPORT

6.1. The report shall include the following:

6.1.1. Drying temperature

6.1.2. Initial drying time

6.1.3. Time interval

6.1.4. Allowable percent change of mass

APPENDIX

(Nonmandatory Information)

X1. DEVELOPING AN ADDITIONAL DRYING TIME INTERVAL

X1.1. Initial drying time and additional intervals can be stated in a standard test. The variables that may influence the drying time would be the relative humidity of the lab, the air flow past the sample, the sample agitation, drying multiple samples at the same time, the particle and sample size, and the temperature the sample reaches during each cycle, etc.

X1.2. It has been found that using a 230 ±9°F oven and a reasonable amount of samples and airflow, an additional drying period of 30 to 60 min., depending upon the material, is adequate.
X1.3. When using heat sources that are not thermostatically controlled, such as hot plates, stove tops, heat lamps or open flame torches, an additional drying period of 10 min. may be sufficient.

X1.4. When using a microwave, consider the wattage and the amount of material you are drying. At 900 watts, an additional time of 2 min. is adequate. When using a flammable container, adjust the time so the container doesn’t char.
Standard Practice for

Asphalt Surface Dielectric Profiling System using Ground Penetrating Radar

AASHTO Designation: XX ##-## (2017)
Release: Group #

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001
1. **SCOPE**

1.1. This standard specifies the equipment and software requirements for a dielectric profiling system (DPS). Calibration and verification procedures are also detailed.

1.2. A DPS uses ground penetrating radar (GPR) technology to continuously measure asphalt compaction quality up to freeway speeds. The DPS system reports the asphalt surface dielectric constant which is strongly correlated to asphalt air void content (FHWA/TX-92/1233-1). As the dielectric constant increases, air void content decreases.

1.3. A DPS may be a single- or multi-channel system and may be cart or vehicle-mounted.

2. **REFERENCED DOCUMENTS**

2.1. **AASHTO Standards:**

- R 37-04, Application of Ground Penetrating Radar (GPR) to Highways
- PP 80-14 (2017), Standard Practice for Continuous Thermal Profile of Asphalt Mixture Construction
- PP 81-14 (2016), Standard Practice for Intelligent Compaction Technology for Embankment and Asphalt Pavement Applications

2.2. **ASTM Standards:**

- D150-11: “Standard Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation”
- D2520 – 13: “Complex Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials at Microwave Frequencies and Temperatures to 1650°C”

2.3. **Federal Highway Administration:**
3. SUMMARY OF METHOD

3.1. This specification describes the hardware and software requirements and calibration procedures for a DPS.

4. TERMINOLOGY

4.1. Definitions: Definitions shall be in accordance with the terms and symbols given in Terminologies and Definitions from AASHTO R 37-04, AASHTO PP 80-14, AASHTO PP 81-14, and ASTM D6432-11.

4.2. dielectric profiling system (DPS)—This term refers to the specific arrangement of the GPR equipment used to measure the dielectric constant including the GPR antennas, radar control unit, and suitable data storage, calculation, and display devices.

4.3. heat map plot—a graphic display of data using color scales. These plots may display raw values or employ varying degrees of smoothing (adapted from AASHTO PP 81-14).

4.4. dielectric constant—the measured dielectric property of the finished asphalt pavement surface. The surface dielectric constant is calculated using Equation 4-1 (S2-R06C-RR-1):

\[
\varepsilon_r = \left( \frac{1 + \frac{A_0}{A_i}}{1 - \frac{A_0}{A_i}} \right)^2
\]

Equation 4-1

where:
\( \varepsilon_r \) = dielectric constant,
\( A_0 \) = amplitude of the reflection at the air/asphalt interface
\( A_i \) = initial antenna amplitude. (May be measured with a metal plate calibration.)

4.5. dielectric profile—the surface dielectric readings and associated stationing, offset, GNSS coordinates, and time stamps.

5. HARDWARE REQUIREMENTS

5.1. Dielectric Profiler System Overview –

5.1.1. The DPS consists of the following components (Figure 1).

- Vehicle or Cart
  - Antenna boom
  - Distance measuring instrument (DMI)
5.1.2. The DPS shall measure the dielectric constant of the asphalt surface based on the GPR surface reflection. The system shall be capable of recording these data at both fixed distance intervals (distance mode) and at fixed time intervals (time mode).

5.2. **Vehicle or Cart:**

5.2.1. A vehicle or cart shall be provided to carry the GPR system, computer, metal plate, antenna boom, and be equipped with a DMI and GPS receiver.

5.2.2. **Antenna boom** – Non-metallic boom to maintain the antenna/s at a fixed vertical height and at least 18 inches away from any large metal body such as the vehicle frame. Processing algorithms should account for vertical movement from the vehicle suspension. When vehicle mounted, the system shall be structurally capable of traveling up to 50 mph with tolerable antenna movement. The position of the antenna(s) should be adjustable to allow for collection at agency specific lateral positions within the pavement lane.

5.2.3. **Distance measuring instrument (DMI)** – The vehicle or cart should be instrumented with a DMI with a minimum operational tolerance of 1 ft/mile.

5.2.4. **Global positioning system (GPS)** – The vehicle or cart should be instrumented with a GPS with a minimum operational tolerance of ± 15 ft. and allow for input of an external GPS string.

5.3. **Air Coupled GPR**

5.3.1. Single or multi-channel air-coupled GPR system with an operational frequency of between 1 and 3 GHz shall be used. All antennas shall have the same frequency.

5.3.2. **Performance Specifications:** The GPR system shall pass the performance specifications in Table 1. These are based on the metal plate reflection tests recommended by the Texas A&M Transportation Institute with the Federal Highway Administration, FHWA/TX-92/1233-1 for general purpose GPR. Each of these measurements shall be determined prior to the first use of the equipment.

**Table 1** — Performance summary table with required limits.
### Measure Description | Required Limit
---|---
Short Term Dielectric Stability | Max: 0.06
Mid Term Dielectric Stability | Max: 0.08
Long Term Dielectric Stability | Max: 0.08
Inter-Antenna Dielectric Variation* | Max: 0.08
Inter-Antenna Amplitude Variation* | Max: 5%

*Multi-channel systems only

#### 5.3.3. Short Term Dielectric Stability (STDS) – Stability of the measured dielectric constant over a short time period. In time-mode, collect 50 surface dielectric measurements over a validation block at a minimum rate of 15 scans per second. Stacking or moving average techniques may be used if the DPS has the capability of collecting data at a faster rate. Calculate the STDS using Equation 5-1.

$$STDS = e_{ST\max} - e_{ST\min}$$  
where:  
$$e_{ST\max} = \text{maximum recorded dielectric over 50 scans.}$$  
$$e_{ST\min} = \text{minimum recorded dielectric over 50 scans.}$$

#### 5.3.4. Leakage Dielectric Stability (LDS) – Stability of the measured dielectric constant over a typical data collection period. In time-mode, collect dielectric measurements over a validation block for 20 minutes continuously at a minimum rate of 15 scans per second. Stacking or moving average techniques may be used if the DPS has the capability of collecting data at a faster rate. Calculate the LDS using Equation 5-2.

$$LDS = e_{L\max} - e_{L\min}$$  
where:  
$$e_{L\max} = \text{maximum recorded dielectric over 20 minute time period.}$$  
$$e_{L\min} = \text{minimum recorded dielectric over 20 minute time period.}$$

#### 5.3.5. Long Term Dielectric Stability (LTDS) – Stability of the DPS between calibrations and over an extended period of time, exceeding the duration of a large paving project. On 5 separate days spanning 21 days between the first and last measurement, collect 10 data sets spanning at least 5 unique days included at least one day with multiple data sets. For each data set, collect 5,000 scans in time-mode over a validation block. Calculate the LTDS using Equation 5-3.

$$LTDS = e_{LT\max} - e_{LT\min}$$  
where:  
$$e_{LT\max} = \text{maximum recorded dielectric over the 10 evaluated data sets.}$$  
$$e_{LT\min} = \text{minimum recorded dielectric over the 10 evaluated data sets.}$$

**Note 1** — Current testing suggests no impact of testing over a period of time. If this trend continues this performance metric may allow for all 10 data sets to be collected over any duration of time as long as the system is completely turned off between data collection sets.

#### 5.3.6. Inter-Antenna Dielectric Variation (IADV) – Variation among the dielectric measurements from the different DPS antennas. Applicable to multi-channel DPS systems only. In time-mode, collect 1,000 dielectric measurements with each antenna over a validation block. Calculate the mean dielectric constant of the block for each antenna. Calculate the IADV using Equation 5-4.
\[ I_{ADV} = e_{Amax} - e_{Amin} \]  

Equation 5-4

where:
\[ e_{Amax} = \text{maximum mean dielectric among all DPS antennas.} \]
\[ e_{Amin} = \text{minimum mean dielectric among all DPS antennas.} \]

5.4. **Validation Block** – A block of plastic insulating material shall be used for performance validation of the GPR antennas. The block shall conform to ASTM D2520 and ASTM D150-11. The block shall have a known dielectric value between 2 and 15. The minimum block size shall be 24 x 24 inches and 3.5 inches thick.

6. **SOFTWARE REQUIREMENTS**

6.1. **Data Collection**

6.1.1. **Meta Data** – As a minimum, the software shall store the following meta-data:
- Dielectric value
- Project Name
- Road ID
- Travel Direction
- Lift Designation
- Lane Designation
- Date-time
- Distance (ft)
- Station (ft)
- Lateral Offset (ft)
- Longitude (°)
- Latitude (°)
- Elevation (ft)
- Moving Average Distance (ft)
- Output Interval Distance (ft)
- Date
- FileName

6.1.2. **Dielectric Data**

6.1.2.1. **Calibration** – Before every data collection period, the software shall prompt the user to perform an air and metal plate calibration process for each antenna, as described in 7.1 and 7.2. Calibration of the DMI shall also be allowed as described in 7.3.

6.1.2.2. **Dielectric** – The software shall calculate the surface dielectric constant from the surface reflection using Equation 4-1. Recording individual trace data is not necessary.

6.1.2.3. **Air Void Conversion** – The software should provide an empirical conversion from dielectric constant to asphalt air void content using a linear, logarithmic, or power equation.

6.1.2.4. **Distance-mode** – The software shall be capable of recording dielectric data at fixed distance intervals as small as every 0.5 inches. The reported value may be the result of moving average, stacking, and/or oversampling techniques.

6.1.2.5. **Time-mode** – The software shall be capable of recording dielectric data at fixed time frequency as fast as 15 measurements per second.
6.1.2.6. **Signal Correction** – The software shall account for potential cell tower interference. This may be done through oversampling, stacking, and/or averaging the data. The DPS should also account for any changes to the amplitude of the signals caused by changes in antenna height up to 0.5 in., or temperature of the hardware components expected during normal operation.

6.1.3. **Distance** – DMI and GPS measurements shall accompany each dielectric measurement.

6.2. **Data Display** – The DPS software shall:
- Display the data in real-time.
- Display the current dielectric values from each antenna, with an appropriate moving average filter. Typically between 0.5 and 5 ft. is reasonable.
- Provide a plot of dielectric vs. distance/time. The plot shall be a heat map and/or line graph (Figure 2). The scale for the dielectric axis should allow the user to adjust the displayed dielectric range, typically centered close to the mean dielectric with a range of 1.5 from the minimum and maximum displayed values. Minimize changes to the scale as much as possible.

![Figure 2—Example heat map and line graph.](image)

6.3. **Data Analysis** — The DPS software shall perform the following data analyses on-site:
- Data Filtering by:
  - Centerline Offset
  - Stationing
  - Antenna Serial #
- Summary Statistics (applied to any combination of data filtering)
  - Average dielectric
  - Median Dielectric
  - Standard deviation of dielectric
  - Dielectric value at n\textsuperscript{th} percentile (user specified percentage)
  - Percent below/within/above limits (user specified dielectric range)
  - Joint ratio (mean dielectric along the joint divided by mean dielectric along the center of the mat)
- Summary Visuals (applied to any combination of data filtering)
Plot of dielectric vs. distance. The plot shall be a heat map and/or line graph.

Histogram of the data

7. CALIBRATION

7.1. Air calibration – Air calibration is used to subtract the direct coupling and associated noise from the antenna from the recorded signal. Follow the manufacturer recommendations for performing the air calibration. Generally, position the antennas in the air at least 1.5 times the height of the antenna during operation.

7.2. Metal plate calibration – Metal plate calibration is used to measure the antenna amplitude, $A_i$, in the dielectric constant calculation. Follow the manufacturer’s recommendations for performing the air calibration.

7.2.1. Metal Antenna Variation – If the metal plate calibration amplitude is outside of 3 standard deviations from the historic mean metal calibration amplitude the equipment should be re-calibrated.

7.3. DMI System—Perform DMI calibration according to the manufactures recommendations. Make sure the DMI is fully functional before beginning each project.

7.4. GNSS — When analyzing data in conjunction with intelligent compaction and/or IR technology the global positioning calibration requirements from PP 80-14 (2016), and/or PP 81-14 (2016), shall be followed.

8. PROFILER ACCURACY

8.1. Dielectric Profile Precision—Currently, no precision information exists for this test method. See performance specifications from Section 5 for guidance.

8.2. Dielectric Profile Bias—Currently, no bias information exists for this test method.

9. KEYWORDS

9.1. Asphalt pavement uniformity; asphalt paving; ground penetrating radar; GPR; global positioning system; GPS; global navigation system; GNSS; dielectric profile; dielectric profiling; dielectric segregation; uniformity; material segregation; mat dielectrics; surface dielectric measurements.

10. REFERENCES


Standard Specification for

File Format of Intelligent Construction Data

AASHTO Designation: MP NN-18¹

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001
1. SCOPE

1.1. This specification describes a tagged file storage format used for geo-referenced intelligent construction data. The type of data includes, but is not limited to, intelligent compaction data and paver-mounted thermal profiling data.

1.2. This specification is designed to be independent of hardware platforms, computer languages, and Operating System (OS).

2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:
   - PP 80-17  Standard Practice for Continuous Thermal Profile of Asphalt Mixture Construction
   - PP 81-14  Standard Practice for Intelligent Compaction Technology for Embankment and Asphalt Pavement Applications

2.2. ASTM Standards:
   - None

2.3. IEEE Standards:

2.4. Other Documents:
   - International Intelligent Construction Technologies Group website: www.IICTG.org
   - Intelligent compaction website: www.IntelligentCompaction.com
   - Example time resolution for programming languages and applications on the Wikipedia website: https://en.wikipedia.org/wiki/System_time#Programming_languages_and_applications
   - The Unified Code for Units of Measure - UCUM: http://unitsofmeasure.org/trac
   - EPSG Geodetic Parameter Dataset: http://www.epsg.org/

3. TERMINOLOGY

3.1. Definitions

3.1.1. ASCII - Method of encoding basic English printable characters and symbols.

3.1.2. Unicode - A set of characters capable of representing almost any writable character.
3.1.3. UTF-8 - Method of encoding Unicode. The first 128 characters encoded the same as ASCII.

3.1.4. Signed - capable of representing negative and non-negative values.

3.1.5. Unsigned - capable of representing only non-negative values.

3.1.6. Byte - data type for an 8-bit, unsigned integer.

3.1.7. Int16 - data type for a 16-bit, signed integer.

3.1.8. Int32 - data type for a 32-bit, signed integer.

3.1.9. Int64 - data type for a 64-bit, signed integer.

3.1.10. Single - data type for a 32-bit, signed real number, e.g. single precision IEEE floating point.

3.1.11. Double - data type for a 64-bit, signed real number, e.g. double precision IEEE floating point.

3.1.12. String - data type for variable-length UTF-8 text. The string is not terminated and must be preceded by the number of bytes used to represent the string, stored as an Int16. All strings are encoded using ASCII, except for data values, which are encoded using UTF-8.

3.1.13. Array (numeric data type) - Sequence of data of the specified numeric data type.

3.1.14. Array (String) - Each element is stored as UTF-8 text and is preceded by length stored as an Int16.

3.1.15. Veta—a standardized intelligent construction data management (ICDM) software that stores, maps, and analyzes intelligent compaction and associated geospatial data (e.g., thermal profile data, spot test data). This software can perform standardized data processing, analysis, and reporting to provide project summary results quickly in the field from various IC manufacturers. The software can provide statistics, histograms, correlations for the IC measurements (e.g., speed, temperature, pass count, Intelligent Compaction Measurement Value - ICMV), and document coverage area; and it can evaluate the uniformity of compaction as part of the project quality control operations. Veta can be downloaded from the www.IntelligentCompaction.com website to validate data files written based on this standard.

3.1.16. Lookup table (LUT) - Array of numeric items, where each item is associated with a number or string value. A lookup table is typically used to conserve space or reduce computation time.

4. DATA SPECIFICATION

4.1. Data value are stored in binary format for maximum performance, minimum file size, and protection against casual modification. The metadata or data descriptions are stored in text format for ease of parsing and understanding.

4.2. Byte Order

4.2.1. All values that require more than one byte must be stored in Little Endian format with the least significant byte (LSB) first and the most significant byte (MSB) last.

4.3. File Name

4.3.1. The file extension must be “tds”, which stands for “Tagged Data Storage”.

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4.3. File Name

4.3.1. The file extension must be “tds”, which stands for “Tagged Data Storage”.
4.4. **File Structure**

4.4.1. The file structure uses a series of blocks. Each block contains a description of the data and the data itself, when applicable.

4.4.2. Blocks are grouped into sections. Sections are noted by text in brackets. The following sections are available and when used, must be present in this order: [file-headers], [lookup-tables], [data-headers], [data-source], and [log-data]

4.4.3. The format is designed to store one set of coordinates for a given timestamp. The file is limited to one machine per file but multiple sensors are allowed. A geographical offset can be defined for each sensor, allowing for different coordinates for each sensor.

4.4.4. The format is generally defined to store measured, not calculated, data.

4.4.5. Measurement data can be stored in the sensor data source section or the log data section. While it is possible to store data in both sections, it is not recommended because the two options are for different scenarios. If all measurement data is available, data should be stored in the sensor data source section for best performance. If data is being stored as it is measured, the log data section is more appropriate for data transmission. After initial values are saved for data, subsequent values are stored only if they have changed from the previous value. This allows for a compact file, but requires more time for the reading software.

4.4.6. Because each block is self-describing, processing software can and must preserve all data blocks, even when they are not recognized.

4.5. **File Header**

4.5.1. The file header shall contain two data blocks that describe the file format: (1) signature, and (2) version.

4.5.2. (1) Signature: The signature block shall contain the string data, “TaggedDataFormat”.

4.5.3. (2) Version: The version for this specification is “1”. The version is only incremented if a file format change breaks compatibility with previous versions.

4.6. **Data**

4.6.1. Two types of blocks are available: (1) data block, and (2) value block.

4.6.2. Data Block

4.6.2.1. A data block describes and optionally includes the data. The block is defined in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>String</td>
<td>Name of the data</td>
</tr>
<tr>
<td>Block ID</td>
<td>Int16</td>
<td>ID unique to this file (optional)</td>
</tr>
<tr>
<td>Measurement unit</td>
<td>String</td>
<td>Unit of measure for the value.</td>
</tr>
</tbody>
</table>
### Data type

<table>
<thead>
<tr>
<th>Data type</th>
<th>String</th>
<th>Data type name (Table 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Byte length</td>
<td>Int32</td>
<td>Number of binary bytes used to store the value.</td>
</tr>
<tr>
<td>Data</td>
<td>Varies</td>
<td>The data bytes appropriate to the block type (optional)</td>
</tr>
</tbody>
</table>

#### 4.6.2.2. Name

Block names must be encoded in ASCII. Names are not case-sensitive, but this specification lists names in lower-case. A list of recognized data is provided in Table 6. Names can contain numbers, but cannot consist solely of numbers. Distinct words in the name are separated by a hyphen, “-”. Multiple sensors of the same type should end with a pound or hash symbol (“#”), followed by a number. Examples: roller-speed, surface-temperature#1, surface-temperature#2

#### 4.6.2.2.1. Block names must be encoded in ASCII. Names are not case-sensitive, but this specification lists names in lower-case. A list of recognized data is provided in Table 6. Names can contain numbers, but cannot consist solely of numbers. Distinct words in the name are separated by a hyphen, “-”. Multiple sensors of the same type should end with a pound or hash symbol (“#”), followed by a number. Examples: roller-speed, surface-temperature#1, surface-temperature#2

#### 4.6.2.2.2. Custom data blocks (blocks not listed in this specification) are allowed. Custom blocks names must have a prefix in the format of: -organization-. Example from company ABC: -abc-unique-measurement

#### 4.6.2.3. Block ID

#### 4.6.2.3.1. The ID is a numeric value greater than zero that is unique to this file. When another block needs to refer to this block, it will use this ID rather than the name to conserve space. This value can be 0 if no other block refers to this block.

#### 4.6.2.4. Measurement Unit

#### 4.6.2.4.1. The measurement unit is specified by ASCII, case-insensitive names in the *Unified Code for Units of Measure*. A value of “none” is used when a unit is not applicable. This provides a standard method for transmitting unit information in a file. When displaying the unit, more common text may be used.

#### 4.6.2.5. Data Type

#### 4.6.2.5.1. The data types recognized by the standard file format are listed in Table 2. Custom data types are allowed, but arrays of custom data types are not allowed.

#### 4.6.2.5.2. Integers are stored as an Int32 unless file size would be significantly affected.

### Table 2—Recognized data types

<table>
<thead>
<tr>
<th>Data Types</th>
<th>Byte Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>1</td>
</tr>
<tr>
<td>byte-array</td>
<td>1 * Length</td>
</tr>
<tr>
<td>int16</td>
<td>2</td>
</tr>
<tr>
<td>int16-array</td>
<td>2 * Length</td>
</tr>
<tr>
<td>int32</td>
<td>4</td>
</tr>
<tr>
<td>Type</td>
<td>Size</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>int32-array</td>
<td>4 * Length</td>
</tr>
<tr>
<td>int64</td>
<td>8</td>
</tr>
<tr>
<td>int64-array</td>
<td>8 * Length</td>
</tr>
<tr>
<td>single</td>
<td>4</td>
</tr>
<tr>
<td>single-array</td>
<td>4 * Length</td>
</tr>
<tr>
<td>double</td>
<td>8</td>
</tr>
<tr>
<td>double-array</td>
<td>8 * Length</td>
</tr>
<tr>
<td>string</td>
<td>Varies</td>
</tr>
<tr>
<td>string-array</td>
<td>Varies</td>
</tr>
<tr>
<td>timestamp</td>
<td>12</td>
</tr>
<tr>
<td>timestamp-array</td>
<td>12 * Length</td>
</tr>
<tr>
<td>boolean</td>
<td>1</td>
</tr>
<tr>
<td>boolean-array</td>
<td>1 * Length</td>
</tr>
</tbody>
</table>

4.6.2.5.3. To conserve space, this specification defines a Boolean as a Byte. A value of 0 is False and a value of 1 is True.

4.6.2.5.4. A timestamp requires a time and UTC offset to ensure historical accuracy. It is insufficient to store one time zone for the file because time zone definitions change over time and the offset can change for daylight savings. When converted to binary storage for this specification, the value is stored as an Int64 for the time and an Int32 for the offset. The Int64 signifies the number of ticks that have elapsed since a specified epoch, a common method of measuring time on computers. The number of seconds represented by a tick varies among programming languages. This specification uses the definition from Microsoft: The tick count is the number of 100 nanosecond intervals that have elapsed since the epoch date of 00:00:00.000, January 1, 0001 in the Gregorian calendar. The Int32 specifies the UTC offset in minutes, including daylight savings time.

4.6.2.6. Byte Length

4.6.2.6.1. Number of binary bytes used to store the value. This value can be 0 to specify that the block does not contain data. The length for each data type is provided in Table 2.

4.6.2.7. Data

4.6.2.7.1. Data for block. If the length is 0, this item will be empty. Some data use values obtained from lookup tables. A list of recognized lookup tables is provided in Table 7.

4.6.3. Data Quality

4.6.3.1. For Single and Double data, values can be recorded as Not a Number (NaN) as specified in the IEEE 754 standard. This signifies the data is not valid. This is most likely to be found in arrays of
data. GPS quality is specified using the gps-quality block. The quality of other data sources is defined using the quality and threshold blocks.

4.6.4. Value Block

4.6.4.1. A value block is used only by the Log Data section. It consists of an ID and one data value. The ID associates the data value with the previously defined data block. The value block is defined in Table 3.

4.6.5. Gridding

4.6.5.1. Software using data from these files will often need to apply a gridding process for display and analysis purposes. For example, a data with a footprint of 3 feet by 1 foot, will use at least 3 squares of a grid that is composed of 1-foot by 1-foot squares. Gridding usually entails processing the data on a computer, whereas ungridded data comes directly from the recording machine.

4.6.5.2. For the purposes of this specification, if gridding is used, offset and footprint blocks for the data sources should not be used. If data has been gridded, the offset and footprint of the data have already been used to determine which grid squares are used by the data. If the data is gridded, the coordinates must be the center of the grid.

Table 3—Definition of value block

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block ID</td>
<td>Int16</td>
<td>Unique ID defined in the associated data block.</td>
</tr>
<tr>
<td>Data</td>
<td>Varies</td>
<td>The data bytes appropriate to the block type.</td>
</tr>
</tbody>
</table>

4.7. Recognized Data Blocks for Sections

4.7.1. File Headers

Table 4—Required blocks for the File Headers section

<table>
<thead>
<tr>
<th>Name</th>
<th>Data Type</th>
<th>Unit Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>file-signature</td>
<td>string</td>
<td>None</td>
<td>Value must be “TaggedDataFormat”</td>
</tr>
<tr>
<td>file-version</td>
<td>int32</td>
<td>None</td>
<td>Value must be “1”</td>
</tr>
</tbody>
</table>

4.7.2. Data Headers

Table 5—Recognized blocks for the Data Headers section

<table>
<thead>
<tr>
<th>Name</th>
<th>Data Type</th>
<th>Unit Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>data-lot-name</td>
<td>string</td>
<td>None</td>
<td>Name for the area covered by this file. The naming convention specified by AASHTO PP 80 and PP 81.</td>
</tr>
<tr>
<td>gridding-height</td>
<td>single</td>
<td>Length</td>
<td>Length in north-south direction</td>
</tr>
<tr>
<td>Name</td>
<td>Data Type</td>
<td>Unit Category</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>---------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>gridding-process</td>
<td>string</td>
<td>None</td>
<td>ungridded, gridded</td>
</tr>
<tr>
<td>gridding-width</td>
<td>single</td>
<td>Length</td>
<td>Length in east-west direction</td>
</tr>
<tr>
<td>lift-design-thickness</td>
<td>single</td>
<td>Length</td>
<td>Thickness of lift</td>
</tr>
<tr>
<td>machine-id</td>
<td>string</td>
<td>None</td>
<td>Unique identifier for a machine</td>
</tr>
<tr>
<td>machine-name</td>
<td>string</td>
<td>None</td>
<td>Common or display name for a machine</td>
</tr>
<tr>
<td>machine-type</td>
<td>string</td>
<td>None</td>
<td>Recognized values: compactor, paving thermal profiler, inertial profiler, rolling density meter, laser test roller</td>
</tr>
<tr>
<td>spatial-reference-authority</td>
<td>string</td>
<td>None</td>
<td>Examples: ESRI, EPSG, PROJ4</td>
</tr>
<tr>
<td>spatial-reference-id</td>
<td>int32</td>
<td>None</td>
<td>Well-known ID used by the authority to identify the spatial reference</td>
</tr>
<tr>
<td>spatial-reference-parameters</td>
<td>string</td>
<td>None</td>
<td>If an ID is not used, parameters that define the spatial reference can be provided using a format defined by PROJ4 or another authority.</td>
</tr>
</tbody>
</table>

4.7.3. Data Sources

**Table 6—Recognized blocks for a Data Source**

<table>
<thead>
<tr>
<th>Name</th>
<th>Data Type</th>
<th>Unit Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>threshold-minimum</td>
<td>double</td>
<td>None or Percent</td>
<td>Minimum threshold for a valid measurement</td>
</tr>
<tr>
<td>threshold-minimum-comparison</td>
<td>int32</td>
<td></td>
<td>Refer to Table 8</td>
</tr>
<tr>
<td>threshold-maximum</td>
<td>double</td>
<td>None or Percent</td>
<td>Maximum threshold for a valid measurement</td>
</tr>
<tr>
<td><strong>Field</strong></td>
<td><strong>Type</strong></td>
<td><strong>Purpose</strong></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------</td>
<td>--------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>threshold-maximum-comparison</td>
<td>int32</td>
<td>Refer to Table 8</td>
<td></td>
</tr>
<tr>
<td>height</td>
<td>single</td>
<td>Length</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Height of the sensor above the measured surface</td>
<td></td>
</tr>
<tr>
<td>id</td>
<td>string</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identifying text of a sensor, such as serial number</td>
<td></td>
</tr>
<tr>
<td>index</td>
<td>byte</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>This number should match the name suffix of the source if</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>there are multiple sources of the same type. If the source</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>is surface-temperature#2, the value for index is 2.</td>
<td></td>
</tr>
<tr>
<td>footprint-perpendicular</td>
<td>single</td>
<td>Length</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Length represented by this sensor perpendicular to the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>direction of machine travel.</td>
<td></td>
</tr>
<tr>
<td>footprint-parallel</td>
<td>single</td>
<td>Length</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Length represented by this sensor parallel to the direction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>of machine travel.</td>
<td></td>
</tr>
<tr>
<td>measurement-name</td>
<td>string</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>For sources that can contain multiple types, such as ICMV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>or Ride Quality, use this block to denote the name of the</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>stored data, such as IRI or RN.</td>
<td></td>
</tr>
<tr>
<td>recording-interval</td>
<td>string</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Continuous or on-demand. On-demand data is valid only at</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>the timestamp of recording. Example: Event generated by a</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>keystroke.</td>
<td></td>
</tr>
<tr>
<td>offset-perpendicular</td>
<td>single</td>
<td>Length</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distance from GPS sensor perpendicular to the direction of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>machine travel in the same plane. A negative value</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>indicates the sensor is to the left of the GPS.</td>
<td></td>
</tr>
<tr>
<td>offset-parallel</td>
<td>single</td>
<td>Length</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Distance from GPS sensor parallel to the direction of</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>machine travel in the same plane. A negative value</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>indicates the sensor is behind the GPS.</td>
<td></td>
</tr>
<tr>
<td>offset-name</td>
<td>string</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Common name for the offset, such as Left or Right.</td>
<td></td>
</tr>
<tr>
<td>transformation</td>
<td>string</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>If a transformation was performed on the data, it can</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>be documented here, e.g. transforming based on a least</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>square regression equation.</td>
<td></td>
</tr>
<tr>
<td>Field</td>
<td>Array Type</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>adjusted-deflection</td>
<td>single-array</td>
<td>Length</td>
<td>Normalized deflection data, e.g. from test rolling</td>
</tr>
<tr>
<td>deflection</td>
<td>single-array</td>
<td>Length</td>
<td>Raw deflection data, e.g. from test rolling</td>
</tr>
<tr>
<td>dielectric</td>
<td>single-array</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>air voids percent</td>
<td>single-array</td>
<td>Percent</td>
<td>Defined as 100 minus density percent.</td>
</tr>
<tr>
<td>density</td>
<td>single-array</td>
<td>Density</td>
<td></td>
</tr>
<tr>
<td>density percent</td>
<td>single-array</td>
<td>Percent</td>
<td>Density as a percent is normally expressed as a percentage of theoretical gravity, e.g. %Gmm.</td>
</tr>
<tr>
<td>easting</td>
<td>double-array</td>
<td>Length or Decimal Degrees</td>
<td>Easting of a coordinate measurement</td>
</tr>
<tr>
<td>elevation</td>
<td>single-array</td>
<td>Length</td>
<td>Elevation of a coordinate measurement</td>
</tr>
<tr>
<td>gps-quality</td>
<td>byte-array</td>
<td>None</td>
<td>Refer to Table 9</td>
</tr>
<tr>
<td>heading</td>
<td>single-array</td>
<td>Plane Angle</td>
<td>North is defined as 0.</td>
</tr>
<tr>
<td>icmv</td>
<td>single-array</td>
<td>Varies</td>
<td>Intelligent Compaction Measurement Values</td>
</tr>
<tr>
<td>icmv compaction mode</td>
<td>byte-array</td>
<td>None</td>
<td>Compaction type as defined in Table 10</td>
</tr>
<tr>
<td>icmv vibration amplitude</td>
<td>single-array</td>
<td>Length</td>
<td>Roller drum vibration amplitude</td>
</tr>
<tr>
<td>icmv vibration frequency</td>
<td>single-array</td>
<td>Frequency</td>
<td>Roller drum vibration frequency</td>
</tr>
<tr>
<td>jump</td>
<td>single-array</td>
<td>Percent</td>
<td>Percentage of drum decoupling</td>
</tr>
<tr>
<td>lift thickness</td>
<td>single-array</td>
<td>Length</td>
<td>Calculated thickness of lift</td>
</tr>
<tr>
<td>machine speed</td>
<td>single-array</td>
<td>Speed</td>
<td></td>
</tr>
<tr>
<td>ride quality</td>
<td>single-array</td>
<td>Ride Quality or None</td>
<td></td>
</tr>
<tr>
<td>quality</td>
<td>single-array</td>
<td>None or Percent</td>
<td>Quality of the measurement</td>
</tr>
<tr>
<td>northing</td>
<td>double-array</td>
<td>Length or Decimal Degrees</td>
<td>Northing of a coordinate measurement</td>
</tr>
<tr>
<td>relative direction</td>
<td>byte-array</td>
<td>None</td>
<td>Machine direction as defined in Table 11Table 12</td>
</tr>
</tbody>
</table>
resonant-meter-value | single-array | None
surface-temperature | single-array | Temperature
timestamp | timestamp-array | None

4.8. Recognized Lookup Tables

Table 7— Recognized lookup tables

<table>
<thead>
<tr>
<th>Table names</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison types</td>
<td>Referred to Table 8</td>
</tr>
<tr>
<td>GPS quality</td>
<td>Referred to Table 9</td>
</tr>
<tr>
<td>Compaction mode</td>
<td>Referred to Table 10</td>
</tr>
<tr>
<td>Gridding type</td>
<td>Referred to Table 11</td>
</tr>
<tr>
<td>Machine gear direction</td>
<td>Referred to Table 11</td>
</tr>
</tbody>
</table>

Table 8— Lookup table for comparisons

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than</td>
<td>1</td>
</tr>
<tr>
<td>Less than or equal to</td>
<td>2</td>
</tr>
<tr>
<td>Equal to</td>
<td>3</td>
</tr>
<tr>
<td>Greater than or equal to</td>
<td>4</td>
</tr>
<tr>
<td>Greater than</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 9— Lookup table for GPS Quality

<table>
<thead>
<tr>
<th>GPS quality</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>No fix (invalid)</td>
<td>0</td>
</tr>
<tr>
<td>GPS</td>
<td>1</td>
</tr>
<tr>
<td>Differential GPS</td>
<td>2</td>
</tr>
<tr>
<td>Precise Positioning System</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 10— Lookup table for Compaction Mode

<table>
<thead>
<tr>
<th>Compaction Mode</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static</td>
<td>1</td>
</tr>
<tr>
<td>Vibratory</td>
<td>2</td>
</tr>
<tr>
<td>Oscillation</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 11— Lookup table for Gridding Type

<table>
<thead>
<tr>
<th>Coverage Type</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ungridded</td>
<td>1</td>
</tr>
<tr>
<td>Gridded</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1111213—Lookup table for Machine Gear Direction

<table>
<thead>
<tr>
<th>Direction</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward</td>
<td>1</td>
</tr>
<tr>
<td>Reverse</td>
<td>2</td>
</tr>
<tr>
<td>Stationary</td>
<td>3</td>
</tr>
</tbody>
</table>

4.9. Custom Lookup Tables

Additional lookup tables can be defined in the lookup-tables section. Each lookup table consists of two blocks, whose names are prefixed by “-organization-lut-names-“ and “-organization-lut-values-“.

Table 121213—Custom Lookup Table Blocks

<table>
<thead>
<tr>
<th>Name Prefix</th>
<th>Data Type</th>
<th>Unit Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-organization-lut-names-</td>
<td>string-array</td>
<td>None</td>
<td>Names for items in a custom lookup table</td>
</tr>
<tr>
<td>-organization-lut-values-</td>
<td>int32-array</td>
<td>None</td>
<td>Values for items in custom lookup tables.</td>
</tr>
</tbody>
</table>

4.10. Recognized Units
<table>
<thead>
<tr>
<th>Kind of Quantity</th>
<th>Description</th>
<th>Case-insensitive Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>International feet</td>
<td>FT_I</td>
</tr>
<tr>
<td></td>
<td>U.S. survey feet</td>
<td>FT_US</td>
</tr>
<tr>
<td></td>
<td>Meter</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Kilometer</td>
<td>KM</td>
</tr>
<tr>
<td></td>
<td>International mile</td>
<td>MI_I</td>
</tr>
<tr>
<td></td>
<td>Millimeter</td>
<td>MM</td>
</tr>
<tr>
<td></td>
<td>International inches</td>
<td>IN_I</td>
</tr>
<tr>
<td></td>
<td>Centimeter</td>
<td>CM</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Celsius</td>
<td>CEL</td>
</tr>
<tr>
<td></td>
<td>Fahrenheit</td>
<td>DEGF</td>
</tr>
<tr>
<td><strong>Speed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meter per second</td>
<td>M/S</td>
</tr>
<tr>
<td></td>
<td>Meter per minute</td>
<td>M/MIN</td>
</tr>
<tr>
<td></td>
<td>International feet per minute</td>
<td>FT_I/MIN</td>
</tr>
<tr>
<td></td>
<td>Kilometers per hour</td>
<td>KM/HR</td>
</tr>
<tr>
<td></td>
<td>Miles per hour</td>
<td>MI_I/HR</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hertz</td>
<td>HZ</td>
</tr>
<tr>
<td></td>
<td>Vibration per minute</td>
<td>HZ/min</td>
</tr>
<tr>
<td><strong>Mass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U.S. short ton</td>
<td>STON_AV</td>
</tr>
<tr>
<td></td>
<td>Metric tonne</td>
<td>TNE</td>
</tr>
</tbody>
</table>
5. Examples

5.1. Format

While an actual file contains binary data, the examples here use text representations of the data for readability. Blank rows in the tables are provided only for presentation purposes.
5.2. **Sample Data**

The examples are representations of sample data in Table 14Table 14Table 15.

<table>
<thead>
<tr>
<th>Timestamp (CST)</th>
<th>Northing (m)</th>
<th>Easting (m)</th>
<th>Direction</th>
<th>Temperature 1 (C)</th>
<th>Temperature 2 (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 15, 2017 13:30:20.100</td>
<td>4480700.00</td>
<td>500100.00</td>
<td>Forward</td>
<td>100.0</td>
<td>90.0</td>
</tr>
<tr>
<td>July 15, 2017 13:30:20.200</td>
<td>4480700.01</td>
<td>500100.05</td>
<td>Forward</td>
<td>100.0</td>
<td>93.1</td>
</tr>
<tr>
<td>July 15, 2017 13:30:20.300</td>
<td>4480700.02</td>
<td>500100.10</td>
<td>Forward</td>
<td>102.5</td>
<td>94.6</td>
</tr>
</tbody>
</table>

5.3. **Ungridded file without log data**

This example is an ungridded representation of the data without log-data.

<table>
<thead>
<tr>
<th>Contents</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>[file-headers]</td>
<td></td>
</tr>
<tr>
<td>file-signature</td>
<td>Not applicable</td>
</tr>
<tr>
<td>none</td>
<td>No unit</td>
</tr>
<tr>
<td>string</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Two bytes for the length and 16 for the data.</td>
</tr>
<tr>
<td>TaggedDataFormat</td>
<td>required text</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>file-version</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>none</td>
<td></td>
</tr>
<tr>
<td>int32</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Four bytes to store an int32</td>
</tr>
</tbody>
</table>
File version is 1

[data-headers]
spatial-reference-authority
0
none
string
6 Two bytes for the length and 4 for the data
EPSG

spatial-reference-id
0
none
int32
4 Four bytes to store an int32
32616 UTM 16N

gridding-process
0
none
string
11 Two bytes for the length and 9 for the data
ungridded

-abc-customA- Property named “customA” defined by an organization named, “abc”.
0 Not applicable
none No unit
CustomDataType Unknown data type.
3 bytes are contained in the custom data.

```
300001 0A 21
```
Custom data shown using hexadecimal representation

### [data-source]

**timestamp**

```
0
```
Not applicable

**none**

**timestamp-array**

```
36
```
12 bytes per timestamp

```
636357222201000000
-300
636357222202000000
-300
636357222203000000
-300
```
Central Standard Time is 5 hours behind UTC, so the offset is -300 minutes.

### [data-source]

**northing**

```
0
```
Not applicable

```
M
```
Meters

**double-array**

double precision array

```
24
```
8 bytes in a double. This property contains 24 bytes in the data, so it contains 3 elements.

```
4480700.000
4480700.010
4480700.020
```
Values

### [data-source]

**easting**

```
0
```
Not applicable

```
M
```
Meters

**double-array**

double precision array
24 bytes in a double. This property contains 24 bytes in the data, so it contains 3 elements.

Values

[**data-source**]

relative-direction

0 Not applicable

none No unit

byte-array

3 1 byte in a byte. This property contains 3 bytes in the data, so it contains 3 elements.

LUT 8

[**data-source**]

offset-perpendicular

0

M Meters

single

4 A single is 4 bytes

-1 The sensor is offset 1 meter to the left of the GPS sensor.

footprint-parallel

0

M

single

4

0.3048
footprint-perpendicular
0
M
single
4
0.3048

surface-temperature#1
Surface temperature property
0
Not applicable
CEL
Celsius
single-array
single precision
12
4 bytes in a single. This property contains 12 bytes in the data, so it contains 3 elements.
100.0
100.0
102.5
The 3 elements of temperature data.

index
0
none
int32
4
1
Data source is surface-temperature#1, so this value is 1.

[data-source]
offset-perpendicular
0
M
Meters
A single is 4 bytes

The sensor is offset 1 meter to the right of the GPS sensor.

footprint-parallel

0

M

single

4

0.3048

footprint-perpendicular

0

M

single

4

0.3048

Surface temperature property

Not applicable

Celsius

single precision

4 bytes in a single. This property contains 12 bytes in the data, so it contains 3 elements.

The 3 elements of temperature data.
Data source is surface-temperature#2, so this value is 2.

5.4. **Ungirded file with log data**

This example is an ungridded representation of the data with log-data.

<table>
<thead>
<tr>
<th>Table 161617—An example of a file with log data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contents</strong></td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td><strong>[file-headers]</strong></td>
</tr>
<tr>
<td>file-header</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>string</td>
</tr>
<tr>
<td>TaggedDataFormat</td>
</tr>
<tr>
<td>file-version</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>int32</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td><strong>[Data-headers]</strong></td>
</tr>
<tr>
<td>spatial-reference-authority</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>none</td>
</tr>
<tr>
<td>string</td>
</tr>
<tr>
<td>spatial-reference-id</td>
</tr>
<tr>
<td>int32</td>
</tr>
<tr>
<td>32616</td>
</tr>
<tr>
<td>gridding-process</td>
</tr>
<tr>
<td>ungridded</td>
</tr>
<tr>
<td>-abc-customA-</td>
</tr>
<tr>
<td>CustomDataType</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>01 0A 213000</td>
</tr>
<tr>
<td>[data-source]</td>
</tr>
<tr>
<td>data-source</td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>northing</td>
</tr>
<tr>
<td>M</td>
</tr>
<tr>
<td>double-array</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[data-source]</th>
<th>Easting coordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>easting</td>
<td>3</td>
</tr>
<tr>
<td>M</td>
<td>Meters</td>
</tr>
<tr>
<td>double-array</td>
<td>double precision array</td>
</tr>
<tr>
<td>0</td>
<td>Log data, so no data is stored in this section.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>[data-source]</th>
<th>Relative direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>relative-direction</td>
<td>4</td>
</tr>
<tr>
<td>none</td>
<td>No unit</td>
</tr>
<tr>
<td>byte-array</td>
<td>Log data, so no data is stored in this section.</td>
</tr>
</tbody>
</table>
offset-perpendicular
0
M                      Meters
single
4                      A single is 4 bytes
-1                      The sensor is offset 1 meter to the left of the GPS sensor.

footprint-parallel
0
M
single
4
0.3048

footprint-perpendicular
0
M
single
4
0.3048

surface-temperature#1   Surface temperature property
5
CEL                     Celsius
single-array             single precision
0                      Log data, so no data is stored in this section.

index
Data source is surface-temperature#1, so this value is 1.

[**data-source**]

offset-perpendicular
0
M
single
4
1
A single is 4 bytes

The sensor is offset 1 meter to the right of the GPS sensor.

footprint-parallel
0
M
single
4
0.3048

footprint-perpendicular
0
M
single
4
0.3048
<table>
<thead>
<tr>
<th>surface-temperature#2</th>
<th>Surface temperature property</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Celsius</td>
</tr>
<tr>
<td>single-array</td>
<td>single precision</td>
</tr>
<tr>
<td>0</td>
<td>Log data, so no data is stored in this section.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>index</th>
<th>none</th>
<th>int32</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

Data source is surface-temperature#2, so this value is 2.

[log-data]

<table>
<thead>
<tr>
<th>1</th>
<th>Timestamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>6363572220100000000</td>
<td>6363572220100000000</td>
</tr>
<tr>
<td>-300</td>
<td>-300</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Northing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4480700.000</td>
<td>4480700.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>Easting</th>
</tr>
</thead>
<tbody>
<tr>
<td>500100.000</td>
<td>500100.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>forward</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5</th>
<th>Temperature 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Temperature 2</td>
</tr>
<tr>
<td>---</td>
<td>--------------</td>
</tr>
<tr>
<td></td>
<td>90.0</td>
</tr>
<tr>
<td>1</td>
<td>Timestamp</td>
</tr>
<tr>
<td></td>
<td>6363572222020000000 -300</td>
</tr>
<tr>
<td>2</td>
<td>Northing</td>
</tr>
<tr>
<td></td>
<td>4480700.010</td>
</tr>
<tr>
<td>3</td>
<td>Easting</td>
</tr>
<tr>
<td></td>
<td>500100.050</td>
</tr>
<tr>
<td>5</td>
<td>Temperature 1</td>
</tr>
<tr>
<td></td>
<td>102.5</td>
</tr>
</tbody>
</table>
5.5. **Gridded file without log data**

This example is a gridded representation of the data without using the log-data.

<table>
<thead>
<tr>
<th>Contents</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>[file-headers]</td>
<td></td>
</tr>
<tr>
<td>file-signature</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>none</td>
<td>No unit</td>
</tr>
<tr>
<td>string</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Two bytes for the length and 16 for the data.</td>
</tr>
<tr>
<td>TaggedDataFormat</td>
<td>required text</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>file-version</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>none</td>
<td></td>
</tr>
<tr>
<td>int32</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Four bytes to store an int32</td>
</tr>
<tr>
<td>1</td>
<td>File version is 1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>[data-headers]</td>
<td></td>
</tr>
<tr>
<td>spatial-reference-authority</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>none</td>
<td></td>
</tr>
<tr>
<td>string</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Two bytes for the length and 4 for the data</td>
</tr>
<tr>
<td>EPSG</td>
<td></td>
</tr>
</tbody>
</table>
spatial-reference-id
0
none
int32
4               Four bytes to store an int32
32616            UTM 16N

gridding-process
0
none
string
9                   Two bytes for the length and 7 for the data
gridded

gridding-height
0
M
single
4
0.3048

gridding-width
0
M
single
4
0.3048
Property named “customA” defined by an organization named, “abc”.

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>none</td>
<td>No unit</td>
</tr>
<tr>
<td>CustomDataType</td>
<td>Unknown data type.</td>
</tr>
<tr>
<td>3</td>
<td>3 bytes are contained in the custom data.</td>
</tr>
<tr>
<td>01 0A 213000</td>
<td>Custom data shown using hexadecimal representation</td>
</tr>
</tbody>
</table>

**[data-source]**

timestamp

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>none</td>
<td></td>
</tr>
<tr>
<td>timestamp-array</td>
<td>12 bytes per timestamp</td>
</tr>
<tr>
<td>36</td>
<td>Central Standard Time is 5 hours behind UTC, so the offset is -300 minutes.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>northing</td>
<td>Northing coordinate</td>
</tr>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>M</td>
<td>Meters</td>
</tr>
<tr>
<td>double-array</td>
<td>double precision array</td>
</tr>
<tr>
<td>24</td>
<td>8 bytes in a double. This property contains 24 bytes in the data, so it contains 3 elements.</td>
</tr>
<tr>
<td>4480700.000</td>
<td>Values</td>
</tr>
<tr>
<td>4480700.010</td>
<td></td>
</tr>
<tr>
<td>4480700.020</td>
<td></td>
</tr>
</tbody>
</table>
### [data-source]

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>easting</td>
<td>Easting coordinate</td>
</tr>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>M</td>
<td>Meters</td>
</tr>
<tr>
<td>double-array</td>
<td>double precision array</td>
</tr>
<tr>
<td>24</td>
<td>8 bytes in a double. This property contains 24 bytes in the data, so it contains 3 elements.</td>
</tr>
<tr>
<td>500100.000</td>
<td>Values</td>
</tr>
<tr>
<td>500100.050</td>
<td></td>
</tr>
<tr>
<td>500100.100</td>
<td></td>
</tr>
</tbody>
</table>

### [data-source]

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>relative-direction</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>none</td>
<td>No unit</td>
</tr>
<tr>
<td>byte-array</td>
<td>1 byte in a byte. This property contains 3 bytes in the data, so it contains 3 elements.</td>
</tr>
<tr>
<td>1</td>
<td>LUT 8</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

### [data-source]

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>surface-temperature#1</td>
<td>Surface temperature property</td>
</tr>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>CEL</td>
<td>Celsius</td>
</tr>
<tr>
<td>single-array</td>
<td>single precision</td>
</tr>
<tr>
<td>12</td>
<td>4 bytes in a single. This property contains 12 bytes in the data, so it contains 3 elements.</td>
</tr>
<tr>
<td>100.0</td>
<td>The 3 elements of temperature data.</td>
</tr>
<tr>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>102.5</td>
<td></td>
</tr>
</tbody>
</table>
### surface-temperature#2

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Not applicable</td>
</tr>
<tr>
<td>CEL</td>
<td>Celsius</td>
</tr>
<tr>
<td>single-array</td>
<td>single precision</td>
</tr>
<tr>
<td>12</td>
<td>4 bytes in a single. This property contains 12 bytes in the data, so it contains 3 elements.</td>
</tr>
<tr>
<td>90.0</td>
<td>The 3 elements of temperature data.</td>
</tr>
<tr>
<td>93.1</td>
<td></td>
</tr>
<tr>
<td>94.6</td>
<td></td>
</tr>
</tbody>
</table>

---

5.6. **Validation**

5.6.1. Validation of a data file can be performed by importing the data into the Veta software.

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6. **KEYWORDS**

6.1. Intelligent Construction; Intelligent Compaction; Intelligent Compaction systems; test rolling, paver-mounted thermal profiles, Ground Penetration Radar, data standard, Veta.

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¹ This draft provisional standard is to be reviewed by AASHTO.