SOUTH AFRICAN

PAVEMENT ENGINEERING MANUAL

Chapter 5

Laboratory Management
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Chapter 5: Laboratory Management

SCOPE

The South African Pavement Engineering Manual (SAPEM) is a reference manual for all aspects of pavement engineering. SAPEM is a best practice guide. There are many appropriate manuals and guidelines available for pavement engineering, which SAPEM does not replace. Rather, SAPEM provides details on these references, and where necessary, provides guidelines on their appropriate use. Where a topic is adequately covered in another guideline, the reference is provided. SAPEM strives to provide explanations of the basic concepts and terminology used in pavement engineering, and provides background information to the concepts and theories commonly used. SAPEM is appropriate for use at National, Provincial and Municipal level, as well as in the Metros. SAPEM is a valuable education and training tool, and is recommended reading for all entry level engineers, technologists and technicians involved in the pavement engineering industry. SAPEM is also useful for practising engineers who would like to access the latest appropriate reference guideline.

SAPEM consists of 14 chapters. A brief description of each chapter is given below to provide the context for this chapter, Chapter 5.

Chapter 1: Introduction discusses the application of this SAPEM manual, and the institutional responsibilities, statutory requirements, and, planning and time scheduling for pavement engineering projects. A glossary of terms and abbreviations used in all the SAPEM chapters is included in Appendix A.

Chapter 2: Pavement Composition and Behaviour includes discussion on the history and basic principles of roads. Typical pavement structures, material characteristics and pavement types are given. The development of pavement distress and the functional performance of pavements are explained. As an introduction, and background for reference with other chapters, the basic principles of mechanics of materials and material science are outlined.

Chapter 3: Materials Testing presents the tests used for all material types used in pavement structures. The tests are briefly described, and reference is made to the test number and where to obtain the full test method. Where possible and applicable, interesting observations or experiences with the tests are mentioned. Chapters 3 and 4 are complementary.

Chapter 4: Standards follows the same format as Chapter 3, but discusses the standards used for the various tests. This includes applicable limits (minimum and maximum values) for test results. Material classification systems are given, as are guidelines on mix and materials composition.

Chapter 5: Laboratory Management covers laboratory quality management, testing personnel, test methods, and the testing environment and equipment. Quality assurance issues, and health, safety and the environment are also discussed.

Chapter 5: Laboratory Management covers laboratory quality management, including the ISO system. The South African National Accreditation System (SANAS) is described. Guidelines are given for the laboratory management of testing personnel, test methods, the testing environment and test equipment. Quality assurance issues, and health, safety and the environment are also discussed. Guidelines for the management of site laboratories are also provided. Appendix A contains an extract from the WCPA Materials Manual (M1), and Appendix B the WCPA Materials Code of Procedure (M2).

Chapter 6: Road Prism and Pavement Investigation discusses all aspects of the road prism and pavement investigations, including legal and environmental requirements, materials testing, and the reporting of the investigations. Chapters 6 and 7 are complementary.

Chapter 7: Geotechnical Investigations and Design Considerations covers the investigations into potential problem subgrades, fills, cuts, structures and tunnels. Guidelines for the reporting of the investigations are provided.

Chapter 8: Material Sources provides information for sourcing materials from project quarries and borrow pits, commercial materials sources and alternative sources.

Chapter 9: Materials Utilisation and Design discusses materials in the roadbed, earthworks (including cuts and fills) and all the pavement layers, including soils and gravels, crushed stones, cementitious materials, primes, stone precoating fluids and tack coats, bituminous binders, bitumen stabilised materials, asphalt, spray seals and micro surfacings, concrete, proprietary and certified products and block paving. The mix designs of all materials are discussed.
Chapter 10: Pavement Design presents the philosophy of pavement design, methods of estimating design traffic and the pavement investigation process. Methods of structural capacity estimation for flexible, rigid and concrete block pavements are discussed.

Chapter 11: Documentation and Tendering covers the different forms of contracts typical for road pavement projects; the design, contract and tender documentation; and, the tender process.

Chapter 12: Construction Equipment and Method Guidelines presents the nature and requirements of construction equipment and different methods of construction. The construction of trial sections is also discussed. Chapters 12 and 13 are complementary, with Chapter 12 covering the proactive components of road construction, i.e., the method of construction. Chapter 13 covers the reactive components, i.e., checking the construction is done correctly.

Chapter 13: Quality Management includes acceptance control processes, and quality plans. All the pavement layers and the road prism are discussed. The documentation involved in quality management is also discussed, and where applicable, provided.

Chapter 14: Post-Construction incorporates the monitoring of pavements during the service life, the causes and mechanisms of distress, and the concepts of maintenance, rehabilitation and reconstruction.

FEEDBACK

SAPEM is a “living document”. The first edition was made available in electronic format in November 2013. It is envisaged that SAPEM will be updated after one year. Feedback from all interested parties in industry is appreciated, as this will keep SAPEM appropriate.

To provide feedback on SAPEM, please email sapem@nra.co.za.
ACKNOWLEDGEMENTS

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Photos for this chapter were provided by:

- Dave Rose, Aurecon
1. INTRODUCTION

This chapter covers the principal aspects of laboratory quality management, required to ensure the reliability of testing by materials testing laboratory facilities. Testing of road construction materials and products plays a critical role in the assessment of pavement construction quality. Hence, the need to have reliable test results is vital.

Testing of road construction materials and products is carried out for various purposes:

- Materials investigations
- Development of mix designs
- Quality control
- Evaluation of processed materials and products
- Research and development

Construction materials typically tested in the course of road construction projects could, depending on the scope of the project, include:

- Soils, gravel and rocks
- Crushed aggregates
- Stabilised materials
- Asphalt
- Bitumen and bituminous products
- Cement and cementitious materials
- Concrete and concrete products
- Steel reinforcement

Note that not all laboratory facilities have the capacity to test all of the different types of materials. There are various types of testing facilities in South Africa which fulfil different primary functions. The four main classes of laboratory are defined by their functions:

- Independent, accredited, or reference
- Independent, accredited or research and development environment
- Supervised, inspected or quality control
- Prescribed, or inspected regularly

When selecting a laboratory facility to carry out testing requirements for a particular project, consider the following:

- Does the laboratory work in accordance with a documented quality management system designed to assure the quality of test results produced?
- Is the laboratory able to perform the scope of testing required?
- Can the laboratory carry out the required testing within the project timeframe?
- Is the laboratory independent and free from any undue pressures or conflicts of interest that may adversely affect the quality of work?

1.1 South African National Accreditation System (SANAS)

The South African National Accreditation System (SANAS) is the single national body recognised by the South African government. It gives formal recognition/accreditation to Laboratories, Certification Bodies, Proficiency Testing Scheme Providers and Good Laboratory Practice (GLP) test facilities, which are competent to carry out specific tasks. SANAS is responsible for the accreditation of laboratories to ISO/IEC 17025:2005, "General Requirements for the Competence of Testing and Calibration Laboratories". SANAS should not be confused with the South African Bureau of Standards (SABS).

SABS is the organisation responsible for publishing standards, method or procedures. Historically, the procedures or standards were published and referenced by a SABS number (e.g., SABS 1083). Currently the standard, method or procedure is referenced with a SANS (South African National Standards) reference number, e.g., SANS 1083.
SANAS certificates are a formal recognition that an organisation is competent to perform specific tasks. SANAS presents a number of useful courses to assist laboratory facilities in obtaining accreditation:

- **Laboratory systems:** This course gives guidance in the implementation of a system in a laboratory and also indicates what is required during an assessment.

- **Technical assessing techniques:** This course gives accredited facilities an insight into how assessments are carried out by SANAS, and practically demonstrates how assessment techniques can be used to maximise accreditation benefits.

- **Internal auditing:** This course guides laboratory personnel on the purpose of an internal audit and how to prepare for, and carry out, the internal audit within the laboratory.

- **Overview of accreditation:** This course informs management and staff of applicant facilities on the SANAS accreditation process and requirements. It will highlights benefits of accreditation and how SANAS fits into the global accreditation structure.

- **Documenting the system:** This course gives direction to what documentation is required in the various tiers of the documented system.
2. LABORATORY QUALITY MANAGEMENT

A Quality Management System (QMS) is defined as a set of policies, processes and procedures required for planning and execution, i.e., production, development and service, in the core business area of an organization. QMS integrates the various internal processes within the organization and provides a process approach for project execution. QMS enables the organizations to identify, measure, control and improve the various core business processes that ultimately lead to improved business performance.

A primary objective of a testing laboratory should be to generate technically valid results. To achieve this, a laboratory should operate under an appropriate quality management system that assures the quality of test results.

Factors relevant to a laboratory’s ability to produce precise, accurate test and calibration data, include:

- **Technical competence** of staff
- **Validity and appropriateness** of test methods
- **Traceability** of measurements and calibrations to national standards
- **Suitability, calibration and maintenance** of test equipment
- **Testing environment**
- **Sampling, handling and transportation** of test items
- **Quality assurance** of test and calibration data

2.1 ISO/IEC 17025:2005

The International Organization for Standards (ISO) is a non-governmental organization that forms a bridge between public and private sectors and is the world’s largest developer and publisher of international standards. ISO’s Secretariat is in Geneva, Switzerland. ISO, together with IEC (International Electrotechnical Commission), have built a strategic partnership with the World Trade Organization (WTO).

ISO/IEC 17025:2005, referred to as the “Standard”, is an international quality standard. It is used as the basis for the accreditation of laboratories that wish to demonstrate that they operate a management system, are technically competent, and are able to generate technically valid results.

In South Africa, there is a trend for road authorities to insist that companies providing testing services on projects are SANAS accredited. Consequently, an increasing number of laboratories are implementing ISO compliant quality management systems. As a minimum requirement, laboratories providing testing services on projects should operate under a quality management system that is generally compliant with ISO/IEC 17025:2005.

The organizations involved with accreditation of road construction materials testing facilities are shown in Figure 1.

ISO 17025 covers every aspect of laboratory management. It involves everyone in the laboratory, including the laboratory manager, assistant laboratory manager or quality manager, as well as all laboratory personnel whose functions relate to the quality of laboratory data generated. A laboratory’s fulfilment of the requirements of ISO/IEC 17025 means that the laboratory meets both the technical competence requirements and management system requirements necessary to consistently deliver technically valid test results and calibrations.

The standard was revised in 2005 to align it with ISO 9001:2000. The two standards are now considered to be compatible rather than fully aligned. The revision makes it clear that meeting the requirements of ISO/IEC 17025 does not automatically mean that the requirements of ISO 9001 are met. The standard does recognise that, by being accredited to ISO/IEC 17025, a laboratory will meet the principles of ISO 9001.

Consequently, laboratories may choose to be accredited to ISO/IEC 17025, or be certified to ISO 9001, or both, but the processes of accreditation and certification would be two separate actions. No longer can a laboratory be accredited to ISO/IEC 17025 and claim that this also means they automatically meet the requirements of ISO 9001. The Standard is designed to help improve, and then maintain, quality and standards in a laboratory.
By following the procedures and methods specified, clients are assured of the accuracy and integrity of a laboratory. However, it is necessary to continually monitor quality processes to ensure that they continue to meet the guidelines of the Standard. Notwithstanding accreditation, failure to comply with the standard guidelines can result in incorrect test results and untrustworthy outcomes.

As more calibration laboratories become accredited, correlation between these accredited laboratories’ measurements will improve, thereby improving the general quality of the measurement process throughout the industry.

SANAS accreditation to SABS/ISO/IEC 17025 involves the following broad processes:

(i) The organisation to establish a laboratory management system aligned to SABS/ISO/IEC 17025 and relevant SANAS requirements. This system will be documented in the laboratory quality manual.

(ii) Submission of the quality manual and application fee to SANAS for document review and SANAS registration.

(iii) SANAS submits document review to applicant for necessary corrective actions to be taken.

(iv) SANAS clears document review corrective actions, finalises arrangements for initial assessment and performs assessment.

(v) The applicant submits corrective actions to SANAS, which may also be cleared on-site. The lead assessor and/or technical assessor to review the corrective actions.

(vi) Once all non-conformances have been cleared, SANAS refers application and all supporting documentation to the Approvals Committee.

(vii) Once accreditation is granted, the lab enters the 5 year accreditation cycle. This includes a 6 month follow-up visit, a 12 month visit and thereafter two 18 month surveillance visits.

Typically, the timeframe for accreditation could range from 15 to 18 months, but may be significantly longer, especially if a laboratory is slow to implement a quality system. The timeframe to obtain accreditation varies depending on:

- Size of the facility
- Scope of testing to be accredited
- Level of quality management system in operation prior to commencing with the accreditation process.

There is a significant initial cost involved with accrediting a laboratory. The cost is dependent on the level of improvements needed to meet the Standard, and includes:

- Fees paid to SANS for document review and external assessment
- Development of quality documents
- Training of laboratory personnel
- Calibration of equipment
- Purchase of new equipment should old equipment not meet the relevant standards
- Fees paid to external consultants to assist with the accreditation process
ISO/IEC 17025 is subdivided into 5 sections, as shown in Table 1.

Table 1. ISO/IEC 17025:2005

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>ISO Clause</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scope</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Normative references</td>
<td>4.2</td>
</tr>
<tr>
<td>3</td>
<td>Terms and definitions</td>
<td>4.3</td>
</tr>
<tr>
<td>4</td>
<td>Management requirements</td>
<td>4.4</td>
</tr>
<tr>
<td>5</td>
<td>Technical requirements</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The Standard specifies the requirements for sound management and technical competence. The specific management and technical requirements covered are shown in Table 1. The recommended basic steps for laboratory accreditation are shown in Table 2.

Table 1. Management and Technical Requirements of ISO/IEC 17025:2005

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Description</th>
<th>ISO Clause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Requirements</td>
<td>Organisation</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>Management system</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>Document control</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Review of requests, tenders and contracts</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Subcontracting of tests and calibrations</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>Purchasing services and supplies</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Service to the customer</td>
<td>4.7</td>
</tr>
<tr>
<td></td>
<td>Complaints</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>Control of nonconforming testing and/or calibration work</td>
<td>4.9</td>
</tr>
<tr>
<td></td>
<td>Improvement</td>
<td>4.10</td>
</tr>
<tr>
<td></td>
<td>Corrective action</td>
<td>4.11</td>
</tr>
<tr>
<td></td>
<td>Preventive action</td>
<td>4.12</td>
</tr>
<tr>
<td></td>
<td>Control of records</td>
<td>4.13</td>
</tr>
<tr>
<td></td>
<td>Internal audits</td>
<td>4.14</td>
</tr>
<tr>
<td></td>
<td>Management reviews</td>
<td>4.15</td>
</tr>
<tr>
<td>Technical Requirements</td>
<td>General</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>Personnel</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>Accommodation and environmental conditions</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td>Test and calibration methods and method validation</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td>Equipment</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Measurement traceability</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td>Sampling</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>Handling of test and calibration items</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>Assuring the quality of test and calibration results</td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>Reporting the results</td>
<td>5.10</td>
</tr>
</tbody>
</table>

One of the first steps in the accreditation of a laboratory facility is establishing and documenting an ISO/IEC 17025 compliant quality management system. The internal quality documents, i.e., documents generated by the laboratory, are given in Table 3.

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ISO/IEC Sample Documentation

The Western Cape Provincial Administration have made available typical ISO/IEC 17025 compliant laboratory documentation as a guide for laboratories embarking on the accreditation process. These documents are available from:

- Pavement Technology Materials Laboratory
- Directorate Design
- Transport and Infrastructure Branch
- Department of Transport and Public Works
- Western Cape Provincial Government
Table 2. Basic Steps to Prepare a Laboratory for Accreditation

<table>
<thead>
<tr>
<th>Step</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Laboratory management must understand the requirements of ISO/IEC 17025 and the accreditation process.</td>
</tr>
</tbody>
</table>
| 2    | Create a plan for the accreditation of the laboratory:  
|      | - Required activities  
|      | - Scheduled timeframe  
|      | - Responsibilities |
| 3    | Brief staff on need for accreditation, and their involvement with the process and the plan. |
| 4    | Carry out a gap analysis to determine the areas of laboratory operation that do not meet the Standard. |
| 5    | Document the quality management system that the laboratory will operate under in order to meet the Standard. |
| 6    | Implement the documented quality management system. |
| 7    | Operate the laboratory quality management system. A period of at least three months is recommended before proceeding to the next step. |
| 8    | Carry out internal auditing to monitor if the quality management system is being correctly implemented. |
| 9    | Investigate the non-conformances raised during Step 8, and implement the necessary corrective and preventive actions. Monitor corrective or preventive actions to ensure their effectiveness. |
| 10   | Carry out management review. |
| 11   | Laboratory is ready for external assessment by SANAS. |

Table 3. Internal Quality Documents

<table>
<thead>
<tr>
<th>Document</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality policy</td>
<td>Describes the overall objectives of the quality management system.</td>
</tr>
<tr>
<td>Quality manual</td>
<td>Backbone of the quality management system. Holds the basic policy statements and definitions related to all the laboratory practices that impact data quality.</td>
</tr>
<tr>
<td>Procedures</td>
<td>Provides guidance on how a general function is performed, e.g., internal audit.</td>
</tr>
<tr>
<td>Work instructions</td>
<td>Provides specific detail of how a single activity is performed, e.g., daily operational check of an electronic balance.</td>
</tr>
<tr>
<td>Forms</td>
<td>Used to record test data or quality information.</td>
</tr>
<tr>
<td>Supporting documents</td>
<td>Other supporting documents include master-lists, registers, job descriptions, organisational charts, process flow charts and schedules. These documents provide specific information as required.</td>
</tr>
</tbody>
</table>

2.2 Use of Software for Operation and Management of Laboratories

There is an increasing need to underpin the operation and management of a materials testing laboratory with purpose developed computer software. The need for such software is becoming even more important in the light of the requirement for laboratories to attain SABS ISO/IEC 17025 accreditation. Typically, in the past, laboratories have operated spreadsheet-based systems to assist in the management of test data. However, the use of the spreadsheet-based systems has many limitations relating to software validation, integrated functionality, maintenance of data integrity, capacity and corruption of the spreadsheet.

Laboratory management software systems are being developed locally to meet the needs of the South African construction materials testing industry. One such system (MTS) has been successfully implemented by the Pavement Technology Materials Laboratory of the Department of Transport and Public Works, Western Cape Provincial Government (WCPG). The functionality of the Materials Testing System (MTS) includes:

- Sample registration and tracking system
- Sample traceability throughout the testing process
- Features to maintain the integrity of test data
- Validated test calculations in accordance with TMH1 test methods
- Test reporting in-line with the requirements of SABS ISO/IEC 17025
- Full traceability indicating who did what and when
- Calculation and reporting of the most frequently used TMH1 Test Methods
- Advanced graphical analyses for CBR and MDD tests
Figure 1 shows a screenshot of CBR graphical analysis being carried out using the MTS software.

Figure 1. Advanced CBR Graphical Analysis using MTS
3. TESTING PERSONNEL

Road pavement designs, product designs, quality control during construction and acceptance testing of road surfacing and pavement layers is totally dependent on the accurate execution of laboratory testing by competent materials testers. There is currently a critical shortage of competent materials testers in the construction industry in South Africa.

To operate a proficient laboratory facility, qualified, experienced, competent testing personnel are essential to produce valid test results. Testing personnel should be:

- **Trained** to competently perform relevant materials testing.
- **Supervised** during training, to ensure competence to perform duties.
- **Authorised** by laboratory management, on the basis of appropriate education, training, experience and demonstrated skills, to carry out specific tasks, e.g., sampling, testing, test evaluation and reporting.
- Aware of, and fully understand, their responsibilities in relation to the requirements of the quality management system operated by the laboratory.
- Aware of, and fully understand, their responsibilities in relation to occupational health and safety requirements.

In addition, personnel responsible for the opinions and interpretation included in test reports should, in addition to the appropriate qualifications, training experience and satisfactory knowledge of the testing, also have relevant knowledge of:

- **Design, construction and quality assessment** of road pavements
- **Material production** processes
- Applicable **specifications and standards**
- **Nature and variability** of the materials being tested

3.1 Training and Qualifications for Materials Testers

3.1.1 South African Qualification Authority and NQF Standards

The South African Qualification Authority (SAQA) is responsible for reviewing qualifications and providing a learning pathway for materials testers. Unit standards have been introduced to provide a specialist qualification for persons executing laboratory testing on construction materials. These are the "National Certificates in Construction Materials Testing and Technology", which have been rated according to a National Qualification Framework (NQF). Table 4 shows the qualifications according to the South African Qualification Authority (SAQA) for construction materials testers, that is, NQF 2 through 6.

Table 4. SAQA Qualifications for Construction Materials Testers

<table>
<thead>
<tr>
<th>NQF Level</th>
<th>Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>National Certificate in Construction Materials Testing - various streams</td>
</tr>
<tr>
<td>4</td>
<td>National Certificate in Construction Materials Testing - various streams</td>
</tr>
<tr>
<td>5</td>
<td>National Diploma in Construction Materials Technology</td>
</tr>
<tr>
<td>6</td>
<td>National Degree in Construction Materials Technology</td>
</tr>
</tbody>
</table>

The following, more recently available, National Certificate Course (ID 48817) replaces the National Certificates (ID 23974, Soils and Aggregates and ID 23975, Bituminous Materials) in Construction Materials testing. The course is split into 3 streams:

- **Bituminous** materials
- **Concrete** materials
- **Soils and aggregates**

Any institution offering learning that enables the achievement of this qualification must be accredited as a provider with the Construction Education and Training Authority (CETA): Educations and Training Quality Authority (ETQA). This qualification may be obtained through the process of Recognition of Prior Learning (RPL). Learners who have met the requirements of any unit standard in this qualification may apply for recognition of prior learning to the relevant body, and are assessed against the assessment criteria and specific outcomes for the relevant unit standard/s.
The individual unit standards that comprise the National Certificate in Construction Materials Testing are listed in Table 5.

### Table 5. Unit Standards for National Certificate in Construction Materials Testing

<table>
<thead>
<tr>
<th>Type</th>
<th>Title</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>Produce and use spreadsheets for business</td>
<td>7576</td>
</tr>
<tr>
<td>Core</td>
<td>Produce word processing documents for business</td>
<td>7570</td>
</tr>
<tr>
<td>Core</td>
<td>Execute laboratory testing pertaining to aggregates</td>
<td>14540</td>
</tr>
<tr>
<td>Core</td>
<td>Execute sampling of aggregates for testing</td>
<td>14543</td>
</tr>
<tr>
<td>Core</td>
<td>Implement Occupational Health and Safety measures in a construction materials testing laboratory</td>
<td>14547</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Accommodate audience and context needs in oral communication</td>
<td>8968</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Interpret and use information from texts</td>
<td>8969</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Use language and communication in occupational learning programmes</td>
<td>8973</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Write texts for a range of communicative contexts</td>
<td>8970</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Apply knowledge of statistics and probability to critically interrogate and effectively communicate findings on life related problems</td>
<td>9015</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Demonstrate an understanding and apply physical science and chemistry in construction materials testing</td>
<td>14539</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Engage in sustained oral communication and evaluate spoken texts</td>
<td>8974</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Measure, estimate and calculate physical quantities and explore, critique and prove geometrical relationships in 2 and 3 dimensional space in the life and workplace of adult with increasing responsibilities</td>
<td>12417</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Read analyse and respond to a variety of texts</td>
<td>8975</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Use language and communication in occupational learning programmes</td>
<td>8979</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Use mathematics to investigate and monitor the financial aspects of personal, business, national and international issues</td>
<td>7468</td>
</tr>
<tr>
<td>Fundamental</td>
<td>Write for a wide range of contexts</td>
<td>8976</td>
</tr>
<tr>
<td>Elective</td>
<td>Demonstrate the ability to use a database for business purposes</td>
<td>7576</td>
</tr>
<tr>
<td>Elective</td>
<td>Produce presentation documents for business</td>
<td>7575</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute laboratory testing pertaining to asphalt materials</td>
<td>110034</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute laboratory testing pertaining to bituminous materials</td>
<td>14541</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute laboratory testing pertaining to concrete</td>
<td>15019</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute laboratory testing pertaining to soils and gravels</td>
<td>14542</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute sampling of asphalt materials for testing</td>
<td>14544</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute sampling of bituminous binder material for testing</td>
<td>14545</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute sampling of concrete material for testing</td>
<td>15021</td>
</tr>
<tr>
<td>Elective</td>
<td>Execute sampling of soils and gravels for testing</td>
<td>14546</td>
</tr>
</tbody>
</table>

### 3.1.2 South Africa Roads Federation and Asphalt Academy

The Asphalt Academy is operated on a non-profit basis with equitable grants contributed by its trustees, SABITA (Southern African Bitumen Association) and CSIR Built Environment. This organization presents various courses, seminars and workshops as well as publishing technical guidelines. The Academy offers a Materials Testers Course (MTC) that has been structured into the following 6 modules that are presented over a one year period. These six modules form part of the Construction Materials Testing Learnerships at NQF levels 2 to 4.

- **Module 1**: Sampling of materials
- **Module 2**: Soils and natural gravel testing
- **Module 3**: Aggregates testing
- **Module 4**: Concrete testing
- **Module 5**: Bituminous binder testing
- **Module 6**: Asphalt testing
4. TEST METHODS

The foreword to the Standard Methods of Testing Road Construction Materials (TMH1, 1986) states: “The importance of standardized and consistent test procedures in establishing the quality of road construction cannot be overemphasized. It has been said that "One test result is worth a hundred expert opinions" but this is only true if such a result is really accurate. In practice is essential that test procedures are clearly specified and uniformly applied.”

Sampling and testing of road construction materials should, wherever feasible, be performed in accordance with well-established, accepted, international, national and regional standard test methods. The appropriate standard methods should be used to meet the clients’ requirements. Where established test methods do not meet a client’s testing needs, it may be necessary to adopt laboratory-developed, or non-standard methods.

Important guidelines for the use of test methods in the laboratory include:

- **Appropriate test methods and procedures** should be used for all testing and where relevant. These methods and procedures should cover sampling, handling, transport, storage and preparation of items to be tested.
- **Test methods and procedures** should be readily available to personnel carrying out testing.
- **Deviations from standard test methods** should only occur if the deviation has been documented, technically justified and accepted by the client.
- **The latest valid editions of standards** should be used, unless it is not appropriate or possible to do so.
- **Clients should be informed** when the methods proposed are considered to be inappropriate or out of date.
- **Laboratory developed, or non-standard methods** should be well documented and validated to confirm that the methods are fit for their intended use.

Test methods used for the testing of different types of road construction materials and products are discussed in detail in Chapter 3 of this manual. The standards associated with the tests are included in Chapter 4.

The Technical Methods for Highways (TMH1) series of standard test methods of road construction materials have been the most widespread methods applied in the South African road construction industry. These methods were first issued in 1979 and updated in 1986. These methods are currently being revised, updated and submitted to SABS for publication as South African National Standards (SANS). The intention is that these methods will replace the old TMH1 methods and also certain SABS test methods. The revisions are being carried out on a consultative basis with industry, and the process is time consuming. The revised methods are intended for immediate use on publication. A year after publication, each test method will be reviewed, and where necessary, further corrections and or amendments made. Chapter 3, Appendix C details of the conversions from TMH1 to SANS, including the new and old test numbers, and lists changes made to the methods.
5. TESTING ENVIRONMENT

The testing environment consists of the physical space in which testing is performed and the environmental conditions within the space. The testing environment is a critical factor affecting the performance of testing.

Laboratory facilities for testing, including energy sources, lighting and environmental conditions should be appropriate for the intended testing. Environmental conditions that can affect test results should be monitored and testing halted if conditions change and could jeopardize the test result.

The layout, furnishing and equipping of laboratory facilities for testing should be planned to ensure that the environmental requirements specified in the test methods are achievable. The following aspects are important to ensure an adequate facility:

- **Provide sufficient space**
  - So that testing can be performed efficiently
  - Risk of injury to staff is minimized
  - Damage to the equipment is minimized
  - Risk of compromising standards is avoided.
- **Separate testing areas** for incompatible activities. Measures must be implemented to avoid cross contamination of samples.
- **Controlled access** to designated testing areas (security and safety).
- **Maintain a clean and safe** operating environment.
- Designate specific areas in the laboratory to **receive and store samples**. Maintain clean and well-organised sample storage areas so that the test samples are accessible and can be readily retrieved. Examples of good storage areas are shown in Figure 2 and Figure 3.
- **Protect** test samples from the weather and from loss, damage, or contamination.
- **Provide adequate storage facilities** for testing equipment.

Useful guidelines relating to the requirements and specifications for laboratory facilities are included in the WCPA Materials Manual, Volume 2, Chapter 1, which is included in Appendix A.

![Figure 2. Sample Storage](image-url)
Figure 3. Storage of Equipment
6. TEST EQUIPMENT

Laboratories need to be equipped with all items required for sampling, measurement and test equipment to ensure the correct performance of the tests, including sampling, preparation, processing and analysis. Test equipment should comply with the specified requirements of the relevant test methods used by the laboratory and/or to the manufacturers specifications.

Laboratories should comply with the following important requirements relating to test equipment, which have a significant effect on the accuracy or validity of the results:

- Prior to being put into service, all equipment used for testing and sampling should either be calibrated, or checked, to verify that the equipment meets the requirements of the applicable test standards.
- Equipment should be routinely calibrated, or checked, to confirm its continued compliance with relevant requirements.
- Equipment records should be maintained, including purchase requisitions, calibrations certificates, verifications and records of equipment.
- Damaged, malfunctioning, suspect or defective equipment should not be used.
- Competent and authorised personnel should operate equipment.
- Up-to-date instructions on the use of equipment should be available.
- Equipment should be maintained in a satisfactory condition.
- Equipment should be identified using a unique identification number and permanently labelled.
- An equipment list should be maintained and kept up-to-date.
- Equipment should be securely and safely transported and stored.

6.1 Calibration and Checking

Calibration is the process of establishing the relationship between a measuring device and the units of measure. This is done by comparing a device or the output of an instrument to a standard having known measurement characteristics. For example, the length of a stick can be calibrated by comparing it to a standard that has a known length. Once the relationship of the stick to the standard is known, the stick is calibrated and can be used to measure the length of other items. Calibration of equipment should be traceable to national measurement standards. Calibration should be done:

- With a new instrument
- When a specified time period has elapsed
- When a specified usage (operating hours) has elapsed
- When an instrument has had a shock or vibration which potentially may have put it out of calibration
- Whenever observations appear questionable

Equipment checking is the process of carrying out a procedure to verify that an item of equipment is fit for purpose, i.e., that it meets the requirements of the test method. Equipment checks should be performed with calibrated measuring devices.

Recommended minimum requirements for the calibration and checking of standard testing equipment for road materials testing laboratories are summarized in Table 6.
Table 6. Recommended Minimum Requirements for Equipment Calibration and Verification

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Requirement</th>
<th>On purchase</th>
<th>Before Use</th>
<th>Daily</th>
<th>Monthly Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compression or loading device</td>
<td>Calibrate</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Dial gauge</td>
<td>Calibrate</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Electronic balance</td>
<td>Verify Operational check</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuclear density gauge</td>
<td>Verify Operational check</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sieve</td>
<td>Verify Operational check</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grooving tool</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Liquid limit device</td>
<td>Verify Operational check</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mould – CBR/MDD</td>
<td>Verify Volume/mass</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Manual compaction hammer – CBR/MDD</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>CBR annular and slotted weight</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>CBR Penetration piston</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>CBR – perforated plate</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Mould – Marshall</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Manual compaction hammer – Marshall</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Working Weight</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Drying oven</td>
<td>Verify Operational check</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample splitter (riﬄer box type)</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Thermometer</td>
<td>Calibrate</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Penetrometer needle</td>
<td>Operational check</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distilling apparatus</td>
<td>Verification of water processed</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Shrinkage troughs</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Water baths</td>
<td>Operational check</td>
<td></td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid limit device calibration block</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Bouyoucos cylinder</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>ACV cylinder and mould</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Slump cone</td>
<td>Verify Operational check</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Concrete cube mould</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Organic impurities bottle</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Marshall breaking head</td>
<td>Verify</td>
<td></td>
<td></td>
<td>✔</td>
<td></td>
</tr>
</tbody>
</table>
6.2 Nuclear Gauges

The management, operation, transportation and storage of radioactive sources used in soil density and moisture gauges require special consideration as they are subject to regulatory control in terms of the South African Hazardous Substances Act, 1973 (Act 15 of 1973).

The body responsible for administering this legislation is the Directorate: Health Technology, Department of Health. The radioactive sources used in these gauges are generally sufficiently radioactive to constitute a significant health hazard unless adequately shielded and handled with proper care. Standards have been set to limit the risk of over-exposure of the operators and the public to ionizing radiation, and to ensure that radiation doses are kept as low as reasonably achievable.

An application for authority to possess and use a soil gauge must be submitted to the Department on form RN 787. The applicant must nominate a radiation protection officer (RPO) as well as an acting radiation protection officer. Should the radiation protection officer or acting RPO change at any stage, the Department must be informed of the change in writing. In the case of a change of radiation protection officer, form RN 785 must be completed and forwarded to the Department. Once a year, the holder of the authority must furnish the Department with a declaration, on form RN 784, confirming that all of the sealed sources, which are reflected on the current authority, are in their possession, and that the details on this authority are complete and correct. This return is due each year before 31 January. Links to download the forms are:

- **RN 784**: Standards for the Safe Use of Industrial Gauges Containing Radioactive Sources. [www.docstoc.com/docs/73301550/](www.docstoc.com/docs/73301550/)

Nuclear gauges should be operated in accordance with the "Code of Practice for the Safe Use of Soil Moisture and Density Gauges Containing Radioactive Sources", compiled by the Directorate Radiation Control, Department of Health, May 2005 and as described in SABS 3001–NG1: The Administration, Handling and Maintenance of Nuclear Density Gauge. The Code can be downloaded from the Department's website, and is included as Appendix C of this Chapter. The following topics are covered:

- Administrative requirements
- Equipment specifications
- Storage requirements
- Handling procedures
- Repair and maintenance
- Leak tests
- Radiation monitoring
- Transport
- Emergency procedures
- Disposal
- Loss or theft
- Pregnant workers
- Responsibilities of radiation protection officer (RPO)
- Radiation warning signs
- Source registers
- Maximum permissible dose limits
- Radiation safety training

A nuclear density gauge, and the badge that must be worn by the operator, are shown in Figure 4.

Using Nuclear Gauges

Nuclear gauges used for density and moisture measurements are sufficiently radioactive to pose a significant health hazard, unless handled with proper care and adequately shielded.
Figure 4. Nuclear Density Gauge and Badge
7. QUALITY ASSURANCE

Laboratories should implement and maintain a quality assurance programme to monitor the validity of its test results. This could be achieved by testing of replicate samples, participation in inter-laboratory comparisons and/or proficiency testing programmes.
8. HEALTH, SAFETY AND THE ENVIRONMENT

Occupational health and safety in the laboratory should meet the relevant requirements of the Occupational Health and Safety Act No. 85 of 1993. Some important aspects relating to safety, health and environment in the laboratory environment are listed below:

- The laboratory should be maintained as a clean and safe operating environment.
- Laboratory personnel should be made aware of their responsibilities in relation to maintaining a safe work environment.
- Personnel should be provided with all the necessary personal protective equipment (PPE) to perform their tasks safely.
- Personnel must wear the required PPE when performing their duties.
- The laboratory should have safe working procedures for working with dangerous and hazardous substances.
- Disposal of samples and used reagents should be carried out in accordance with legal requirements and responsible environmental practices.
- Only adequately trained and authorized personnel should operate equipment.
- Nuclear gauges should be operated in accordance with the "Code of Practice for the Safe Use of Soil Moisture and Density Gauges Containing Radioactive Sources", compiled by the Directorate Radiation Control, Department of Health, May 2005 and SANS 3001-NG1.
- Sampling from test pits or other excavations is potentially a hazardous activity and must only be carried out under the supervision of a competent person and in strict compliance with OHS requirements. For guidance in relation to OHS issues, refer to "The Safety of Persons Working in Small Diameter Shafts and Test Pits for Geotechnical Engineering Purposes", Code of Practice 2007, SAICE Geotechnical Division.
9. **PROJECT (SITE) LABORATORIES**

For larger road construction projects, it is standard practice to establish a temporary site laboratory to carry out testing requirements for the duration of the project. The consulting engineering company appointed for the contract supervision is typically responsible for the overall laboratory function on a project. This function is primarily focused on acceptance control testing of the as-built roadbed and road pavement.

As for permanent laboratories, project laboratories should operate under an appropriate quality management system that assures the quality of test results produced. Guidelines for the management and operation of site laboratories on SANRAL projects are given in the Materials Code of Procedure M2, Construction Quality Control, June 2002, which is included in Appendix B.

The management and operation of a project laboratory could be the designated responsibility of either:
- An independent, commercial laboratory service provider, or, the consulting engineering firm appointed for the contract supervision.
- The appointed consulting engineer and contractor, i.e., a jointly operated facility.

The use of jointly operated laboratories for the execution of both process as well as acceptance control testing has become a preferred option due to several advantages that include:
- **Avoiding disputes** relating to significant differences between the contractor’s and consultant’s test results.
- **Cost savings** for the client and contractor.

Important aspects to take into account when planning a project laboratory are summarized in Table 7.

**Table 7. Planning a Site Laboratory**

<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope of Testing</strong></td>
<td>Determine the scope of testing required, i.e., the test methods required to be carried out in the laboratory, and the approximate quantity of each test method to be carried out.</td>
</tr>
<tr>
<td><strong>Testing Frequencies</strong></td>
<td>Based on the project programme, determine the anticipated testing frequencies, i.e., testing frequencies for each test method to be employed. For example, ± 60 gradings tests per month from month 1 to month 12.</td>
</tr>
</tbody>
</table>
| **Resource Requirements** | On the basis of the scope of testing and testing frequencies, determine resource requirements:  
  - **Laboratory Facilities**  
    - Assess if all testing requirements would be carried out in the site laboratory, or would selected tests (specialized or of limited quantity) be carried out off-site.  
    - Should off-site testing be required, identify suitable facilities.  
    - Decide the types of laboratory required (asphalt, chemical, concrete, seal or soil).  
  - **Laboratory Building**  
    - Decide requirements for: size and layout, services, fittings and furniture.  
  - **Testing Equipment**  
    - Determine the type and quantity of items of test equipment required.  
    - Determine the type of consumables to be used in the laboratory.  
    - Determine computer hardware and software needs.  
  - **Testing Personnel**  
    - Establish an organisational structure.  
    - Decide if untrained, local people will be employed in the laboratory and trained as testers. Should untrained personnel be employed, provisions for on-site training should be made.  
    - Decide level and number of personnel required to manage and operate laboratory.  
  - **Vehicles**  
    - Decide vehicle type and quantity required to carry out the sampling and testing requirements. |
The following factors are crucial to the establishment of a project laboratory:

- The laboratory should be operated in accordance with an **acceptable quality management system** compatible with SANS 9001 or second tier accreditation.
- The **laboratory building** must be fit for purpose.
- The laboratory should be **adequately staffed** with suitably qualified and experienced supervisory and technical personnel.
- The laboratory should be **fully equipped** with fit for purpose, **calibrated** and/or verified test equipment to cover the intended scope of testing.

Table 8 provides a useful checklist to use for a preliminary assessment of the satisfactory establishment of a project laboratory.

**Table 8. Checklist for the Establishment of a Project Laboratory**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Details</th>
</tr>
</thead>
</table>
| **Documents Required in Site Laboratory** | - Quality management documentation relating to the quality system to be operated in the laboratory. This documentation should include a **quality manual**, **laboratory procedures** and **work instructions**.  
- Copies of valid, latest editions of **test methods** to be employed.  
- Copy of **OHS Act**.  
- **Contract specifications**.  
- Relevant **Technical Manuals**.  
- Test **report forms** and **bench sheets** (to record tester, equipment and sample details).  
- **Equipment register**, indicating all items of equipment in the laboratory.  
- Equipment **calibration and verification records**.  
- **Personnel records** including copies of training certificates. |
| **Facilities** | - **Suitable areas** for sample, preparation, testing and storage  
- **Equipment storage**, including adequate storage facilities for nuclear density gauges  
- **Storage for consumables**, including secure and safe storage for hazardous chemicals  
- **Toilet** and ablation facilities  
- **Office space**  
- **Kitchen**  
- **Parking area**  
- Fully equipped **first-aid boxes**  
- All necessary **fire fighting apparatus**  
- Appropriate **security** measures |
| **Test Equipment** | - All items of **major and accessory equipment** required to perform the scope of testing.  
- All items of equipment used for the **measurement of data** should be labelled with a unique reference identity number.  
- All items of equipment used for the measurement of data should be **calibrated or verified**.  
- All necessary **consumables** required to carry out the scope of testing.  
- All necessary **computer hardware and software** for use in the management and operation of the laboratory. |
| **Testing Personnel** | - An adequately qualified and experienced **laboratory manager** to manage the laboratory.  
- Adequately **qualified and experienced personnel** to perform the scope of testing. |
## REFERENCES AND BIBLIOGRAPHY


SAPEM CHAPTER 5: LABORATORY MANAGEMENT

APPENDIX A

Extract from:

Provincial Government of the Western Cape
Department of Transport and Public Works
Roads and Infrastructure Branch

MATERIALS MANUAL, Chapter 1
2005
A.1. LABORATORY FACILITIES

A.1.1 Introduction

The laboratory facilities must be adequate to perform the necessary tasks. The following aspects should be considered in assuring an adequate facility:

- Laboratory modules suitable for the planned activities.
- Space for employee interactions.
- Free flow of personnel between laboratory between laboratory modules and offices.
- Provision for easy expansion.
- Location acceptable to laboratory personnel and convenient for transport. The latter aspect is also important for transfer of samples to reference laboratories. Site control laboratories are usually located according to project needs.
- Access to senior management and technikons is important for regional and reference laboratories.
- Access to suppliers of equipment and calibration facilities is important for regional and reference laboratories.
- Provision of a safe working environment (Occupational Health and Safety Act [Act no 85 of 1993 and regulations]).
- Access to information services and data processing.

A.1.2 Specifications

A.1.2.1 Introduction

The layout of the laboratory complex should be according to guidelines given in Figure 1. The detailed location of the power points, work benches, doors, furniture and laboratory apparatus will be left to the discretion of the Officer-in-Charge. The proposed facility shall first be approved by the Materials Engineer or his representative before construction.

Figure 1. Layout of Laboratory
A.1.2.2 Standard Requirements

The minimum standard requirements for the various sections of the complex are as set out below.

A.1.2.2.1 Main Laboratory

- Concrete floor
- 10 m long work bench, 0.8 m wide
- 3 m long bench 1 m wide (approximately half to have wooden top and half concrete top)
- Sink and drain board with taps for hot and cold water, inside
- Soaking bath for CBR with dimensions 1.74 m x 0.64 m x 0.3 m (L x W x H)
- Curing trough for concrete cubes with inside dimensions of 3.1 m x 0.6 m x 0.3 m (L x W x H)
- Air conditioning unit with a cooling capacity of at least 5.0 kW & 2 heaters each of at least 2.0 kW
- Fluorescent light units of 80 watt each
- 2 x 80 amp power points
- 6 x 15 amp power points
- 4 x Laboratory stools
- 1 x Dust extractor

A.1.2.2.2 Asphalt Laboratory (when required)

- Concrete floor
- 4 m long work bench 0.8 m wide with concrete top
- 2 x fluorescent light units of 80 watt each
- 1 x 80 amp power point
- 4 x 15 amp power points
- 2 x Laboratory stools
- Air conditioning unit with a cooling capacity of at least 5.0 kW and 2 heaters each of at least 2.0 kW

A.2. EQUIPMENT APPROVAL AND CALIBRATION

A.2.1 Ordinary Apparatus

All laboratory apparatus shall be approved by the Head: Materials Testing Technical Services, or his/her representative, and be adequate to perform tests in accordance with TMH1, or as specified by the Administration.

Calibration certificates shall be available for scrutiny during the inspection visits described under “Inspection and Reporting” on page 1-18 (of original document).

A.2.2 Nuclear Apparatus

All nuclear apparatus, such as nuclear density gauges, shall be registered by the Department of Health, Directorate: Radiation Control, before it is allowed on site. (South African Hazardous Substances Act, 1973, Act 15 of 1973). The certificate of authority issued by the Department of Health, Directorate: Radiation Control, shall be available at all times. Before any nuclear apparatus is used for testing, it must first be verified and certified at least once every year, or after servicing and after repairs.

Before any operator is allowed to use a nuclear apparatus he/she must prove that he/she is capable of operating the instrument and be acquainted with all the safety precautions.

Records must be kept of the monthly standard counts taken on the apparatus reference block. These readings must be taken with the reference block on the same spot every time a standard count is taken. This data must be submitted at the end of every month to the Head: Pavement Technology, Cape Town. Refer to Chapter 9, “Acceptance Control: Basic Concepts” for further details on calibration.

Daily standard readings shall be taken prior to and after the testing of a construction test section, before moving to another test sections remote form the first test sections.

The reference block of the apparatus must be kept on the same spot every time when taking the counts before and after the testing of each section.
Extract from:

South African National Roads Agency (SANRAL)

MATERIALS CODE OF PROCEDURE M2,
Construction Quality Control
June 2002

Note: In the original document, this section is numbered from 23 to 26. This numbering has been reset to B.1 in this extract.
B.1. LABORATORY TESTING

The testing of materials forms an integral part of the total quality control system. The relatively high level of testing carried out contributes significantly to the total cost of supervision. These costs can however be justified through the accurate assessment of quality as well as uniformity of the final product, thus reducing the risk of any premature failures. The provision of a materials testing service is dependent on the size and scope of the project and can take the form of one, or more, of the following options:

- Dedicated site laboratory for acceptance control
- Dedicated "combined" site laboratory for process as well as acceptance control
- Off-site testing in a commercial facility
- Dedicated "Test House"

Prior to commencement of a project, the supervisory engineer is required to carry out a full costs exercise in order to establish which of the above options would be the most cost effective. Although the type and frequency of the various tests, as envisaged for the project, plays a significant role in any decisions regarding the above, the location and capacity of off-site commercially testing facilities should be carefully assessed in order that no delays in testing occur. Notwithstanding any recommendations made, the final decision regarding the above remains the prerogative of the Agency.

B.1. SITE LABORATORY

B.1.1 Laboratory Building

The site laboratory shall be constructed and fitted according to the layout and dimensions as indicated in the relative project document. Any proposed deviations from the approved plan shall be discussed with the Regional Materials staff prior to implementation.

The building, light fixtures, windows, doors, work benches, etc., shall be maintained in good order for the duration of the project. While provision in this respect is included in the relevant pay items of the schedule of quantities, it should be noted that the supervisory firm would be responsible for any damage resulting from negligence by its staff. The laboratory shall at all times be kept clean and tidy and as dust free as possible, with items of clothing, food and other personal belongings of staff not allowed to lie about. The preparation of food in the laboratory is not permitted as a separate cooking facility is normally provided for near the laboratory building.

B.1.2 Provision of Equipment

The supervisory consulting firm shall, unless otherwise agreed, supply all site laboratory equipment and consumables necessary for the control and testing of materials. This equipment must comply with the requirements of the latest edition of TMH1 "Standard Methods of Testing Road Construction Materials", as well as any other approved test methods as specified for the project, such as the new SANS methods. The number of apparatus items required will depend mainly on the size and scope of the project to be controlled. Prior to commencement of the project the supervising Consulting Firm is required to submit their laboratory equipment proposals to the Regional Manager on the standard equipment lists, as issued by the Agency, for approval. The various items of laboratory equipment shall be classified as indicated in the relevant tables contained in the Agreement for Consulting Engineering Services. Remuneration for the provision of equipment shall be based on the relevant rates applicable at the time of entering into the "Agreement" and shall be fixed for the duration of the project. The establishment and de-establishment dates for the "laboratory types" shall be mutually agreed during the course of the construction works.

B.1.3 Maintenance of Laboratory Equipment

It is regarded by the Agency as of utmost importance that all laboratory equipment is kept in good working order and in compliance with the permitted tolerances. The technician in charge of the laboratory is responsible for the condition of all equipment in his laboratory and serious breaches in this direction may result in him being considered unacceptable to the Agency.

All laboratory equipment must be regularly inspected for compliance with the requirements at least once a month by the technician in charge. An appropriate checklist for this purpose must be completed for each inspection and shall be available for inspection at all times. A similar inspection of the site laboratory must be carried out by a representative of
the supervisory Consulting Firm’s controlling laboratory at least once every three months, with a formal report submitted to the Agency’s Regional Manager after each inspection.

Listed below are some of the more common routine maintenance checks and aids, which must be carried out at intervals not exceeding those indicated:

**B.1.3.1 Balances and Scales**

Balances must be serviced and calibrated by an approved agency on an annual basis with certificates to this effect available for inspection. It is considered good practise to monitor the accuracy of all balances on a weekly basis by means of standard weights.

**B.1.3.2 Ovens**

All ovens must be of the force draft type. The temperature of each oven shall be measured and recorded each morning and afternoon of every working day, with a continuous record of all measurements displayed for inspection on a monthly basis. Ovens being used for the accelerated curing of stabilised materials may not be simultaneously utilised for any other purpose. Ovens utilised for the drying of extracted asphalt samples shall be explosion proof.

**B.1.3.3 Sieves**

Sieves must be thoroughly checked at least once every week for excessive wear or stretch. However a brief inspection of sieves should be carried out each time they are used in order to ensure that no tear or fault has developed. The 0.075 mm sieve must never be used for washing or sieving unless protected by the 0.150 mm sieve. Sieves shall be replaced as soon as any stretching of the mesh is evident.

**B.1.3.4 Liquid Limit Devices**

The liquid limit devices must be checked before the start of each day’s use to ensure that the correct drop is being effected, with the fall being free and unrestricted. The grooving tool must be checked daily for correct width, and the bowl must be replaced as soon as any roughening of the surface, or excessive wear of the front edge, occurs.

**B.1.3.5 Compaction Hammers**

All compaction hammers, including those utilised on automatic compaction equipment, must be inspected and checked every week for compliance with the specified mass and drop. Where the production rate for testing is high, it is considered good practice to monitor conformance to the specified criteria on a daily basis. A table recording these measurements shall be continuously kept up to date and available for inspection.

**B.1.3.6 Moisture Content Tins**

All tins and or bottles utilised for the determination of moisture contents must be air tight, with their mass checked monthly. All tins as well as lids must be free from rust and must have clearly marked numbers.

**B.1.3.7 Compression Testing Machines**

All compression-testing machines (CTMs) must be calibrated by an approved agency at the following frequencies given in Table 1.

**B.1.3.8 Moulds**

All moulds utilised for the determination of Maximum Dry Density and CBR values must be calibrated every month, with the perforated base plates and moulds kept clean and well-oiled when not in use. A list of all mould masses and volumes should be displayed on the laboratory wall for easy reference.

Concrete cube moulds must be checked for critical dimensions after each dismantling and reassembling.
### Table 1. Calibration of Compression-Testing Machines

<table>
<thead>
<tr>
<th>Type of CTM</th>
<th>Characteristic</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete cube to BS 1881 and BS 1620</td>
<td>Load reading</td>
<td>Annually and after relocation. (See note A)</td>
</tr>
<tr>
<td></td>
<td>Frame stability</td>
<td>Initial commissioning. (See note B)</td>
</tr>
<tr>
<td></td>
<td>Lockable head</td>
<td>Initial commissioning, annually and after relocation.</td>
</tr>
<tr>
<td></td>
<td>Axial loading</td>
<td>Initial commissioning, annually and after relocation.</td>
</tr>
<tr>
<td></td>
<td>Platen flatness</td>
<td>Annually</td>
</tr>
<tr>
<td>Concrete beam to BS 1881 and BS 1610</td>
<td>Load reading</td>
<td>Annually and after relocation.</td>
</tr>
<tr>
<td></td>
<td>Frame stability</td>
<td>See Note B.</td>
</tr>
<tr>
<td>CBR to TMH 1 method A8</td>
<td>Load reading</td>
<td>Annually and after relocation.</td>
</tr>
<tr>
<td></td>
<td>Depth reading</td>
<td>Annually and after relocation.</td>
</tr>
<tr>
<td>UCS/ITS to TMH 1 method A14/A16-T</td>
<td>Load reading</td>
<td>See Note B.</td>
</tr>
<tr>
<td>Marshall to TMH 1 method C2</td>
<td>Load reading</td>
<td>See Note B.</td>
</tr>
<tr>
<td></td>
<td>Flow reading</td>
<td>See Note B.</td>
</tr>
</tbody>
</table>

**Notes**

A. A machine designed to be portable need not be verified if it is moved to a new site.
B. Annually and after relocation for machines with a detachable frame.
C. All the above mentioned compression testing machines of which the load rate is applied automatically needs to be verified for load rate annually and after relocation.

### B.1.4 Health and Safety Standards

The Occupational Health and Safety (OHS) Act (Act 85 of 1993) protects the health and safety of every worker, including laboratory personnel. This Act requires that all reasonable measures be taken by employers to safeguard their employees against injury and health risks. These requirements include the following:

- A copy of the act, with its regulations, must be available in the office at all times.
- Responsibility structures, e.g., senior technician and safety committee, first aid officers and fire fighting officers shall be in place.
- Training of staff members in the particular work hazards, e.g., toxic fumes, falling objects, corrosive chemicals, etc.
- Provision of a safe working environment including the provision of protective clothing such as goggles, boots, etc., to workers at reasonable intervals.

#### B.1.4.1 Municipal and Regional Council By-Laws

Municipalities or Regional Councils may have differing by-laws dealing with issues such as fire protection, storage of toxic chemicals, flammable liquids, etc. These cannot therefore be covered here in any detail, however the responsible person is required to ensure that laboratory conforms to all fire prevention requirements pertaining to the relevant authority in which the laboratory is located.

Good housekeeping is a prerequisite in accident prevention. The chances of accidents occurring are generally greater in a site laboratory than would normally be the case due to the following reasons:

- The laboratory buildings are usually of a temporary (portable) type, which could be flammable.
- Laboratory assistants are frequently employed locally and on a temporary basis, leading to insufficient understanding of safety procedures.
- Site laboratories are invariably under pressure to produce results timeously, which frequently requires night work.
- Inadequate or insufficient storage facilities.

#### B.1.4.2 General Requirements

Notwithstanding the requirements of the (OHS) Act, following are some aspects that have specific bearing to any materials testing laboratory:

- The laboratory must be kept clean and free of any potential fire hazards, e.g., loose papers, excess solvents, etc.
- Escape routes should be clearly marked and kept clear of any samples, equipment, etc.
- Suitable and regularly serviced fire fighting equipment must be readily available, with their location clearly identifiable.
- Storage of gas cylinders must comply with accepted norms as well as any relevant by-laws.
- An appropriately stocked first aid kit must be readily available.
Chapter 8: Laboratory Management

- At least one permanent employee, who is generally employed full time within the laboratory must be trained and in possession of a valid first aid certificate.
- All employees working with hot binders, corrosive chemicals and or toxic solvents should be conversant with the first aid practices applicable.
- Safety equipment, e.g., safety boots, dust masks, heat resistant gloves, aprons, etc., must be provided for the workers protection where necessary.
- A suitable supply of cold water should be readily at hand for the emergency treatment of bitumen and other burns.
- A suitable eye wash station should be conveniently located for emergencies.
- Telephone numbers of emergency services must be prominently displayed.

B.1.4.3 Asphalt Laboratory

- A separate fireproof room, for the storage of solvents and other flammables must be available.
- The binder extraction room is to be a separate, dedicated room, with no other testing allowed within it, with the exception of the distillation of solvents for re-use.
- All equipment utilised within the extraction room must be flameproof.
- An extraction fan and or fume cupboard must be supplied in the extraction room which is capable of reducing the level of concentration of fumes to within accepted limits.
- The solvent drainpipes of centrifuges must lead into sealed containers, and all exhaust fumes must be emitted outside through means of adequate exhaust pipes.
- Not more than 40 litres of toluene solvent may be kept in the testing room at any one time. This includes dirty solvent.

B.1.4.4 Chemical Laboratory

The use of highly concentrated acids and alkalines in this section of the site laboratory lends itself to potentially dangerous situations. Staff should thus be thoroughly aware of all the dangers pertaining to such chemicals. The provision of adequate protective clothing is essential and the use thereof must be enforced. All shelves utilised for the storage and use of these chemicals must be of sturdy construction to prevent any collapse.

B.1.4.5 Nuclear Gauges

The transportation, storage and use of nuclear gauges for the determination in-situ densities is governed by the Hazardous Substances Act, 1973 (Act No 15 of 1973).

Nuclear gauges have been classified as a Group IV hazardous substance by the Department of Health and all persons utilising such equipment are thus by-law required to comply with the requirements of this Act. Notwithstanding these requirements, all persons employed in the laboratory should be fully informed of the potential dangers associated with such nuclear devices.

A brief overview of the pertinent requirements is included in Appendix I (of the original document).

B.1.5 Standard of Work

Whilst the saying “one result is worth a hundred opinions” might have some merit, it is essential that such result, or results, is correct. To ensure an acceptable standard or accuracy of testing it is a requirement that a quality assurance program be implemented in the site laboratory. Such a program should cover all the stages necessary to produce a test result, i.e.:

- Sampling
- Sample preparation
- Test method/procedures

It is a requirement that the consulting firms appointed for the supervision of the project institute a quality assurance programme in the site laboratory. Such a programme shall include a full laboratory inspection at least once every six weeks by an experienced external member of the firm or main laboratory together with a correlation-testing programme. Such inspection and test programmes shall be formalised with reports submitted to the Agency on each occasion. In addition, the Agency regularly conducts its own audits on site and where major non-conformance to requirements is noted, it may instruct an increased frequency of control by the consulting firm.
B.1.6 Equivalent Indicator Units (EIU)

Equivalent Indicator Units (EIU) are utilized as a tool to monitor the productivity/efficiency of a site laboratory. The format to be utilized is included in Appendix J (of the original document) and this should be submitted to the Agency's Project Manager on a monthly basis. While it is normal for the EIU values to be relatively low, i.e., < 5, during the start-up of the project, or for periods when excessive inclement weather has been experienced, continuous low values should be seen as a sign of overstaffing or poor planning (excessive overtime) in the laboratory. For the purpose of calculating the EIU only those staff members located in the laboratory for sampling, preparation and testing should be included. Tally clerks, etc., located at an asphalt batch plant/paver should thus not be included in the calculations. Where no equivalent unit is available for a specific test procedure this should be determined in conjunction with the Agency.

B.1.7 Payment

B.1.7.1 Site Laboratory Equipment

Prior to commencement of the project the supervisory firm is required to submit to the Agency for approval a proposed list of all the laboratory equipment to be established on site. This proposal shall be based on the standard schedules as contained in Annexure 3 of the Agency's Standard Agreement. Items of equipment established on site for "standby" purposes are generally not claimable. The relevant rates shall be those applicable to the year of appointment or, where a considerable period of time has elapsed between the original appointment and commencement of construction, the year in which the construction phase has commenced. This applicable monthly rate and factors should thereafter, unless the nature of the works changes substantially, be fixed for the duration of the project. The periods for which the equipment shall be remunerated shall be mutually agreed between the parties during the course of the construction works. Reimbursement for the established and approved equipment is claimed on Form S11 of the Standard Supervision Fee Claim.

B.1.7.2 Off-Site Testing

Where testing in an off-site facility has been approved, payment for such testing must be claimed under the normal supervision fee claim. The standard Form S11 utilised for site laboratory equipment claims makes allowance for off-site testing costs. Claims for such testing shall however be in accordance with the relevant rates as approved by the Agency, with all such claims accompanied by a copy of the invoices from the accepted service provider.

B.2. OFF-SITE TESTING

For small projects, or projects where specific testing will only be required intermittently over a lengthy period of time, it is often found that the acceptance control testing can be far more cost effectively carried out in an off-site facility than by the establishment of a dedicated site laboratory. Cognisance must however always be taken of any possible delays that may ensue through the use of a commercial facility. The distance of such a laboratory from the project should also be taken into account in weighing up all factors.

The use of external laboratories for acceptance control testing must be fully motivated and requires the necessary approval of the Agency. Where the total cost of testing is estimated to not exceed R100 000.00 the supervisory engineer may utilise his own or an associated commercial laboratory to carry out the necessary testing subject however to the rates being approved.

Where the estimated cost of testing exceeds R60 000.00 the consulting engineer is required to call for quotations from at least three suitably located commercial laboratories. In these circumstances a formal agreement is entered into between the consulting firm and the successful commercial laboratory as approved by the Agency. Guidelines for the compilation of such an Agreement are contained in Appendix K (of the original document).

B.3. COMBINED LABORATORIES

The use of combined laboratories for the execution of both process as well as acceptance control testing has become more popular. The use of such common facility has certain advantages, i.e.:

- Better control
- Time savings for the contractor
- Cost savings for the Agency as well as contractor
In principle the Agency favours the use of such combined testing facilities subject however to certain conditions and monitory contributions from the contractor.