

SOUTH AFRICAN PAVEMENT ENGINEERING MANUAL

Chapter 5

Laboratory Management



**AN INITIATIVE OF THE SOUTH
AFRICAN NATIONAL ROADS AGENCY SOC LTD**

Date of Issue: October 2014

Second Edition

**South African Pavement Engineering Manual
Chapter 5: Laboratory Management**

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BACKGROUND

1. Introduction

2. Pavement Composition and Behaviour

TESTING AND LABORATORY

3. Materials Testing

4. Standards

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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 relevant 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 covering all aspects of pavement engineering. 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, basic principles of roads, the road design life cycle, 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. A list of the major references and guidelines for pavement engineering is given in Appendix B.

Chapter 2: Pavement Composition and Behaviour includes typical pavement structures, material characteristics and pavement types, including both flexible and rigid pavements, and surfacings. Typical materials and pavement behaviour are explained. The development of pavement distress, and the functional performance of pavements are discussed. 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, 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 Western Cape Government Materials Manual.

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 reporting on the investigations. The road pavement investigations include discussions on the investigation stages, and field testing and sampling (both intrusively and non-intrusively), and the interpretation of the pavement investigations. Chapters 6 and 7 are complementary.

Chapter 7: Geotechnical Investigations and Design Considerations covers the investigations into fills, cuts, structures and tunnels, and includes discussion on geophysical methods, drilling and probing, and stability assessments. 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. The legal and environmental requirements for sourcing materials are given. Alternative sources of potential pavement materials are discussed, including recycled pavement materials, construction and demolition waste, slag, fly ash and mine waste.

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 pre-coating fluids and tack coats, bituminous binders, bitumen stabilized materials, asphalt, spray seals and micro

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surfacing, 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 design 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; the tender process; and the contract documentation from the tender award to the close-out of the Works.

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 January 2013, and a second edition in October 2014. Feedback from all interested parties in industry is appreciated, as this will keep SAPEM relevant.

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

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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, and integral, 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
- Stabilized materials
- Asphalt
- Bitumen and bituminous products
- Cement and cementitious materials
- Concrete and concrete products
- Steel reinforcement



Materials Testing

Testing of road construction materials and products plays a critical role in relation to the assessment of pavement construction quality. Hence, reliable test results are vital.

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**, inspection 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? This is an ISO 17025 requirement.

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 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, specifications 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.



The Standard

ISO 17025:2005 is known as the Standard, as is referred to as such in this chapter.

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 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



Accredited Laboratories

A laboratory's fulfilment of the requirements of ISO 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.

2.1 ISO 17025

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 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 17025.

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

Consequently, laboratories are now required to be accredited according to ISO 17025 and not be certified to ISO 9001. The processes of accreditation (ISO 17025) and certification (ISO 9001) are two separate actions. No longer can a laboratory be accredited to ISO 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.



Certification and Accreditation

Accreditation is the comprehensive evaluation of the laboratory management system by an independent body.

Certification is the formal declaration (a certificate), that a product, service or system meets specific requirements.

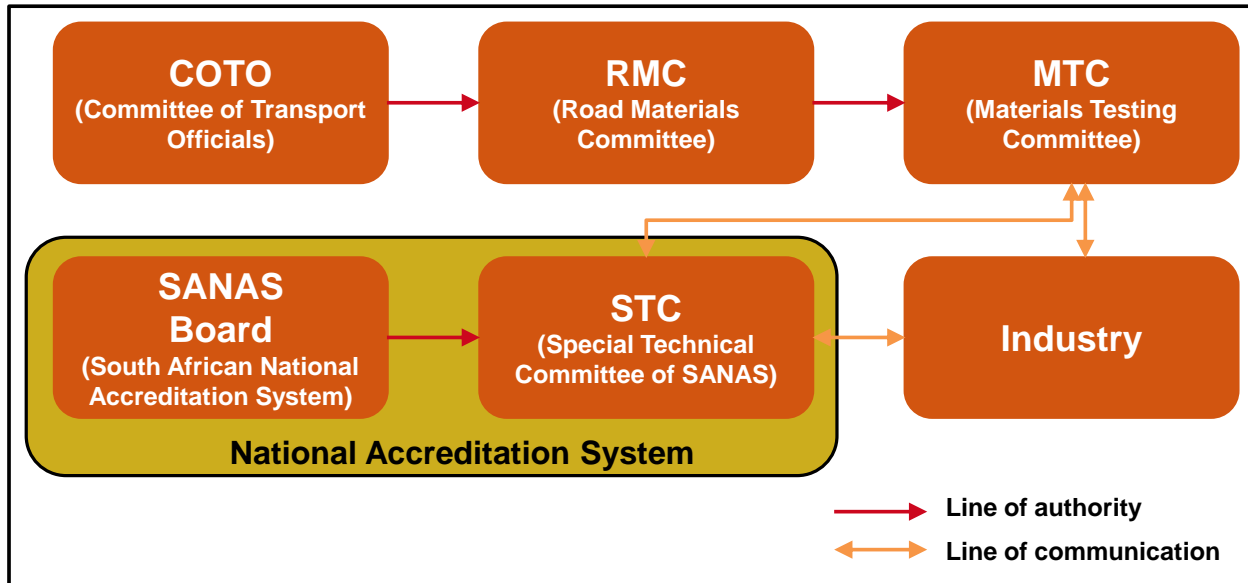


Figure 1. Organizations Involved with Accreditation

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 ISO 17025 involves the following broad processes:

- (i) The organisation to **establish a laboratory management system** aligned to ISO 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

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- **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 17025 is subdivided into 5 sections, as shown in Table 1.

Table 1. ISO 17025

Section	Title
1	Scope
2	Normative references
3	Terms and definitions
4	Management requirements
5	Technical requirements



ISO Sample Documentation

The Western Cape Provincial Administration, have made available typical ISO 17025 compliant laboratory documentation as a guideline to assist 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 Government*

The Standard specifies the requirements for sound management and technical competence. The specific management and technical requirements covered are shown in Table 2. The recommended basic steps for laboratory accreditation are shown in Table 3.

Table 2. Management and Technical Requirements of ISO 17025

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

One of the first steps in the accreditation of a laboratory facility is establishing and documenting an ISO 17025 compliant quality management system. The internal quality documents, i.e., documents generated by the laboratory, are given in Table 4.

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Table 3. Basic Steps to Prepare a Laboratory for Accreditation

Step	Item
1	Laboratory management must understand the requirements of ISO 17025 and the accreditation process.
2	Create a plan for the accreditation of the laboratory: <ul style="list-style-type: none">– 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 4. Internal Quality Documents

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

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 ISO 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 Government (WCG). 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 SANS 3001 test methods
- Test **reporting** in-line with the requirements of ISO 17025
- Full **traceability** indicating who did what and when

- **Calculation and reporting** of the most frequently used TMH1 and SANS Test Methods. It is intended to convert from the TMH1 to the new SANS methods by the end of 2015. See more on the conversion of TMH1 to SANS test methods in the appendix to Chapter 3.
- Advanced **graphical analyses** for CBR and MDD tests.

Figure 2 shows a screenshot of CBR graphical analysis being carried out using the MTS software.

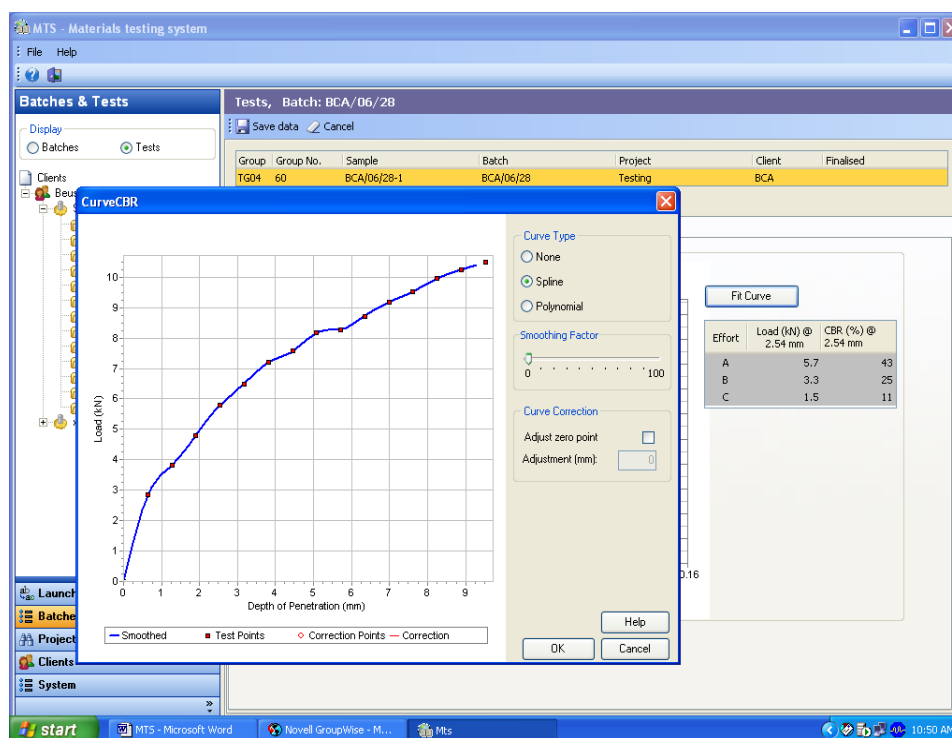


Figure 2. Advanced CBR Graphical Analysis using MTS

A system for standardized reporting of laboratory testing for quality management is included as part of the planned South African Pavement Design Method, the development of which is currently underway.

2.3 Other Important Aspects of Laboratory Management

As the quality of laboratory test results is so critical to developing cost-effective and reliable designs, the importance of good test results cannot be over-emphasised. Accreditation of a laboratory does not necessarily impact on the quality of the testing, but it simplifies the tracing of problems resulting from poor test results. Although an accredited laboratory should always have well-calibrated equipment in good condition, the onus remains with the laboratory technicians to ensure that changes in the equipment are timeously noted and that the necessary action is taken when changes are noted. Aspects regarding the operation of a laboratory that cover such issues have been summarised for the Botswana Roads Department (<http://www.vegvesen.no>).

It is also the responsibility of the Laboratory Manager or supervisor to ensure that all of the tests are carried out correctly, no short-cuts are taken and all the calculations are correct. Many erroneous results are traced to incorrect calculations, even though the testing was correct. The use of regular "blind" duplicate testing and inter-laboratory correlation studies allows laboratories to assess the quality of their testing.

Most laboratories retain duplicate (and/or tested material) for extended periods, usually 3 months, after completion of the project. This allows the client to check, and have duplicate testing done, where queries arise. It is important, however, that the storage of such samples is methodical, either by sample number (recommended) or by chronological sequence of testing.

It has been suggested that more research should be carried out on Laboratory Management. This is probably not warranted, but concentrating on the proper implementation of normal management principles, together with the accreditation systems and conscientious laboratory staff, is probably all that is required.

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



Competent Materials Testing

The ultimate quality of constructed road pavements depends heavily on accurate laboratory testing by competent materials testers.

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 5 shows the qualifications according to the South African Qualification Authority (SAQA) for construction materials testers, that is, NQF 4 through 6 (Janse van Rensburg, 2005). The Quality Committee for Trades and Occupations (QCTO) role is to oversee the design, implementation, assessment and certification of occupational qualifications (www.qcto.org.za).

Table 5. SAQA Qualifications for Construction Materials Testers

NQF Level	Qualification
4	Occupational Certificate: Civil Engineering Technician (Civil Engineering Materials Tester)
5	National Diploma in Construction Materials Technology
6	National Degree in Construction Materials Technology

The Civil Engineering Technician (Civil Engineering Materials Tester) at NQF Level 4 qualification is to prepare a learner to operate as a Civil Engineering Materials Tester with the applicable competence required in the execution of field sampling and testing, laboratory sample preparation and laboratory testing of aggregates, bituminous products, soils, gravels and crushed stone materials or concrete. The course providers need accreditation from the National Laboratory Association (NLA).

Learners will mostly be employed in the construction industry or in the manufacturing sector including quarries where the focus is on the manufacturing of construction material products. A qualified learner will be able to:

- Conduct laboratory activities, housekeeping and organise data.
- Execute field sampling and on-site testing, calculate and submit results.
- Execute sample preparation activities and conduct physical testing of aggregate materials, calculate and submit results.

- Execute sample preparation activities and conduct physical testing of:
 - Soils, gravels and crushed stone materials
 - Bituminous binders
 - Asphalt
 - Concrete and constituent materials
- Calculate and submit results.

This qualification is made up of compulsory “Knowledge and Practical Skill Modules” applicable to the level required for laboratory testers, as well as physically applying this knowledge as covered in the Practical Skills & Work Experience Modules.

Entry requirements are a National Senior Certificate or National Vocational Certificate (Civil Engineering and Building Construction), NQF Level 4.

The skills development providers use the curriculum to guide the stipulated internal assessment criteria and weighting. They also apply the scope of practical skills and applied knowledge, as stipulated by the internal assessment criteria. This integrated formative assessment leads to entrance into the integrated external summative assessment.

An external integrated summative assessment, conducted through the NLA is required to issue this qualification. The external integrated summative assessment focusses on the exit level outcomes and associated assessment criteria.

The external assessment is conducted by means of a combination of practical assessments concluded on the job and at approved assessment sites. During both types of assessments, the understanding and knowledge of candidates are tested through probing questions. Practical tasks are assessed by a panel that includes at least one assessor registered with the NLA. The external assessment is conducted over a period of two working days for each type of material.

Recognition of Prior Learning (RPL) for access to the external integrated summative assessment is obtained from accredited providers and approved workplaces, as determined by the internal assessment criteria specified in the related curriculum document to establish and confirm prior learning. Prior learning must be acknowledged by a statement of results. Accredited providers and approved workplaces may also recognise prior learning against the relevant access requirements

The National Laboratory Association provides the acceptance criteria and processes based on industry requirements for prospective learners to be eligible for the RPL process for access to the qualification. These industry requirements must be determined in accordance with experience, problem solving ability, ethics and professional practice, accessing, processing and managing information, producing and communicating information and accountability.

Qualified testers can transfer their qualification to other occupational qualifications such as Materials Tester Trainer and Civil Engineering Technician Diplomas or other qualifications relating to the following occupations: laboratory supervisor, laboratory manager or civil engineering materials technician.

Part qualifications can also be obtained by completing the required compulsory knowledge modules, as well as the particular modules required by the specific division in which they work.

4. TEST METHODS

The foreword to the Standard Methods of Testing Road Construction Materials (TMH1) 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 it 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. 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, until recently, 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 a series of South African National Standards (SANS) test methods. The new SANS test methods 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, and many methods are already available. A year after publication, each test method is 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.



TMH1 to SANS

TMH1 is in the process of being revised and translated into SANS 3001 Standards. The latest list of SANS 3001 Standards published to date is available on the Internet via SABS's WebStore (www.sabs.co.za, under Quick Search Criteria" enter "3001").

A complete list of the New SANS methods and the TMH1 methods which have been replaced are included in Chapter 3: Appendix C.

It is recommended that wherever possible these standards should take precedence over the old TMH1 methods. In the text, the SANS 3001 Standard Numbers are quoted. If the Standard has not yet been published then refer to TMH1. Please note that certain TMH1 methods deemed as no longer in use or appropriate have been omitted from the SANS 3001 series.



Test Methods and Standards

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.

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. Such environmental conditions are:

- Temperature
- Air conditioning
- Air flow
- Humidity

The layout, furnishings 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.
- The area is free of **fire hazards**, and suitable and regularly serviced firefighting equipment is readily available.
- 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 3 and Figure 4.
- **Protect** test samples from the weather and from loss, damage, or contamination.
- Provide **adequate storage facilities** for testing equipment.



Controlling Environmental Conditions

Environmental conditions that can affect test results should be carefully monitored. Testing must be halted if conditions change and could jeopardize the test result.



Figure 3. Sample Storage



Figure 4. Storage of Equipment

The testing environment must be maintained in good working order.

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.

5.1 Asphalt Laboratory

The following requirements are necessary for an asphalt laboratory:

- A separate **fireproof room**, for the storage of solvents and other flammables is available.
- The **binder extraction room** is a separate, dedicated room, with no other testing allowed within it, with the exception of binder recovery. The distillation of solvents, e.g., toluene, for re-use may not be undertaken in the room, due to risk of explosion, and must be carried out either in a separate room or preferably outside under a roofed structure.
- All equipment utilised within the extraction room is **flameproof**.
- An **extraction fan and or fume cupboard** is supplied in the extraction room, and is capable of reducing the level of concentration of fumes to within accepted limits.
- The **solvent drainpipes of centrifuges** lead into sealed containers, and all exhaust fumes are emitted outside through means of adequate exhaust pipes.
- Not more than 40 litres of **toluene solvent** is kept in the testing room at any one time, including dirty solvent.

5.2 Chemical Laboratory

The use of highly concentrated acids and alkalis 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.

5.2.1 Material Safety Data Sheets

A material safety data sheet (MSDS) is an important component of product stewardship and occupational safety and health. The MSDS are a widely used system for cataloguing information on chemicals, chemical compounds, and chemical mixtures. These sheets provide workers and emergency personnel with procedures for handling or working with that substance in a safe manner, and includes information such as physical data, for example, melting point, boiling point, flash point, toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill-handling procedures. These data sheets should be found anywhere where chemicals are being used, and can be obtained from the product supplier.

6. TEST EQUIPMENT

Laboratories need to be equipped with all items required for sampling, measurement and testing 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 and/or validity of the results:

- Prior to being put into service, all equipment used for sampling and testing should either be calibrated, or verified, to ensure that the **equipment meets the requirements** of the applicable test standards.
- Equipment should be **routinely calibrated**, or verified, to confirm its continued compliance with relevant requirements.
- **Equipment records should be maintained**, including purchase requisitions, owner's manuals, calibrations certificates, verifications and records of equipment.
- Damaged, malfunctioning, suspect or **defective** equipment should be labelled accordingly and not be used.
- Only **competent and authorised personnel** may 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, Verification and Checks

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 which in turn is traceable to an international standard. Calibration should be done as and when required for the specific item of equipment:

- 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 may potentially have put it out of calibration
- Whenever **observations appear questionable**
- After **maintenance or repairs**

Equipment verification 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 verification should be performed with calibrated measuring devices.

Recommended minimum requirements for the calibration and verification of standard and frequently used testing equipment for road materials testing laboratories are summarized in Table 6. These are just guidelines, for each laboratory the specific requirements are included in the accreditation details. Guidelines are also given by the United Kingdom Accreditation Service (UKAS) in their Lab 21 publication (2000), which is available for download at www.ukas.com.

Equipment should be regularly calibrated and verified according to requirements outlined in ISO 17025, or as may be specified in a specific project document. Equipment shall also always be traceable to a national and international measurement standard. See more in Section 7.



Checking of Equipment

All equipment should be visually checked every time it is used. Check that all workings are functional. Use your common sense!

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Table 6. Minimum Requirements for the Calibration and Verification of Frequently used Equipment

Equipment Type	Requirement	Interval					
		Before Use	Daily	Weekly	Monthly Intervals		
					3	6	12
Compression or loading devices	Calibrate						✓
Dial gauge	Calibrate						✓
Electronic balance	Verify		✓				
	Calibration						✓
Nuclear density gauge	Verify	✓	✓				
	Calibration						✓
Sieve	Verify					✓	
Grooving tool	Verify						✓
Liquid limit device	Verify		✓				
	Calibration						✓
Mould – CBR/MDD	Verify Mass		✓				
	Verify Volume					✓	
Manual compaction hammer – CBR/MDD	Verify mass & drop			✓			
	Impact size & shape				✓		
	No. of mechanical blows		✓				
Marshall wooden block							✓
Securing Turn buckles				✓			
CBR annular and slotted weight	Verify					✓	
CBR Penetration piston	Verify					✓	
CBR – perforated plate	Visual inspection		✓				
Mould – Marshall	Verify dimensions						✓
Manual compaction hammer – Marshall	Verify mass and height			✓			
	Impact size & shape				✓		
	No. of mechanical blows		✓				
Standard Mass Pieces	Verify						✓
Drying oven	Verify Temperature		✓				
Sample splitter (riffler box type)	Verify					✓	
Thermometer¹ Master	Calibrate						✓
Thermometers (other)			✓				
Calipers							✓
Penetrometer needle	Visual inspection	✓					
Distilling apparatus	Verification of water processed				✓		
Shrinkage troughs	Verify					✓	
Water baths	Verify temperature		✓				
ACV cylinder and mould	Verify condition						✓
Slump cone	Verify						✓
	Visual inspection	✓					
Concrete cube steel mould	Verify						✓
Marshall breaking head	Verify condition					✓	

Notes

1. Certain types of thermometers, e.g., those in daily use, may require more frequent checking

6.2 Good Practise for Laboratory Equipment

The following list contains good practise guidelines for some laboratory equipment. At all times in a laboratory, common sense should prevail, and testers should be constantly checking and/or verifying the equipment used.

(i) Ovens

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

(ii) Sieves

Sieves must be thoroughly checked at least once every week for excessive wear or stretch. However a brief inspection of sieves, as detailed in SANS 3001-PR10, should be carried out each time they are used 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 must be replaced as soon as any stretching of the mesh is evident.

(iii) Liquid Limit Devices

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

(iv) Moisture Content Tins

All tins and/or bottles utilised for moisture content determination must be air tight, with their mass checked monthly. All tins and lids must be free from rust and have clearly marked numbers on the tin itself. The lid may also be marked.

(v) Moulds

The moulds utilised for the determination of Maximum Dry Density and CBR values must be calibrated every month. The perforated base plates and moulds must be 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 verified for critical dimensions and squareness after each dismantling and reassembling.

6.3 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:



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.

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- **RN 784:** Standards for the Safe Use of Industrial Gauges Containing Radioactive Sources.
www.docstoc.com/docs/73301550/
- **RN 785:** Application in Terms of Article 3A of the Hazardous Substances Act, 1973 (ACT 15 of 1973) for the Transfer of Sealed Radioactive Nuclides by a Radiation Protection Officer to his Successor.
www.doh.gov.za/docs/forms/2009/rn785.pdf
- **RN 787:** Application in Terms of Article 3A of the Hazardous Substances Act, 1973 (ACT 15 of 1973) to Acquire, Possess, Use, Convey and Cause to Convey Radioactive Nuclides.
www.doh.gov.za/docs/forms/2009/rn787b.pdf

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 (DoH, 2005) and as described in SANS 3001-NG1: The Administration, Handling and Maintenance of Nuclear Density Gauge. 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 5. The gauge shown is a Troxler; other common devices currently available in South Africa are the Humboldt and CPN (strata gauge). Chapter 3: 2.7.1 contains more on nuclear devices, specifically how they work.

SANS 3001 test methods, relating to nuclear gauges, have been developed and were published in April 2014. These are shown in Table 7. Chapter 3: 2.7.1 contains more on nuclear gauges and how they work.

Table 7. SANS 3001 Nuclear Gauge Tests

Test Number	Test Name
NG1	Administration, Handling and Maintenance of a Nuclear Gauge
NG2	Validation of Standard Calibration Blocks
NG3	Calibration of a Nuclear Gauge
NG4	Verification of a Nuclear Gauge
NG5	Determination of In Situ Density Using a Nuclear Density Gauge

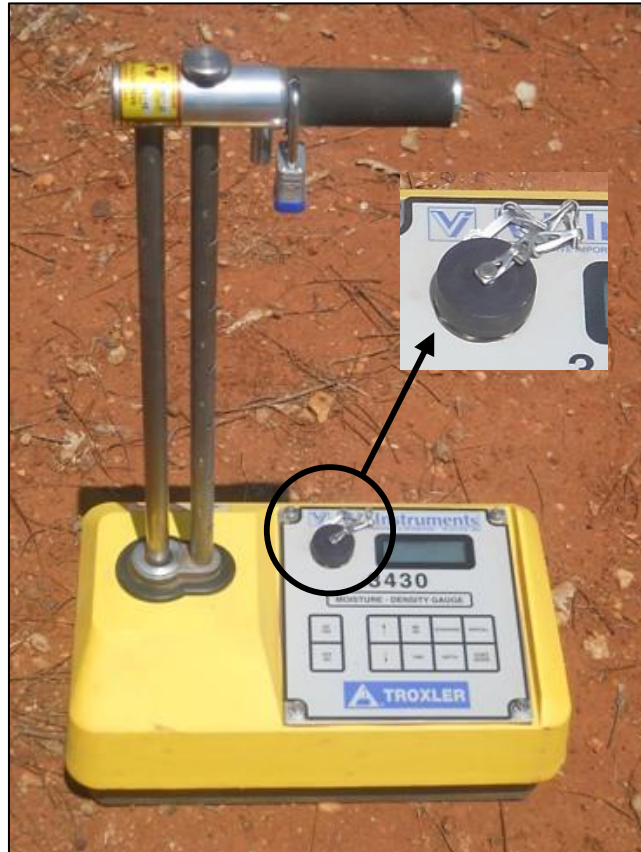


Figure 5. Nuclear Density Gauge and Badge

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 schemes.

Quality Assurance is achieved through a proactive approach to make sure all the factors that may influence the accuracy and precision of the test results are controlled, to the extent that the variation in test results are minimized.

The items listed in ISO 17025: General Requirements for the Competence of Testing and Calibration Laboratories, that could influence the accuracy of the test result include:

- Personnel
- Accommodation and environmental conditions
- Method of testing
- Equipment
- Measurement traceability (or accuracy of measurement)
- Sampling
- Handling of the sample
- Assuring the accuracy of test results
- Reporting of results

It should be noted that the management of the laboratory needs to constantly review these elements and ensure that the risk of issuing incorrect test results is limited and minimized.

(i) Personnel

The competence, ability and skill of the testing personnel must be continuously evaluated and assessed by an experienced person that knows the test very well. It should not be assumed that a tester is still doing the test precisely to the prescribed method after years of performing the test. It is human nature to create shortcuts, the consequence of which may be an incorrect test result.

(ii) Accommodation and Environmental Conditions

The civil engineering materials test methods are generally robust and not very susceptible to influences from the environment in which the test is executed. Careful note should, however, be taken of any particular environmental requirement, e.g., temperature or humidity, that any test method may specify.

(iii) Method of Testing

The test methods used are usually prescribed by the client or road authorities. The SANS 3001 suite of test methods are specified for use by laboratories for SANRAL projects.

(iv) Equipment

The test method stipulates the requirements to which the equipment must comply. The laboratory should continuously check and/or verify the equipment for wear and tear and periodically for accuracy of measurement. The accuracy to which equipment must measure is usually prescribed in the test method, and must always be suitable for the material type and associated specification.

(v) Measurement Traceability

Equipment must always be **traceable** to a national measurement standard. Simply put, a kilogram in the testing laboratory must have the same mass as a kilogram at the National Metrology Institute of South Africa (NMISA). The laboratory is required to be able to prove that their mass is the same, within acceptable tolerances, as NMISA's.

(vi) Sampling

Care should always be taken when materials are sampled as incorrect sampling can result in huge variations or a completely incorrect result, even if the test was perfectly conducted. Correct and careful **sampling** that is as



Quality Assurance and Control

Quality Assurance is a system by which all the factors that may result in risks are managed and controlled.

Quality Control is a system whereby the end product is measured against specifications.

Quality Management for construction is covered extensively in Chapter 13.

representative as possible should be clearly prescribed in the methods used, and the laboratory should inform the client if any problems occurred during the sampling process. TMH5 provides guidance on sampling.

(vii) Handling of the Sample

The sample should at all times be identifiable to ensure that samples do not get mixed up. In addition, samples should be handled in such a way that their determining characteristics are not changed in any way. For example, asphalt should only be transported to the laboratory in an insulated container to ensure that the sample does not cool down before it is tested. Should it happen that the asphalt is too cold to test, when the results are presented the client should be made aware that the sample required re-heating.

(viii) Assuring the Accuracy of Test Results

The laboratory must be able to provide proof that the results are reliable within an acceptable tolerance. This is often done by comparing the results with other laboratories that tested the same sample in proficiency testing schemes or interlaboratory testing. The laboratory should also establish their ability to reproduce and repeat a test result for the same sample.

(ix) Reporting of Results

The test results should be correctly reported and all the information required related to the sample, the test method and the test result should be clearly and accurately communicated to the client. It is better to provide too much information than too little.

8. HEALTH, SAFETY AND THE ENVIRONMENT

Occupational, Health and Safety (OHS) 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 and trained in the correct use of the PPE's.
- Personnel must be trained to handle particular **work hazards**, for example, toxic fumes, falling objects, corrosive chemicals as detailed in the applicable MSDS documentation.
- An appropriately stocked **first aid** kit is readily available. At least one permanent employee, who is generally employed full time within the laboratory is trained and in possession of a valid first aid certificate. Telephone numbers of emergency services are prominently displayed.
- 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 and only by those authorised to do so.
- **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.
- **Municipal and regional by-laws** must be complied with.

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.

The management and operation of a project laboratory could be the designated responsibility of either:

- An independent, **commercial laboratory**
- A **combined laboratory**

An **independent, commercial laboratory** service provider, or, the consulting engineering company is appointed for the contract supervision. This requires the contractor to provide their own laboratory for their internal process control testing.

Combined laboratories are a joint venture between the employer/consultant and the contractor. Both parties contribute financially, normally 50/50 or as agreed, for the provision of personnel, laboratory equipment and transport. Both parties accept joint responsibility for all process and acceptance control results done by this laboratory. Some advantages of such a joint facility are:

- Improved **control**
- **Time savings** for the contractor
- **Cost savings** for the client and contractor
- **Avoiding disputes** relating to significant differences between the contractor's and consultant's test results

Due to the general shortage of qualified and experienced testing personnel currently experienced, the use of combined laboratories has become popular. Some road authorities, such as SANRAL, have made the use of combined laboratories obligatory, thus ensuring better control in the testing laboratory in the most cost effective manner possible.

The following conditions for a successful combined laboratory are required from the contractor:

- An undertaking that the **contractor will accept the test results** of the combined laboratory. Should there be any doubt with regard to the validity of certain test results, the issue shall be resolved through the use of an independent laboratory mutually agreed upon. The costs involved in such instances will be to the account of the party at fault.
- An undertaking that the **engineer is in charge of the combined laboratory**, and that staff and equipment supplied by the contractor are under the sole control of the engineer.
- The recent move by most Road Authorities to prescribe that all testing on site be undertaken under the "umbrella" of a **SANAS accredited laboratory** implies that a contractor generally cannot contribute staff or testing equipment towards a combined site laboratory. For example, SANRAL limits the contribution of the contractor to a financial one, i.e., they are required to tender a fixed monthly sum, which is then deducted from the payment certificates.

Important aspects to take into account when planning a project laboratory are summarized in Table 8.

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 ISO 17025 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 to ensure testing is properly done and at a rate that keeps up with construction.
- The laboratory should be **fully equipped** with fit for purpose, **calibrated** and/or verified test equipment to cover the intended scope of testing.

Table 9 provides a useful checklist to use for a preliminary assessment of the satisfactory establishment of a project laboratory.

Table 8. Planning a Site Laboratory

Item	Details
Scope of Testing	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.
Testing Frequencies	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.
Resource Requirements	<p>On the basis of the scope of testing and testing frequencies, determine resource requirements:</p> <ul style="list-style-type: none"> ● Laboratory Facilities <ul style="list-style-type: none"> – 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 <ul style="list-style-type: none"> – Decide requirements for: size and layout, services, fittings and furniture. ● Testing Equipment <ul style="list-style-type: none"> – 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 <ul style="list-style-type: none"> – 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 at a level sufficient to ensure testing is properly done and at a rate that keeps up with the construction. ● Vehicles <ul style="list-style-type: none"> – Decide vehicle type and quantity required to carry out the sampling and testing requirements.

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Table 9. Checklist for the Establishment of a Project Laboratory

Topic	Details
Documents Required in Site Laboratory	<ul style="list-style-type: none"> ● Quality management documentation relating to the quality system to be operated in the laboratory. This documentation should include a quality manual, laboratory procedures, work instructions and proof of competence. ● 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, traceable to national measurement standards ● Personnel records including copies of training certificates.
Facilities	<ul style="list-style-type: none"> ● Suitable areas for sample preparation, testing and storage ● Equipment storage, including adequate and appropriate storage facilities for nuclear density gauges ● Storage for consumables, including secure and safe storage for hazardous chemicals ● Toilet and ablution facilities ● Office space ● Kitchen ● Parking area ● Fully equipped first-aid boxes appropriate for the laboratories functions/operations – e.g., Bituminous laboratories require specialist first aid kits ● All necessary fire fighting apparatus ● Appropriate security measures
Test Equipment	<ul style="list-style-type: none"> ● 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 and/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	<ul style="list-style-type: none"> ● An adequately qualified and experienced laboratory manager to manage the laboratory. ● Adequately qualified and experienced personnel to perform the scope of testing.

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REFERENCES AND BIBLIOGRAPHY

- Botswana Roads Department. 2003. Operating Procedures for Central Materials Laboratory. Ministry of Works and Transport, Roads Department, Botswana. ISBN 99912-0-451-2.
[http://www.vegvesen.no/attachment/336341/binary/585486?fast_title=Botswana+Guideline+10+-+Operating+Procedures+for+Central+Materials+Laboratory+\(2003\).pdf](http://www.vegvesen.no/attachment/336341/binary/585486?fast_title=Botswana+Guideline+10+-+Operating+Procedures+for+Central+Materials+Laboratory+(2003).pdf)
- DoH. 1973. **South African Hazardous Substances Act**, 1973 (Act 15 of 1973), amended (No 16) 1976, (No 31) 1981, (No 53) 1992. Department of Health.
- DoH. 2005. **Code of Practice for the Safe Use of Soil Moisture and Density Gauges Containing Radioactive Sources**. The Directorate Radiation Control, Department of Health, May 2005.
http://www.doh.gov.za/department/radiation/codeofpractice/radionuclides/soilmoisture_1.pdf
- ISO 17025. 2005. **General Requirements for the Competence of Testing and Calibration Laboratories**. International Organisation for Standards.
- Janse van Rensburg, J.P.L. 2005. *Overview of Qualifications: Road Construction, Materials Testing, Civil Engineering and Construction Management Qualifications, Registration on the National Qualifications Framework*. Proceedings **24th South African Transport Conference (SATC)**. Pretoria. ISBN: 1-920-01712-7.
- OHS. 1993. **Occupational Health & Safety Act No. 85 of 1993**, As Amended.
- SAICE. 2003. **Code of Practice: The Safety of Persons Working in Small Diameter Shafts and Test Pits for Civil Engineering Purposes**. South African Institution of Civil Engineering, Geotechnical Division.
- SANS 3001-NG1. 2011. The Administration, Handling and Maintenance of Nuclear Density Gauge. South African National Standards. Pretoria. SABS webstore www.sabs.co.za.
- SANS 3001 Series. 2010. **Test Methods to Replace Those in TMH1**. SABS webstore www.sabs.co.za.
- TMH1. 1986. Technical Methods for Highways. **Standard Methods of Testing Road Construction Materials**. Committee of State Road Authorities. Pretoria. Available for download www.nra.co.za
- TMH5. 1981. **Sampling Methods for Road Construction Material**. Technical Methods for Highways. Committee of State Road Authorities. Pretoria. Available for download www.nra.co.za
- UKAS. 2000. **Calibration and Measurement Traceability for Construction Materials Testing Equipment**. United Kingdom Accreditation Service. UKAS Publication Reference: Lab 21. Edition 2.
<http://www.ukas.com/library/Technical-Information/Pubs-Technical-Articles/Pubs-List/Lab21ed2.pdf>
- WCPA. 2005. **Materials Manual, Volume 2**. Provincial Government of the Western Cape, Department of Transport and Public Works, Roads and Infrastructure Branch.



TRH Revisions

Many of the TRH guideline documents are in the process of being updated. See the SANRAL website, www.nra.co.za for the latest versions.

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

South African Pavement Engineering Manual

Chapter 5: Laboratory Management

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 technicians 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.

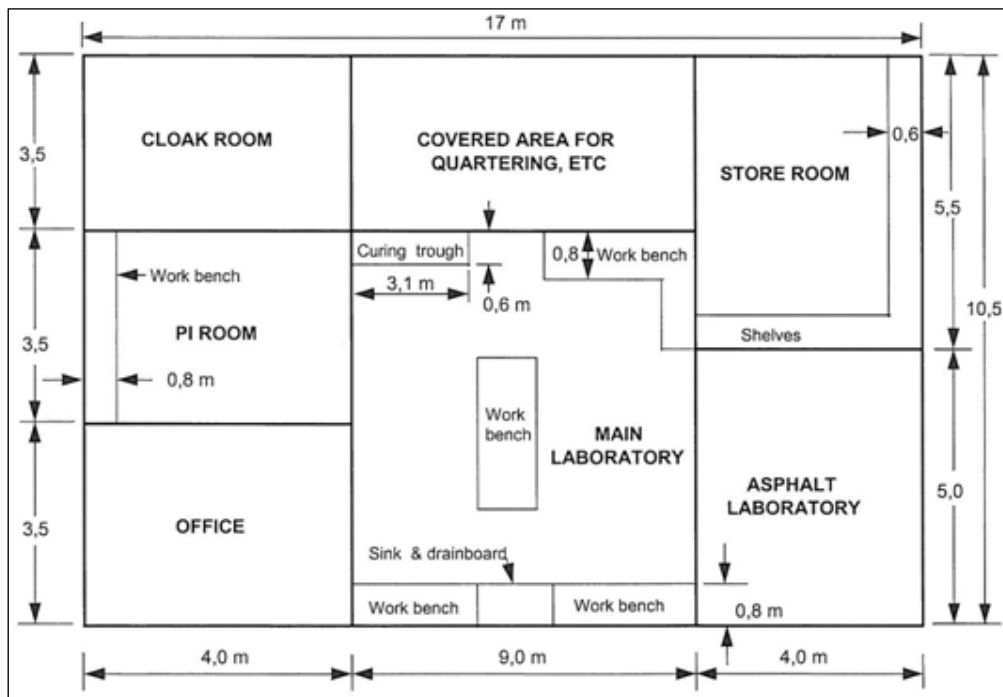


Figure 1. Layout of Laboratory

South African Pavement Engineering Manual

Chapter 5: Laboratory Management

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 from 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.