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**Measurement Management System**
Class # 8250

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## Introduction

Hydrocarbons have long been a main energy source for civilization in the modern era. Reliable hydrocarbon transportation from supply to demand is among the most critical factors in sustaining our way of life. Transported hydrocarbons are measured for environmental protection and/or accounting systems. Hydrocarbon measurement is a dynamic, unique field with unique challenges. Equipment, instruments, procedures, and computing systems undergo continuous change as technology continues to evolve at an increasingly rapid pace. New technology requires new skills and companies are faced with the task of developing, maintaining, and delivering training for these necessary advanced work force competencies. Because a decrease in work force knowledge and skills coupled with an increase in infrastructure complexity can lead to a perfect storm of inefficiency and poor measurement performance, a process-based approach to managing hydrocarbon measurement is necessary to control and improve a company's measurement performance.

Accurate and efficient measurement data acquisition requires the appropriate equipment for operating conditions being tested and calibrated by skilled personnel according to the right procedures at appropriate testing frequencies using appropriate instruments and tools. Beyond data acquisition, controlling system measurement performance also requires effective data management, technical system analysis and recommendations, appropriate managerial decisions, and a value-added assurance program. With such a wide spectrum of requirements, a process-based management system is necessary to effectively monitor and control hydrocarbon measurement systems. This paper outlines some learnings and recommendations for the consideration, development, implementation, or evaluation of a measurement management system to achieve accurate and efficient measurement performance.

A measurement management system is a body of integrated processes with which a company can control and improve measurement performance. An effective measurement management system should address equipment design and installation, equipment operation, work force proficiency, measurement procedures, calibration instruments and tools, calibration frequencies, information technology, information management, data analysis, management decisions, and system assurance. **Management system implementation and maintenance has an associated cost and is a value-added activity when the cost of inefficiency outweighs the cost of implementation.**

*ISO 9001 Quality Management System – Requirements* provides more detailed information related to the implementation of a management system.

The International Organization for Standardization (ISO) is a standard-setting body comprised of approximately 158 of 203 countries worldwide. The ISO 9001 standard documents requirements for quality management systems, with which a company can document, implement, maintain, and improve requirements related to performance and effectiveness. The ISO 9001 standard can guide an organization that strategically chooses to implement an ISO-compliant management system, for which ISO-certification is also an option.

## Management System Structure

A measurement management system structure should be simplistic and easily understood by all affected personnel from top management to technicians and operators. Processes that make up a measurement management system can be categorized according to the process types listed below as an organization understands and defines management system structure.

- Core Processes, which are fundamentally necessary to achieve organizational measurement objectives. Measurement management system core processes might include the cyclic measurement activities of ticket generation, inspection, verification, calibration, measurement performance analysis, and measurement reporting.
- Resource Processes, which support the required human and physical resources. Measurement management system resource processes might define measurement training, instrument management, and computer hardware/software support.
- Analysis & Improvement Processes, which assess compliance and effectiveness to achieve continuous improvement. A measurement management system should include an assurance process to assess system control by comparing actual performance with desired results.
- Management Processes, which modify the measurement management system as necessary based on results of analysis and improvement processes. A measurement management system must be continually assessed and improved in order to achieve performance within business targets. Management system documents, including processes and work procedures, must be reviewed and updated as necessary maintain applicability with technological advancement and changing business objectives.

## Core Process Considerations

Measurement management system core processes would define requirements related to equipment operation, inspection, verification, calibration, measurement analysis, and measurement reporting.

### Physical Measurement Process

A Physical Measurement Process defines requirements for the execution of physical measurement activities, such as proving flow meters, generating measurement tickets, inspecting measurement equipment, verifying device accuracy, and calibrating devices when found to out of tolerance. The following criteria should be considered when defining or improving a physical measurement process.

- Minimum required inspection, verification, and calibration tasks should be defined for measurement equipment. In addition to meter proving and inspection, for example, maintenance activities should be defined for meter provers, strainers, flow conditioners, sampling systems, instrumentation, flow computers, and valves.
- Inspection, verification, and calibration tasks should be clearly assigned to and accepted by measurement personnel.
- Minimum inspection, verification, and calibration (i.e. maintenance) frequencies should be defined.
- Defining an inspection, verification, and calibration plan for each measurement site provides a robust measurement management system. Site-level maintenance definition can be key to effective site-specific measurement training and more objective site-specific audits or surveys.
- Technical procedures should be easily understood, readily accessible, and routinely utilized by necessary personnel during task execution.
- Technical procedures should be well defined so that measurement tasks are executed consistently over time and by various personnel. Consistent task execution increases measurement error stability, which facilitates troubleshooting, identifying, and eliminating error sources.
- Technical procedures should clearly define recording and reporting requirements for inspection, verification, and calibration tasks.
- Technical procedures should be routinely reviewed and improved.

- Measurement equipment can only deliver stated accuracy within its design envelope. Equipment must be operated within design limits and any additional company-specified ranges. Operation outside of the permissible envelope should be automatically or manually detected and addressed. Additionally, site conditions can change over time (e.g. decreased volume and/or flow rate at a production facility), leaving once appropriate metering and sampling systems no longer applicable.
- An automated alarm should exist for all critical equipment failures (e.g. meter or flow computer failure).
- A process should be established to address volume determination upon device failures and approval of volumes determined other than by the established method (e.g. alternate equipment source or analytical determination).
- A reporting system should be defined to identify, communicate, and track necessary measurement equipment repair or replacement (e.g. maintenance request tickets).

Measurement Analysis

Measurement records are the primary output of the physical measurement process. These records include measurement tickets, inspection, verification, and calibration reports, and maintenance request tickets. These records are the source documents that are compiled to generate measurement system performance. These records also serve as the data that is analyzed to fuel measurement system performance improvement.

- Management should establish measurement performance targets relative to business objectives.
- Measurement system performance should be evaluated relative to these established targets.
- Systems that are not achieving targets should be technically analyzed for the purpose of generating technical recommendations to management. Technical recommendations should include risk-based cost/benefit assessments.
- Management should make budget and resource decisions based on technical recommendations designed to improve measurement system performance.
- Technical recommendations, resulting management decisions, and associated corrective actions should be clearly documented and retained as a system record to build an analytical history and avoid redundant efforts over time for the same issues.

High jumpers will set the bar, assess performance against the bar, analyze when not clearing the bar, make changes, and remember adjustments and their positive and negative effects. Analysis and improvement of measurement systems succeed with the same routine.

Measurement Reporting

Physical Measurement Reports (measurement tickets, calibration reports, etc.) are records that provide a measurement audit trail. Measurement tickets, specifically, are inputs into the business accounting system. Measurement Analysis Reports (i.e. issue tracking and resolution) should also be retained as measurement records.

- Measurement record software should be assessed for calculation accuracy relative to legal agreements and industry calculation standards. Software must be secure to prevent unauthorized algorithm modification.
- Measurement records must remain legible, readily identifiable, and accessible.
- A record control protocol should establish controls necessary for record identification, storage, protection, retrieval, retention, and disposition.

Figure 1 illustrates the interdependency between the measurement management system core processes of physical measurement, measurement analysis, and measurement reporting. The core processes are cyclic with one cycle typically occurring each accounting period.

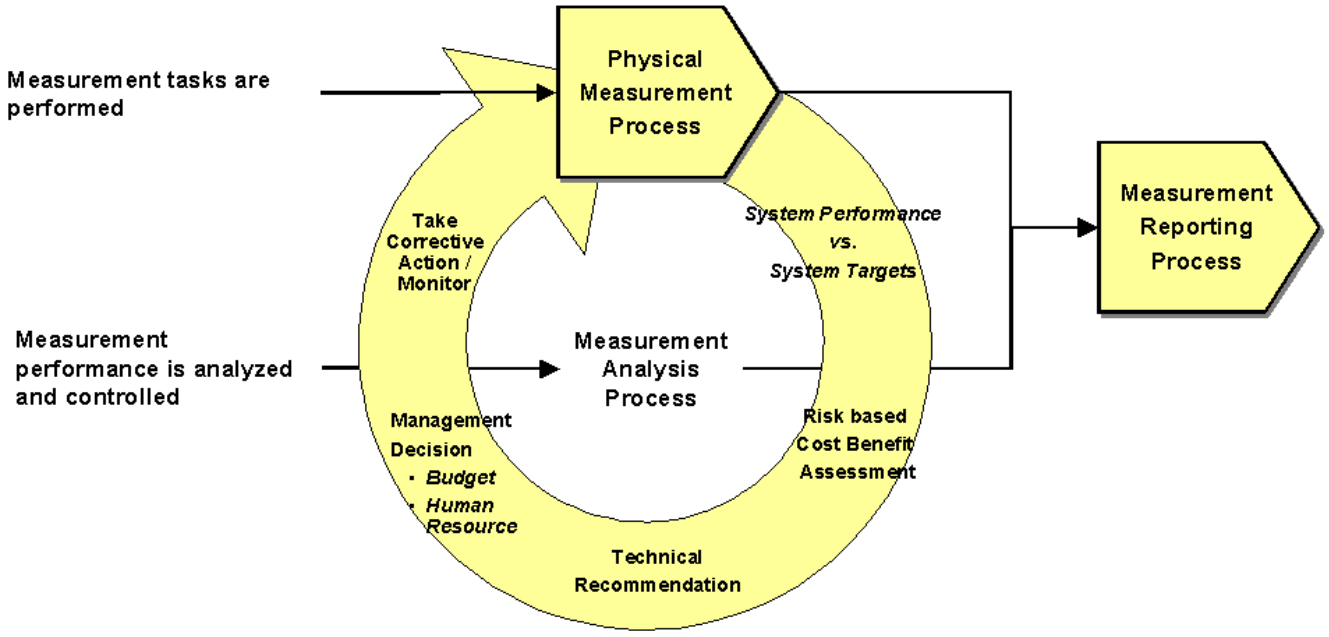


**Figure 1. Measurement Management System Core Processes Interdependency.**

## Resource Process Considerations

Measurement resource processes define requirements related to providing personnel and tools necessary to execute the measurement system core processes. Resource processes may address training, required knowledge and skills, approved tools such as measurement instruments, and computer hardware and software.

### Personnel Training and Proficiency

The knowledge and skills of measurement personnel are the most important and most overlooked aspect of a measurement system.

- Mandatory measurement training should be defined for each measurement personnel role.
- Training courses should be assessed, improved, and company-approved.
- Personnel training profiles should be reassessed upon an employee role change within the company.
- Training records should be maintained such that records are secure and readily accessible.
- Required knowledge and skills should be well defined for critical measurement roles such as technician and analyst.
- Measurement proficiency should be periodically evaluated on an individual basis through a witnessing program.
- Supervision should ensure individuals performing technical measurement tasks have been trained and witnessed to be proficient within the required time period.
- Controls should be in place to ensure that any outsourced labor meets the same training and proficiency requirements as company labor because an individual's affect on measurement performance is not a function of their direct employer relationship.

Instrument Management

The best doctors using inaccurate thermometers would miss simple fevers.

- Instruments approved for measurement tasks should be identified and documented, including any necessary model numbers, precision, and accuracy.
- Approved instruments shall traceable to a national metrology institute standard.
- Inspection, verification, and calibration activities should be performed with approved traceable instruments.
- Instruments shall be verified and/or calibrated at defined frequencies.
- Purchasing requirements for measurement instruments should be documented, including approved vendor requirements.

Information Technology

- Devices approved for measurement calculations, such as flow computers, should be identified and documented, including any necessary model numbers and firmware revisions.
- Measurement calculation device programs/configurations should be verified to meet defined criteria at an established frequency.
- Measurement calculation devices should be secured to prevent unauthorized or unintended modifications to calculation parameters or routines.
- Each site's measurement automation device programs/configurations should be backed up and stored in a designated location.
- Measurement software programs, such as meter ticket and meter proving report programs, should be verified to be compliant with specified calculation routines and protected from unintended modifications to calculation parameters or algorithm.
- Information technology support should be established to provide efficient resolution of computing hardware and software issues.

## Management Process Considerations

A measurement management system's performance should be routinely compared to system requirements or targets in order to continuously improve performance and efficiency. A management process should define management system documents, including the required frequency of system, process, and document reviews. A measurement management system is certain to fall short of its intended purpose without management and employee commitment to the system.

Management and Measurement Personnel Commitments

- Management must establish business measurement requirements and ownership for measurement performance.
- Management must commit to establish and maintain the measurement management system, including employee training, procedures, equipment, and tools necessary to execute the required measurement tasks.
- Measurement personnel must clearly understand and accept their measurement roles, responsibilities, and authorities.
- Measurement personnel must commit to identifying, communicating, assessing, and addressing measurement management system opportunities for improvement.
- Measurement personnel must continuously improve their knowledge and skills to maintain task proficiency in a system of continuous changes.

Change Management

- A systematic process should be established to facilitate and document the review, approval, and implementation of changes to the measurement management system.
- A change management process should include screening guidelines to define whether a change is significant and must be reviewed and approved prior to implementation.

Document Structure and Updates

- A measurement management system should define document requirements, including owner identification, format, storage, and revision identification.
- A document structure should be organized according to document type (process, procedure, etc) and primary user group.
- A single log should be maintained that identifies all measurement management system documents, including each document's owner, current revision, and official storage location.
- A single document owner should be defined by position title for all measurement management system documents.
- System documents should be assessed for applicability and effectiveness at defined periodic frequency.
- System document updates should be facilitated with the Change Management Process.
- A measurement management system document hierarchy should be defined, such as:
  - Measurement Policy
  - Operating and Design Standards
  - Processes
  - Procedures
  - Site-Specific Requirements

Figure 2 illustrates an example measurement management system document hierarchy.

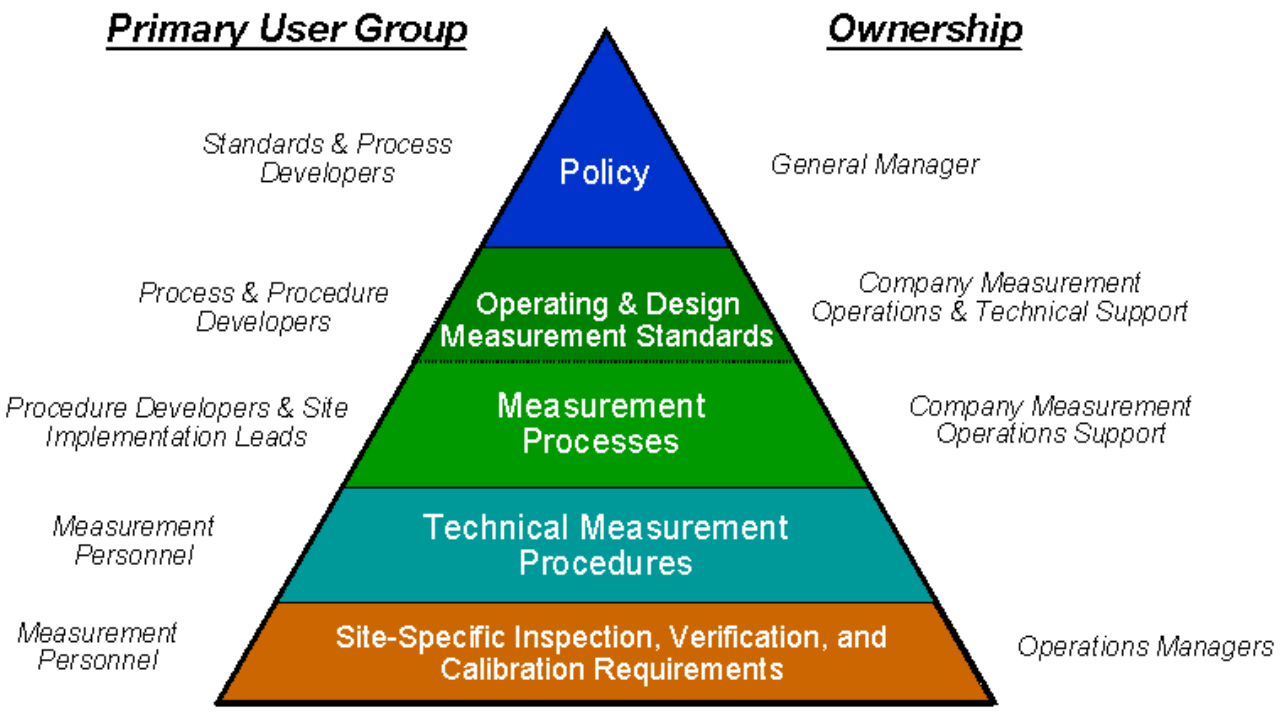


**Figure 2. Example Measurement Management System Document Hierarchy.**

Measurement Support to Projects

The purpose of a measurement management system is to control measurement system performance. A system modification, such as the addition of a new facility, is a disturbance this control system and must be introduced in a manner that minimizes adverse affects on an operating system.

- Company-approved measurement equipment should be documented in design standards, including both facility design considerations and specifications for components such as flow meters, meter provers, secondary instrumentation (e.g. temperature, pressure, and density transmitters), valves, and measurement control panels.
- Project engineers should ensure that system modifications are designed and installed in accordance with applicable design standards.
- Measurement apparatus design should be approved as compliant prior to construction.
- Any project exceptions to established design standards should be documented using the Change Management Process.
- Measurement apparatus should be inspected upon fabrication to ensure conformity with approved design.
- Required pre-commissioning tasks should be verified as complete prior to initial equipment operation.

## Assurance Process Considerations

A measurement assurance process facilitates verification of measurement activity in accordance with established measurement management system requirements, including assessment of process and procedure execution, equipment installation and operation, device inspection, verification, and calibration, data analysis and reporting, document and record management, personnel training, and performance analysis. An assurance process provides a feedback loop to management that measures the success of the implemented measurement management system relative to desired performance. ISHM Class 2220 provides more information on measurement assurance processes.

Figure 3 relates a measurement management system to a pipeline flow rate control system. An assurance process measures actual performance much like a flow meter measures actual flow rate. This feedback measure is compared to desired system performance and ongoing adjustments are made as necessary.

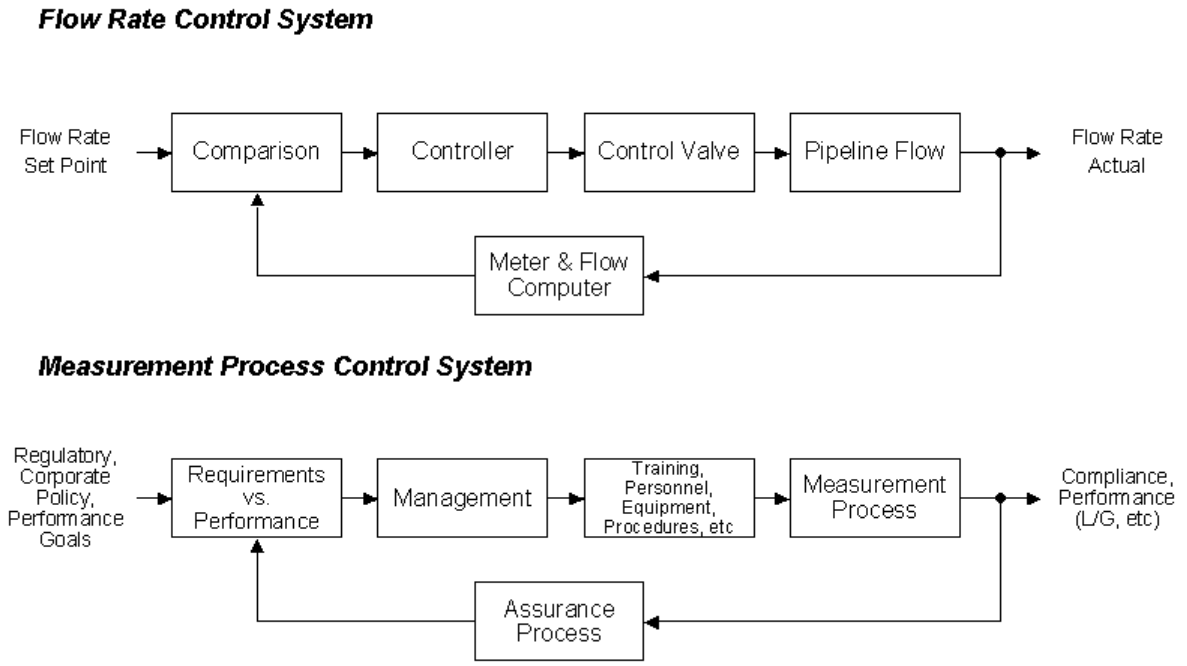


**Figure 3. Measurement Management System – Control System Model.**

Key Performance Indicators

Key performance indicators provide an ongoing measure of system performance like a meter continuously measures pipeline flow rate.

- Measuring actual system performance relative to desired performance is critical to identifying and implementing opportunities for improvement.
- Key performance indicators should be strategic measures of implementation effectiveness. Defining too few indicators will not provide an objective view of system performance and may lead to inefficient improvement efforts while defining too many indicators may unnecessarily tax information management resources. A couple of indicators per implemented process should initially provide a reasonable measure of system performance, after which additional KPI's could be strategically adjusted.
- KPI tracking and reporting responsibilities should be clearly defined.
- KPI metrics should be included in the periodic measurement management system review.
- KPI calculations, targets, and ongoing performance should be transparent and readily accessible by the personnel that affect the performance being measured.

Periodic Assurance Activities

In addition to ongoing measures that key performance indicators provide, it is necessary to periodically conduct a more detailed assessment of factors that may be contributing to overall error. This periodic health check would look at components in more detail than ongoing primary measures.

- Assurance activities, such as audits, surveys, investigations, or check rides, should be conducted in accordance with an established assurance process.
- A planned schedule should be maintained for audits and surveys.
- Measurement investigations can often be a recommendation to Management based on measurement performance analysis.
- Check rides should be more informal (typically one-on-one) observations of specific tasks designed to provide direct feedback related to personnel proficiency.

## Conclusion

Figure 4 illustrates the example measurement management system as described in this paper, including process types, example processes, and interlinks through which the output of one process is often the input to one or more other processes.

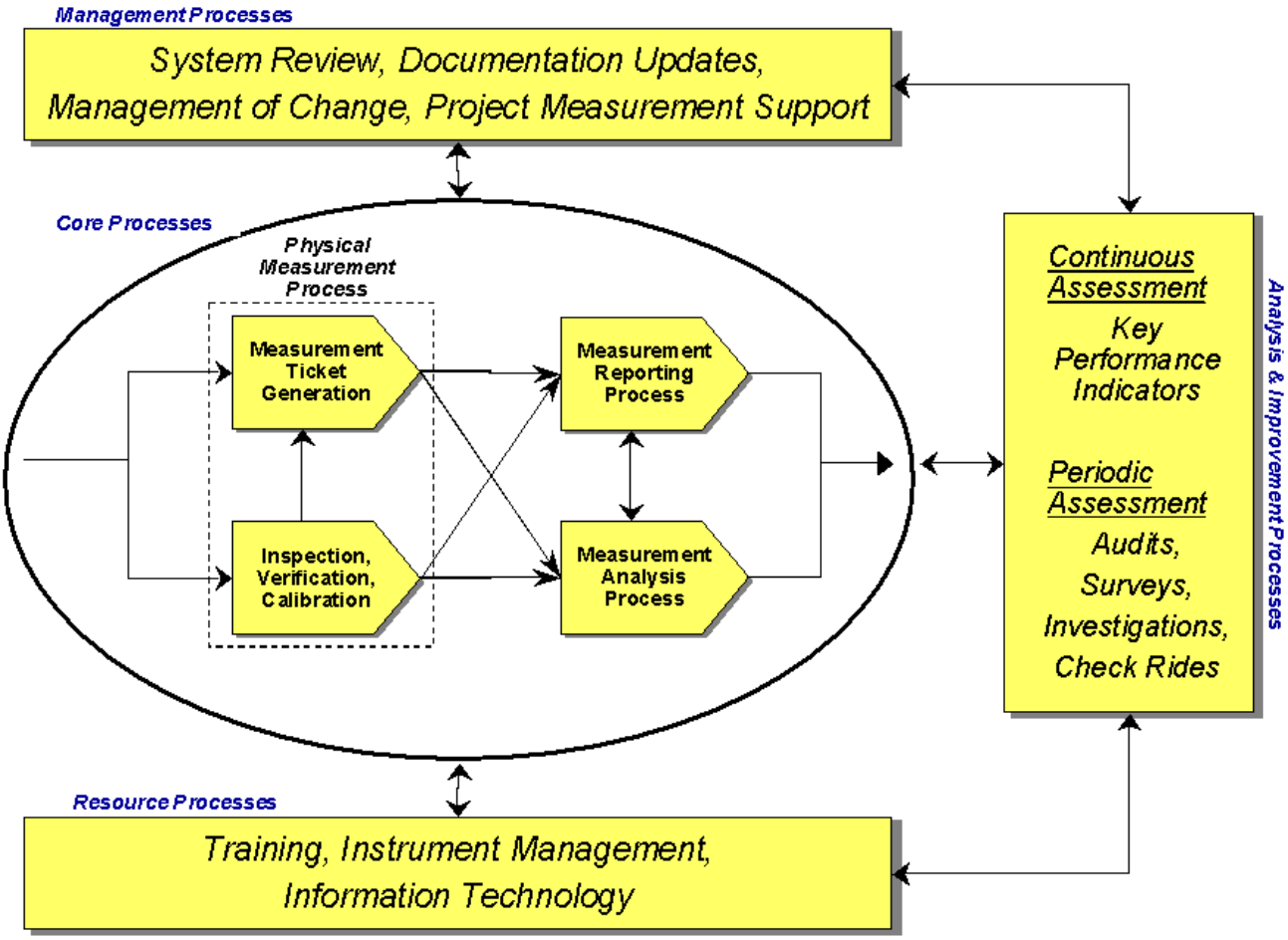


**Figure 4. Example Measurement Management System Structure.**

When faced with dynamic personnel and infrastructure challenges, a process-based approach to measurement management can enable control and improvement of a company's measurement performance. A measurement management system can clearly define integrated processes that specify requirements for the execution, support, management, and assurance of measurement tasks.

The ISO 9001 Quality Management System Standard provides guidance for the implementation of a measurement management system, for which ISO certification is also an option. Developing and implementing a measurement management system can be easily stated as value-added when the cost of inefficiency outweighs the cost of measurement management system implementation and maintenance; however, monetarily quantifying the benefit is nearly impossible due to the complexity of variables involved. Therefore, successful implementation requires management commitment.

Measurement management system development should incorporate the core, resource, management, and assurance processes necessary to achieve desired overall system performance. All affected personnel should easily understand measurement management system structure and document hierarchy. Measurement management systems must be assessed on a continuous and periodic basis for both compliance and effectiveness to achieve continuous improvement.