EXPRO
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Expenditure Efficiency & Projects Authority

National Manual of Assets and Facilities Management
Volume 6, Chapter 27

Post Maintenance Testing (PMT) Acceptance Criteria Procedure

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IMPORTANT NOTICE

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1.0 PURPOSE

The aim of this Post Maintenance Testing (PMT) Acceptance Criteria procedure is to ensure a high quality repair, replacement, alteration, integration, or extension to an existing asset and system with full restoration of service and performance with no violation of legal regulation. This can be demonstrated and supported by documentary evidence.

This PMT Acceptance Criteria procedure, when used in conjunction with the National Manual of Assets and Facilities Management (NMA&FM) PMT Test Plans and Procedure - EOM-ZM0-PR-000008 document, is designed to guide an individual responsible for ensuring that applicable maintenance work has been carried out to a predetermined objective and acceptable standard that meets the requirements of all stakeholders and applicable procedures.

This procedure will help ensure that any PMT Acceptance Criteria procedures and test plans are designed, drafted, and applied to a high and consistent standard.

2.0 SCOPE

This procedure provides information and advice on the different types of testing and focuses on PMT Acceptance Criteria.

This PMT Acceptance Criteria procedure provides guidelines across the breadth of engineering situations in which setting acceptance criteria may be applicable, with examples given of scenarios unique to specific environments including technical, contractual, and sector. This procedure provides guidance on selecting the technical performance criteria for a successful installation.

While it is possible to apply PMT Acceptance Criteria to many periodic, planned maintenance activities that involve the replacement of consumable items, e.g., air filters and lamps, the focus of this procedure is on the repair of a fault within an asset or system, as well as alteration, integration or extension to assets and systems which require testing upon completion of the works.

This document provides guidance on the competence of those responsible for writing the requirements for and acceptance of performance testing, and recommends an approach to achieve a good quality outcome.

Finally, this procedure provides examples of existing technical standards that may be adopted for certain situations.

The guidance presented in PMT Acceptance Criteria, resides within the context of several related documents within NMA&FM, Volume 6. In particular, reference should be made to Chapter 2 & 3 titled ‘Conduct of Maintenance’ and ‘Types of Maintenance’.

This PMT Acceptance Criteria procedure is supported by the NMA&FM, PMT Test Plans and Procedure - EOM-ZM0-PR-000008 document within this volume.

3.0 DEFINITIONS

Term	Definition
Asset/System (Installed)	The asset or system that the repair, replacement, alteration, integration or extension is being installed or attached to. Refer to Volume 2 for more information
Commissioning	Testing within the operational environment with the objective of assessing whether the integrated system achieves the desired results
Criteria (In the context of PMT Acceptance Criteria)	Established engineering parameters, where they exist, that objectively can define the acceptability of the repair, replacement, alteration, integration or extension of engineering assets.
Facilities Management Team	The team that is responsible for managing the requirements of the client, maintenance contractor, and other aspects that support the core function or business of the building, site, estate, or others

Factory Acceptance Testing (FAT)	When a plant item that has been built or configured specifically for a customer is being tested for the benefit of, and witnessed by, the customer (or their technical representative). Testing is carried out at the manufacturers' location or other test site that is not the final installation location
Hard Services	Services and plans for the management of sensitive systems related to fixed asset (e.g., air conditioning, generators, elevators, plumbing)
Integration	In the context of PMT, integration is used to describe when successful control feedback between the new and existing asset is relevant to the success of the work
PMT Acceptance Criteria procedure	Sets the objective requirements that must be applied to the specification, procurement, delivery, and conclusion of repairs, replacements, alterations, integration, or extensions to an existing engineered system with the objective of ensuring successful integration and full functionality.
PMT Level	Level of complexity of the PMT, from 'functional' check, through 'Limited' to 'Comprehensive' testing
Soft Services	Services that protect the environment and make it more luxurious and safer (e.g., cleaning, security, pest control, landscape)
Subject Matter Expert (SME)	A person who has special skills or knowledge on a particular job or topic
Statement of Requirement (SOR)	The requirement as stated by the client or their technical representative. This forms a central part of the instruction to the contractor
Testing	Testing can be functional, or performance based, and can be carried outside of or within the operational environment
Acronyms	
AHU	Air Handling Unit
ANSI	American National Standards Institute
ASTME	American Society of Tool and Manufacturing Engineers
BMS	Building Management System
BOD	Basic of Design
FM	Facilities Management/Manager
ISO	International Organization for Standardization
OEM	Original Equipment Manufacturer
UPS	Uninterrupted Power Supply
WMC	Work Management Center

Table 1: Definitions

4.0 REFERENCES

- American National Standards Institute/The International Electrical Testing Association (ANSI/NETA MTS-2019) – Standard for Maintenance Testing Specification
- International Facility Management Association, 1998-2019
- Expro Projects White Book Volume 10, Chapter 2, Section 3 – Basis of Design (BOD)
- Expro Projects White Book Volume 10, Chapter 2, Section 6.1.3.2 – (Partial) Type Testing
- National Manual for Assets & Facilities Management Volume 11 – Quality Execution
- National Manual for Assets & Facilities Management Volume 11 – Quality Assurance Audits
- National Manual for Assets & Facilities Management Volume 6 - Conduct of Maintenance
- National Manual for Assets & Facilities Management Volume 6 - Types of Maintenance
- National Manual for Assets & Facilities Management Volume 9 – Contract Management
- National Manual for Assets & Facilities Management, Volume 2, Asset Register Process - EOM-ZA0-PR-000004
- National Manual for Assets & Facilities Management, Volume 6, Formality of Maintenance Performance Procedure - EOM-ZM0-PR-000001
- National Manual for Assets & Facilities Management, Volume 7, Estimating Work Procedure - EOM-ZW0-PR-000006
- NRC Inspection Manual – Inspection Procedure 71111 Attachment 19: Post-Maintenance Testing

5.0 RESPONSIBILITIES

Responsible	Description
Entity	Refers to the government Entity, authority, or ministry responsible for the O&M works
Competent Witness	A client representative that is considered competent in the engineering area(s) required by the testing
Competent Writer	A client representative that is considered competent and knowledgeable of the specific requirements, and is responsible for drafting the SOR
Service Provider	The technical team that is considered competent and knowledgeable with the SOR and is responsible for the maintenance work. This team will likely include a suitably competent 'Test Engineer'
Work Management Center (WMC)	The office and staff where all work is screened, assessed, assigned, and communicated
Facilities Management Team	Team responsible for managing the requirement of client, maintenance contractor, and other aspects that support the core function or business of the building, site, estate, or others
Asset Management Team	Team responsible for maintaining records of the asset's condition and systems being maintained
Operations Team	The team responsible for taking on operational ownership of the repaired, replaced, altered, or extended assets or systems

Table 2: Responsibilities

6.0 PROCESS

PMT Acceptance Criteria can be applied to all engineering disciplines and types of engineering assets, systems, and components. Within the built environment, acceptance criteria can be applied to civil engineering such as, but not limited to, buildings and infrastructure assets e.g., bridges, roads, mechanical and electrical building service systems (e.g., plumbing, air conditioning), Building Management Systems (BMS), and lighting systems. Within these disciplines, acceptance criteria can be applicable to specialist systems e.g., traffic management asset, medical gas system, baggage handling equipment, intruder detection systems.

Because of the breadth of engineering discipline that this procedure applies to, and the wide range of repairs, replacements, alterations, integration and extension to assets and systems, it will not be possible in this procedure to describe its application for all eventualities. Therefore, its applicability is demonstrated by way of examples only.

6.1 Acceptance Criteria Applicability

PMT Acceptance Criteria is not always applicable. For example, PMT Acceptance Criteria may not be applicable if the repair or replacement is 'like for like', or 'equivalent', For example equipment's error that requires simple fixing as reset only. The need is reduced further if the manufacturer and model of the replacement is identical, rather than being 'nominally' the same.

While it is occasionally acceptable to make the statement in inquiries or instructions to contractor and/or manufacturer that the equipment 'operates to commonly accepted performance standards and good practice', it is better practice to make more specific technical requirements.

Setting acceptance criteria within planned, periodic maintenance that includes the replacement of consumable parts e.g., air filters in an Air Handling Unit (AHU), will depend on the details of the maintenance contract. Many AHUs have a 'pressure drop manometer' fitted across the filter section of the unit, but it may not be a requirement of the maintenance contract that the pressure drop is recorded at each air filter change. PMT Acceptance Criteria is not automatically applicable for planned, periodic maintenance. However, it is possible that requiring the pressure drop recording across an AHU air filter following a repair

to the AHU, be used as a measure to help assure that the repair has not had a detrimental effect on the performance of the Unit.

A periodic, planned maintenance includes condition monitoring where the performance of an asset or system is constantly or frequently measured in order to predict the best timing for replacing a part or consumable. Following a repair and certainly the replacement of a major part, the baseline profile is likely to fundamentally reset and, hence, the historical data is no longer accurately connected with the future readings, although historical data ought to be retained for the purposes of trend analysis.

6.1.1 Post Maintenance Testing

Certain PMT Acceptance Criteria can only be meaningfully tested following installation and are very dependent on the quality of the installation workmanship.

As far as practicable, and for complex or high impact maintenance work, it is necessary to assess the acceptability and compliance of any repair, replacement, alteration, integration, or extension to a system, holistically. For example, the creation of a meeting room may have an impact on the fire detection system, audibility of the alarms, provision of fresh air to the space, or minimum spatial requirement; all of which will carry an acceptance criterion and potentially, compliance with a statutory requirement.

Some engineered systems are affected by seasonal variations, such as facility electrical grounding systems that will perform differently depending on the moisture content of ground condition. For this reason, it is not uncommon for the ‘annual’ testing of an electrical grounding system actually occurring at an 11-months frequency so that the installation is tested ‘annually’ over a period of 12 months and over the full range of seasonal conditions. Also for this reason, it can take several years to assess the performance of installation over time. Specifying the PMT Acceptance Criteria in this example requires specialist knowledge of the electrical regulations and ‘good practice’ recommendations. Both the seasonal impact and technical requirement need to be stated in the PMT Testing Plan and Statement of Requirement (SOR).

For complex installations, such as that for a stand-by electrical generator, the PMT has necessarily been planned for time that is several months after manufacture and Factory Acceptance Testing (FAT), it may be that the equipment is out of the standard warranty period. Clarification from the manufacturer is recommended if this situation arises, on whether or not plant or equipment items are under warranty affects, who becomes responsible for rectifying the fault(s) or unacceptable performance discovered during testing.

6.2 Selection of PMT Acceptance Criteria

PMT Acceptance Criteria falls under one of the two following categories:

- Recognized engineering standards, including Basis of Design (BOD)
- Customer focused

Selecting the appropriate acceptance criteria depends on several factors. However, the criteria should be as objective as possible.

The objective nature of the PMT Acceptance Criteria means that there is a wide range of measurable parameters that can be utilized including, but not limited to voltage, current, temperature, time, pressure, pressure difference, decibels, thickness, and viscosity. Indeed, criteria can combine these parameters, such as volts per second.

6.2.1 PMT Acceptance Criteria – Recognized Engineering Standards

A variety of government or industry bodies are recognized for testing standards for a wide range of engineering systems. They do not necessarily ensure compliance with statutory requirements, but provide high quality instructions on how to test the acceptance criteria and the threshold that should be achieved. ISO, British Standard, NEC, ANSI, ASTME, and other similar non-sector specific bodies provide good quality advice.

Adoption of BOD as the testing criteria is readily available but relies on the availability of technical information from the time of construction or installation, or the modified installation. BOD states that any repair, replacement, alteration, integration, or extension must meet the design intent of the installation prior to the repair, replacement, alteration, integration, or extension. This specification is limited by the quality of the available information.

The PMT Acceptance Criteria should reflect the extent of the repair, replacement, alteration, integration, or extension to the asset or system. For example, the replacement of a major component of a chilled water system has a direct impact of the average Coefficient of Performance (COP) of the system. It should be tested on representative days throughout the year in order to confirm the claimed performance.

For example, with regard to the installation of a lifting hoist, it may be that the BOD initially tested the installation to '1.5 times the stated maximum capacity' with a maximum deflection stated. If one, two, five or similar year frequency of '1.5 times' load testing is required by good practice, statutory or contract requirements, the performance of any repair that has been carried out will need to be assessed at the time of repair work and wait for the planned, periodic testing.

6.2.2 PMT Acceptance Criteria – Customer Focused

Customer focused acceptance criteria should be technical, objective, and achievable and be based on real requirements. How testing, or confirmation of compliance is carried out, needs to be considered at the time of writing the PMT Test Plan.

It is acceptable to seek the opinion of a potential installation contractor on what the requirement is likely to be, or commonly possible performance criteria. However, checks should be made to ensure that the contractor is not creating a situation where only their product will meet the requirement.

6.3 Competency of Contractor, Writer and Witness (SME)

As discussed, the range of situations in which PMT Acceptance Criteria may or may not be applicable whether they require FAT, whether to include a customer focus, and what technical testing standards and parameters apply; varies depending on the situation. For example, the 'criticality' of the asset may promote the need for PMT. It is therefore necessary that the person making these decisions and statement of acceptance criteria are technically competent to do so. While there is no educational or industry endorsed qualification requirement, a significant level of technical knowledge, holistic familiarity, and understanding of the operational environment is required.

Dependence on a PMT Acceptance Criteria for compliance with a statutory requirement is mostly limited to specialist industries such as the health service sector and any government directive such as on energy performance and life safety systems. Alterations and extensions to existing systems are more likely to have a statutory compliance requirement. The latter may feature in leakage testing requirements for ventilation ductwork or the installed performance of a refrigerant-based system. Hence, the specifier needs to have an adequate level of legislative requirements at least such as, to initiate further research.

PMT Acceptance Criteria related to specialist sectors such as the healthcare and education are represented by documents written for such environment by Subject Matter Experts (SME). It is not unusual for the Facilities Management (FM) team to lead projects within specialist sectors, and hence need to become familiar with standards and criteria outside of those normally known to be working in the built environment FM industry. For example, depending on the involvement of operational or clinical specialist, it may become necessary for the FM team to be familiar with very specific testing standards such as 'BS EN ISO 15883-4:2018 Washer-disinfectors: Requirement and tests for washer-disinfectors employing chemical disinfection for thermolabile endoscopes'.

To ensure that PMT Acceptance Criteria is correctly set and managed, it is recommended that the person writing the SOR consults on several levels with front line staff, to technical managers, and from operational stakeholders to health and safety representatives. This approach will contribute in addressing quality assurance requirements of the company and/or good practice. It is sometimes necessary to consult with external bodies as well, including potential suppliers/contractors.

PMT is usually witnessed by the Entity client, or the Entity client's representative, and hence it is necessary that the Entity client presents a witness that is technically competent and knowledgeable of the specific project.

The recording of the SOR and PMT Test Plan, and subsequent management of these, is recommended through Work Management Center (WMC).

6.4 PMT Standard Requirements

Generally, PMT 'shall' be applicable where there is a legal, health and safety issue, or risk that needs to be managed appropriately and 'should' be followed where there is 'good practice' in terms of operations and maintenance management.

- Where PMT is required, PMT Acceptance Criteria is required
- PMT Acceptance Criteria should be objective
- Where the technical contractor, installer, and/or manufacturer is aware of additional or higher applicable testing criteria, they should bring this to the attention of the client at the earliest opportunity
- PMT Acceptance Criteria, Test Plan and Procedure should respect the relationships and dependencies of asset management, operations management, financial and performance management, supply chain management (Inventory), business reputation, and health and safety
- PMT Acceptance Criteria documents are dynamic documents and should be reviewed as part of a continuous improvement activity. This review should be done in a frequency of 2 years as good practice, unless the client or organization have specific requirement for documents of this type. This suggested period is not to exclude adoption of improvements arising from continuous improvement opportunities that arise such as those following manufacturer or industry updates
- When the quality of a repair, replacement, alteration, integration, or extension to an asset or system can be improved by specifying the Original Equipment Manufacturer (OEM) fluids and materials are used, the PMT Acceptance Criteria should state this requirement
- During the time period when replacement parts have been stored in poorly controlled environment, the PMT Acceptance Criteria should require the retesting of parts prior to delivery and/or installation
- Where the installation of equipment could potentially affect the electrical power quality, suitable testing criteria shall be required
- Where the repair, replacement, alteration, integration, or extension to an asset or system is connected to or associated with a control feedback system, a comprehensive range of tests shall be required
- PMT should be managed through a central Information Management System and/or Computerized Maintenance Management System or similar
- Where a repair, replacement, alteration, integration, or extension to a system that required an external inspector at time of construction. An external inspector is required to be consulted for criteria and requirement
- PMT Tests and Acceptance Criteria shall equate or exceed the full maintenance regime for the entire asset or system that the work has been carried out on
- Where the client has decided to relax, partially or fully remove the testing criteria, this instruction shall be made in writing following a written consultation with all stakeholders
- Where the performance of a repair, replacement, alteration, integration, or extension to a system may be affected by seasonal or cyclic variation, such as weather or occupation level, the acceptance criteria should include these variations
- PMT Acceptance Criteria should be selected to fully reflect the extent of the repair, replacement, alteration, integration, or extension to the asset or system
- PMT Acceptance Criteria should adopt internationally recognized units, or combined units, of measurement
- PMT Acceptance Criteria testing recorded values may be needed as the new Maintenance History benchmark for future planned maintenance measurements, for example, the voltage output from an Uninterrupted Power Supply (UPS) system