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Post Maintenance Testing Plan and Procedure

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1.0 PURPOSE

The aim of this Post Maintenance Testing (PMT) Test Plan and Procedure document is to ensure a successful and high quality PMT activity by following the advice outlined and by complying with the PMT Acceptance Criteria Standard.

It is therefore essential that this PMT Test Plan and Procedure document is applied appropriately and managed competently throughout.

The objective of this PMT Test Plan and Procedure document is to provide guidance on when PMT is required or recommended, and when it is of limited value. This document will assist in this decision-making process, as well as provide practical advice through examples that may prove useful in a number of situations.

This document will guide the reader in making the right decision of when PMT is required, the main aspects to address and when PMT is planned and carried out.

The PMT procedure elements of this document set out the activities required to take a repair, replacement, alteration, integration, or extension to an asset or system from the Statement of Requirement and Factory Acceptance Testing stages through the writing of the PMT Test Plan to carrying out of the PMT and Work Order Closure.

2.0 SCOPE

This document provides information and advice on the different types of testing associated with the specification, purchasing, and installation of components and sub-systems, focusing on PMT.

This PMT Test Plan and Procedure document discusses the applicability of setting a testing criteria, the inter-relationship between the different types of testing and how to select the most appropriate when specifying testing.

This document confirms the breadth of engineering situations in which the setting testing criteria may be applicable, with examples of scenarios unique to specific environments, including technical, contractual and/or sector. This guidance is applicable across varying types of contracts and operating models and can be particularly effective when applied to multi-site contracts, out-sourced delivery models, and specialist environments.

The guidance given in this document is intended for application within a hard services maintenance environment, though the principles can be applied to the soft services environment.

This PMT Test Plan and Procedure document presents advice to assist the following stakeholders to carry out their responsibilities:

- Test Witness
- Requirements Writer
- Service Provider team
- Work Management Center
- Asset Management team
- Facilities Management team
- Operations team

The advice presented herein resides within the context of several related documents within Volume 6. In particular, reference should be made to sections of Volume 6 titled ‘Conduct of Maintenance’ and ‘Types of Maintenance.’ Maintenance plans are essential to the writing and execution of maintenance procedures. Refer to Volume 7 for maintenance procedures.

This PMT Test Plan and Procedure document is supported by a PMT Acceptance Criteria - Standard.

PMT is the last of three testing opportunities for the components being installed as part of a repair, replacement, alteration, integration, or extension to an existing asset/system. Quality Assurance testing in the factory is the baseline testing that all components are tested under, before being available for purchase. Factory Acceptance Testing (FAT) is the next level up of testing. Finally, PMT, which can only be carried out when the components are installed in the system, is the last and most critical 'testing and commissioning' opportunity. The PMT Acceptance Criteria Standard sets the technical performance standard required for an installation to be called a successful installation. Some PMT can be as simple as a functional check, for example, 'does the pump work?' Other PMT may focus on specific engineering parameters.

PMT is optional and useful for many types of maintenance work, and essential for certain types of maintenance work. Appropriate use of PMT can provide confidence that the maintained asset is back fully to service rather than exposed to risk of operational disturbance following a maintenance activity.

Adoption of good quality PMT Standards, Plans and Procedures can help ensure optimized operational efficiency for the asset or system, which has a beneficial environmental impact aspect.

3.0 DEFINITIONS

A procedure is defined as a series of instructions and advice that guides the activities that need to be carried out to achieve the desired outcome. A procedure will advise on the quality, sequence, and interactions with other procedures and processes in order to achieve the desired outcome.

A plan is defined as a document that states and records the basis and requirements for any given activity or project.

This PMT Test Plan and Procedure document is defined as the collective advice that should be considered so as to ensure that the quality, sequence, and interactions of activities that are needed for the successful repair, replacement, alteration, integration, or extension to an existing engineered system are carried out in such a way as to achieve the objective of ensuring successful integration and full functionality.

A PMT Test Plan is a key component in the PMT Procedure as illustrated by the high-level flowchart in this document.

The term **'criteria'** used in the context of PMT Test Plan and Procedure refers to technical parameters, where they exist, that can objectively define the acceptability of the repair, replacement, alteration, integration, or extension of engineering assets.

Term	Definition
ANSI	American National Standards Institute
Asset/System (installed)	The system that the repair, replacement, alteration, integration, or extension is done on or attached to
ASTME	American Society of Tool and Manufacturing Engineers
BMS	Building Management System
CMMS	Computerized maintenance management system
Commissioning	Testing within the operational environment with the objective of assessing whether the integrated system achieves the desired results
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, etc
FAP	Fire Alarm Panel
FAT	Factory Acceptance Testing - When an item of plant 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, for example (air conditioning, generators, elevators, plumbing, etc.)
IBC	International Building Code
Integration	In the context of PMT, integration is used to describe when successful control feedback between the new and existing assets is relevant for the success of the work
IRL	Inclusive Repair Limit (often referred to as the 'Comp' or 'Comprehensive' limit. This is the value of repairs that are inclusive within the maintenance contract, a cost that the contractor absorbs
ISO	International Organization for Standardization
MEWP	Mobile Elevating Work Platform
MTS	Maintenance Testing Specifications
NCR	Nuclear Regulatory Commission
NEC	National Electrical Code (US)
NETA	InterNational Electrical Testing Association
NFPA	National Fire Prevention Association
OEM	Original Equipment Manufacturer
PDU	Power Distribution Unit
PMT Level	Level of complexity of the PMT, from 'Functional' check, through 'Limited' to 'Comprehensive' testing
ppm	parts per million
PRVs	Pressure relief valves
PTW	Permit to Work
QA	Quality Assurance
RAL	Reichs-Ausschuß für Lieferbedingungen und Gütesicherung. An internationally recognized system of color specification
RAMS	Risk Assessment/Method Statement
Scope of Work (SOW)	The statement by the contractor on what they will do in order to meet the requirements of the client
Soft Services	Services that protect the environment and make it more luxurious and safer, for example (cleaning, security, pest control, landscape, etc.)
SOP/EOPs	Standard Operating Procedures/Emergency Operating Procedures
Statement of Requirement (SOR)	The requirements as stated by the client or their technical representative. This forms a central part of the instruction to the contractor
Subject Matter Expert (SME)	A person who has special skills or knowledge on a particular job or topic
Testing	Testing can be functional, or performance based, and can be carried out outside of or within the operational environment
UPS	Uninterruptible Power Supply

4.0 REFERENCES

- National Manual for Assets & Facilities Management – Volume 2: Asset Management
- National Manual for Assets & Facilities Management – Volume 6: Maintenance Management
- National Manual for Assets & Facilities Management – Volume 7: Work Control
- National Manual for Assets & Facilities Management – Volume 9: Contracts Management
- Expro Projects White Book - Volume 10

5.0 RESPONSIBILITIES

- **Witness** – a representative that is considered competent in the engineering area(s) required by the testing
- **Requirements Writer** – a client representative that is considered competent and knowledgeable of the specific requirements and is responsible for drafting the Statement of Requirement (SOR)
- **Service Provider** – the technical team is considered competent and knowledgeable of the SOR and is responsible for the maintenance work. This team will likely include a suitably competent 'Test Engineer'
- **Work Management Center** – the office and staff where all work is screened, assessed, assigned, and communicated
- **Facilities Management team** – 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, etc.
- **Asset Management team** – responsible for maintaining the record of condition of the assets and systems being maintained, financially orientated
- **Operations team** – the team who will take on operational ownership of the repaired, replaced, altered, or extended asset or system

6.0 PROCESS

6.1 Test Plans and Procedure

PMT Test Plans and Procedure can be applied to all engineering disciplines and types of engineering assets, systems, and components.

The motivation for this PMT Test Plan and Procedure document is to help ensure, through a holistic understanding of the risks and complexity of some maintenance work, the repair, replacement, alteration, integration, or extension to an asset or system is successful and goes according to plan. For example, the successful replacement of an air conditioning condenser unit that is part of a BMS controlled climate control system can only be confirmed when the full and successful integration with the BMS is confirmed by comprehensive testing; it is not enough for the condenser to simply provide cooling in manual (or hand) mode.

In a facilities management office, it is not uncommon for the specification of a repair to be poorly written. This document will reinforce the importance of correctly specifying work. Whilst it is occasionally acceptable to communicate to contractors and/or manufacturers that the equipment 'operates to commonly accepted performance standards and good practice,' it is a better practice to make more specific technical requirements.

6.1.1 Testing Timing Options.

Testing of equipment that is to be installed as part of a repair, replacement, alteration, integration, or extension to an installed asset/system can be carried at various stages of manufacture, pre-installation, and post-installation.

- Testing at the time of manufacture only, i.e., 'Quality Assurance testing' (QA testing)
- Testing post manufacture for a client, i.e., 'Factory Acceptance Testing' (FAT)
- Testing at the time of post-installation, i.e., 'Post Maintenance Testing' (PMT)

Testing of newly-manufactured equipment in the factory is usually carried out as part of the manufacturer's QA management. It is recommended that suppliers of all equipment are compliant and/or are registered members of Quality Assurance authorities, institutions, and processes.

The term 'Factory Acceptance Testing' is used when an item of equipment 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). Any risk of failure at the time of installation can be reduced by the FAT being designed to test the operating conditions as close as possible to that of the installed arrangement.

Testing at the time of manufacture and FAT are, therefore, not Post Maintenance Testing but are mentioned here for completeness. The decision on how much testing is necessary can be attributed to risk management.

6.1.2 QA Testing

Certain types of components need only be tested in the factory at the time of manufacture and with no specific client in mind. Such components and equipment need not be tested until the next planned maintenance or, if applicable, following the maintenance work. An example is pressure relief valves (PRVs), which are factory set, tested, and certified for safety and insurance purposes. Assuming the valves have been delivered undamaged and been installed in accordance with the manufacturer's instructions and advice, PRVs usually then only require periodic testing once installed as part of a planned maintenance program. It is important to reset the timer on the periodic testing as this is likely to be different from that of the valve that was replaced.

A high degree of certainty of a good quality repair of a complex engineered system can be achieved without the need for PMT. For example, the hydraulic oil in an elevator or mobile elevating work platform (MEWP) hydraulic system, or the brake fluid in fleet vehicles, can be specified within the maintenance contract in general terms and conditions or the statement of requirement instructions as 'OEM only' or 'manufacturer approved.' These types of situations present the opportunity to ensure a high quality maintenance activity without the need to test but are partly reliant on installation 'according to manufacturer's instructions, guidelines, and advice.' These opportunities are limited to certain simple maintenance tasks that are well within the skillset of the maintenance operatives.

If a higher level of testing is required on a pressurized hydraulic system, a maximum leakage rate under certain load conditions can be the acceptance criteria. This type of test will provide a check on workmanship and quality of materials, for example, the effectiveness of the installation of new oil seals. This level of testing would be categorized as 'Limited.'

Another example when testing at the time of manufacture is the only realistic quality check related to uninterruptible power supply (UPS) battery cells. However, a project for the partial replacement of battery cells within a UPS could require FAT under a simulated load condition in an effort to increase confidence that they will perform as intended when installed; it would not normally be possible to test part of a UPS in the installation stage.

6.1.3 QA Testing with Factory Acceptance Testing (FAT)

One advantage of FAT is that the discovery of any fault happens before the new equipment is installed. The effort and impact of installation, as well as any consequential damage to the installed system, is avoided. The risk of failure and/or impact on the installed system and the operations of the facility need to be considered when deciding whether to pursue FAT as a testing strategy. Usually, the more complex the equipment and the more critical the facility, the stronger the recommendation for FAT and PMT. For example, installing UPS batteries without FAT, only to discover the batteries do not perform as expected, results in the UPS system within the building having to be isolated again, presenting an operations risk. There are also likely to be cost implications and, potentially, claims dispute between the contractor and client.

FAT can be limited in effectiveness because the new equipment is not connected to a live system and hence, the various operational situations that can be presented are limited by the set-up of the factory testing plan. An example of when FAT is likely to be too limited to be of value is the testing of a diesel generator which will be connected to a UPS, cooling system, fuel management system, fire detection/protection systems, and potentially extensive and complex electrical load. One function that can only be tested when connected to the facility systems is the successful initiation of the starting of the generator from the command signal and taking on the electrical load, an aspect that may be particularly at risk from communication between electronic control systems of differing design and complexity. Note also

that FAT is only a 'snapshot' of the operation of the tested equipment on the day of testing. For these reasons, FAT alone can be of limited value.

A successful FAT may not guarantee acceptable performance once the new equipment is installed because damage has occurred on route to the facility. Damage can be visible or invisible. For example, UPS batteries can have their performance compromised if they are not stored correctly as high ambient temperatures can reduce their performance. Dust can be another damaging factor and hence, storage and transportation need to be suitable if the performance of the new equipment is to be maintained at the level indicated by the FAT.

Vibration during transport also presents risk of damage, which can be difficult to locate in electronic equipment. Discovery of faults that were not present at factory testing time but are apparent at installation time is a risk to schedule for reinstatement of the system. Depending on the complexity of the components, the risks present since the time of manufacture or FAT, it may therefore be necessary to carry out a sample of checks of the delivered components prior to connection to the installed system.

6.1.4 QA Testing, Factory Acceptance Testing (FAT) with PMT

Combining QA testing, FAT, and Post Maintenance Testing is the most thorough approach to testing designed to ensure a successful repair and integration.

The expression 'testing and commissioning' is sometimes used instead of PMT, though the 'testing and commissioning' expression is more commonly and correctly used when referring to the 'first' installation of an asset or system. This normally occurs at the time of construction or the installation of a 'new', i.e., not a replacement asset or system. 'PMT' is correctly used 'post maintenance.'

Certain acceptance criteria can only be meaningfully tested following installation and/or are very dependent on the quality of the installation workmanship. In these situations, FAT is not applicable. For example, the creation of a meeting room by the construction of internal walls and doors may warrant testing for acoustic isolation if the new meeting room is located adjacent to either a noisy or quiet environment. Specifying the acoustic attenuation of the constructed enclosure is recommended at the time of writing the statement of requirement but can only be tested once the construction is complete. The decision to carry out testing may warrant waiting until the construction is complete and hence needs to be included in the statement of requirement and scheduled in the scope of work for the construction project.

Whenever possible, and for complex or high impact maintenance work, it is highly recommended to view 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, or provision of fresh air to the space, all of which will carry an acceptance criterion and possibly compliance with a statutory requirement. Testing for this type of projects falls into the 'comprehensive' category because the testing crosses over engineering disciplines and system types. Since acoustic testing requires specialist equipment and follows well-defined methods, it is recommended that acoustic experts experienced in the measurement of sound are engaged if there is doubt or dissatisfaction in a project with an acoustic acceptance criterion.

Replacement or additional Power Distribution Units (PDUs) installed in a data center can only be tested for acceptance when connected to the installed electrical system. Harmonics is unintentional feedback from electrical equipment to the power supply lines. Harmonics in an electrical system need to fall within an acceptable tolerance, which is unique to each installation and hence cannot be measured until the new equipment is installed. There are industry accepted methods for the testing for harmonics, but the setting of the criteria needs to be done considering the site-specific standards and harmonics level created by the existing equipment. Testing for this type of projects falls in to the 'comprehensive' category because the testing is on secondary or associated electrical equipment, and not only the electrical equipment that was the primary focus of the scope.

This contrasts with a pulley replacement within an elevator as this will likely affect the floor positioning sensors causing the lift carriage to not come to a rest within acceptable tolerance. The resting level of the lift car at each floor should be tested in both the ascending and descending travel direction to ensure adjustment is made as necessary. Other testing will ensure that the repair has not impacted the safety features of the lift. Testing for this level of maintenance falls into the 'comprehensive' category because the testing covers more than the replaced component alone and crosses system types and operating modes.

Post maintenance testing may be classified as 'comprehensive' for other reasons. For example, testing of a fire detection system following the replacement of the FAP (fire alarm panel) may require the witnessing by a fire official or a representative of an insurance company. The technical testing of this type of system may also be extensive because of the requirements from the planned maintenance regime. For example, if the fire protection system planned maintenance has an annual test that confirms the correct releasing of 'Hold Open' corridor fire doors and closing of fire shutters and ductwork dampers, it is recommended that this full range of testing be carried out at the time of installation in an effort to ensure the safety of the facilities as well so that the contractor will not want to return to site at the time of the annual maintenance, should a fault be discovered. In this example, compliance with the Test Plan and Acceptance Criteria requires external involvement and a prolonged testing period. For these reasons, this testing would be classified as 'Comprehensive.'

Some engineered assets that are static in nature can also only be tested when installed following repair or replacement. Guy ropes that restrain masts or architectural elements can be tested for tension following replacement, alteration or integration by means of measuring the thickness of the restraining rod or cable. In this example, 'repair' is uncommon and not recommended. Note that this approach is sensitive to errors caused by surface corrosion or erosion. With the restraining cables removed, the securing points can be tested with a strain gauge with the criterion being 'no visible disturbance' to the anchoring point. In-situ cable thickness measurement is also applicable to planned maintenance checks, in particular on elevators motivated by cables. Reference can be made to the cable manufacturer on the acceptance criteria because they will be motivated, and likely have laboratory 'strain testing' data, that indicates an elevated risk of failure.

Some engineered systems are affected by seasonal variations, such as facility electrical grounding systems that will perform differently depending on the moisture content of the ground. The specifying of the PMT in this instance requires specialist knowledge of the criterion and testing will have to be deferred to meet the seasonal conditions. Both aspects need to be stated in the statement of requirement and PMT test plan.

Reinstating of a system to operational service following the repair, replacement, alteration, integration, or extension to a major part needs to be carried out in accordance with the manufacturer's requirements and the installer's method statement. For example, if there has been a change to the system design, the start-up procedure may need to be different from that advised at the time of the original construction.

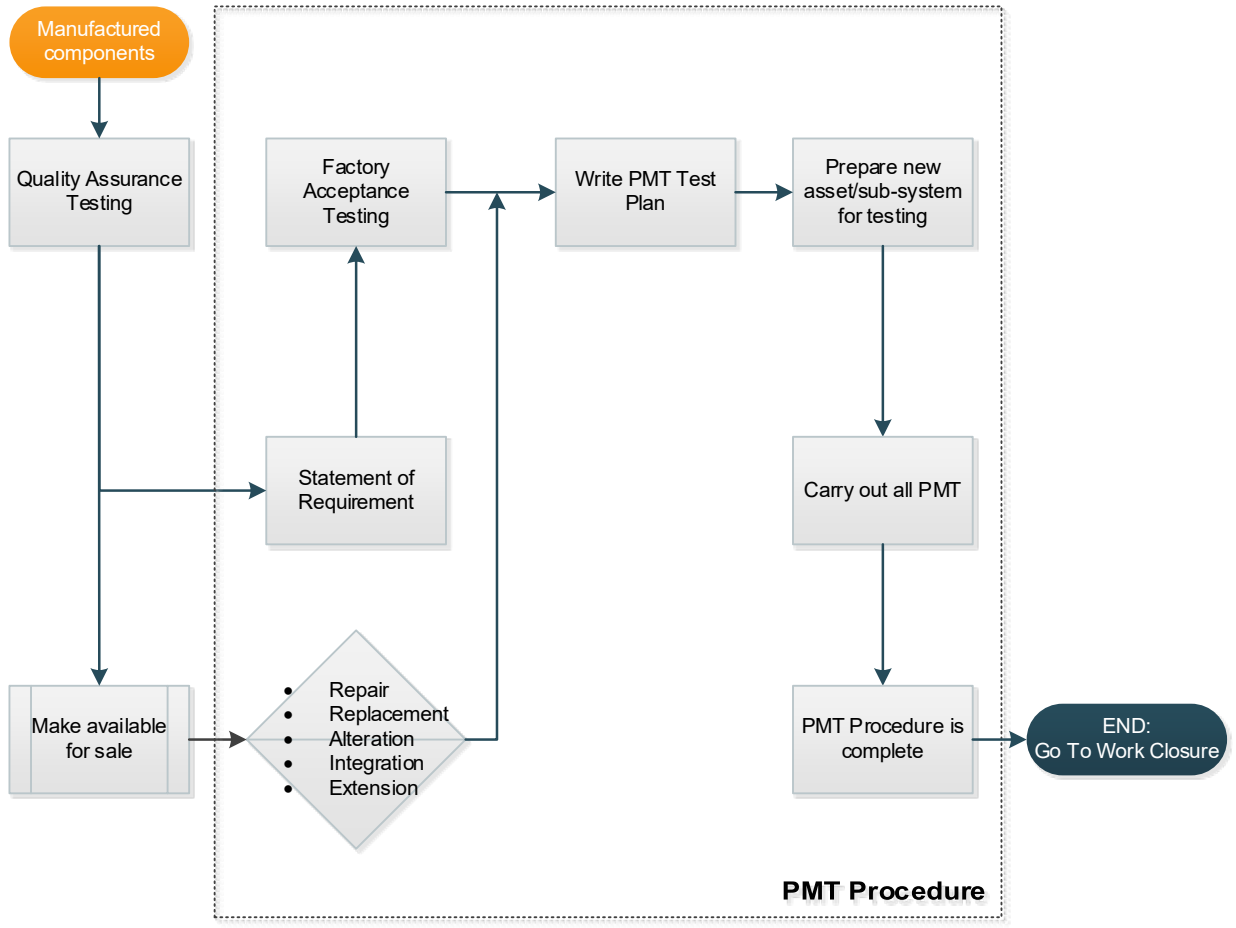


Figure 1 **High level PMT procedure flowchart**

Above is a high-level flowchart showing the possible routes and types of testing that a component or asset may undergo depending on the complexity of the repair, replacement, alteration, integration, or extension to an asset or system.

The improvement to the asset/system following the repair, replacement, alteration, integration, or extension to an asset or system is recommended to be reported to the asset management team so that they can reset any condition-based statement or benchmark in their registers, most likely the life cycle replacement plan.

Repair, replacement, integration, alteration, or extension to any asset or system should follow 'Change Control' requirements of the organization so that the quality of information held is maintained at the acceptable level.

6.2 Selection of PMT Level.

PMT Level falls into one of three categories:

1. Functional
2. Limited
3. Comprehensive

The levels are intended to guide those involved in PMT in their decision making and document preparation by acknowledging that testing needs to be appropriate to the complexity and risks of the technical and operational aspects of the work.

Examples of work in each category are given in this document.

A maintenance effort could have a combination of PMT Levels. Considering the repaired or replacement door example, the carpentry workmanship standard could be defined by the gap dimensions between the door and the frame – a one-dimensional functional criterion. The criterion related to the door closure rate, which is partly contributed to by the closer selection, fitment and setting could be considered 'limited.' The criteria related to the acoustic isolating performance of the door is more complex and could be described as comprehensive because the factors affecting success are not solely related to the door material and carpentry workmanship.

The decision for the requirement of testing and the setting of criteria does not always reside with the facilities management team. For example, if a contractor is installing replacement batteries to a data center UPS, it may be the contractor that insists that the integrated installation is tested to an internationally recognized standard if there is a concern that any unplanned outage of power could bring financial penalty to the contractor, damage to their reputation, or credibility to win future work. In this situation, testing is acting as an insurance against potential litigation or damage to reputation. Similarly, if a domestic water storage tank has been out of service for some time, the decision to test the water quality following repair, replacement, alteration, integration, or extension may be influenced by a Legionella risk assessment. Bacterial analysis of water requires the incubation of the growth of spores, which takes several days and is usually carried out by a specialist. This is an example where the PMT cannot be completed within one day.

6.3 Testing Level and Acceptance Criteria.

PMT has different levels of complexity depending on the situation. For example, if the replacement door closer make and model is the same as the other door closers in the building and is being fitted to the same door type as the others, there seems little need to test the resistance experienced when operating the door. A simple 'functional' level test is adequate.

The decision to carry out PMT to a specific standard, to 'good practice,' or in a manner that is considered logical and appropriate will depend on several factors, mainly the complexity and risks associated with the maintenance work.

6.3.1 Functional testing.

Advanced PMT is not always applicable.

PMT Acceptance Criteria are not applicable for simple work or work that presents a low risk of impact to either the occupants, processes, or adjacent engineered assets/systems. Acceptance in these circumstances could be as simple as checking that a door handle operates, or hot water comes out of the faucet. It would only be necessary to require that the work is carried out to a good standard of workmanship including, for example, the location is left clean, tidy and all debris and packaging have been removed. Often the customer paying for the work does not see the finished job and signs off the Work Order without question. Depending on the quality assurance requirements of the contract, it may be enough that a selection of Work Orders are periodically audited as the means of checking the successful completion of repair work, especially if a site visit is part of the auditing process. Other simple checking mechanisms include periodic customer satisfaction surveys and 'customer signature' on reactive Work Orders.

6.3.2 Limited testing.

However, referring to the door example, if the door is operated by people of infirm mobility, children or those having other limited strength such as in a healthcare environment, and/or the door closer model or the door is materially different from others installed elsewhere in the facility, it is recommended to specify a maximum opening effort when writing the statement of requirement, raising the Work Order, etc. Typically, 40 Newtons is a requirement under mobility-impaired guideline measures before a door needs to be power-assisted. A door closing time may also be relevant. This level of testing is classified as 'Limited.'

Even for a more complex item of equipment, such as a cooling system chilled water storage buffer vessel, or domestic hot water storage vessel, if the repair or replacement is 'like for like,' there may be no need to test the duration/capacity or recovery/response times that the vessel can perform to. The need is reduced

further if the manufacturer and model of the replacement are identical, rather than being 'nominally' the same.

6.3.3 Comprehensive testing.

Specifying a door operation acceptance criteria requirement will be relevant to door repairs, replacement, alteration, or integration for doors that form part of the fire and smoke management strategy. For example, a 'Hold Open' door must close in the required manner to the required signal from the fire detection system. This type of repair, replacement, alteration, integration, or extension is more complex because the testing criteria go beyond the door's primary function of opening and closing and now involve checking that no consequential compromises have been made. The Hold Open device, and it is an acceptable attachment to the new door, can only be tested by operating a separate system, in this example the fire control system. This type of testing is classified as 'Comprehensive.'

PMT requiring a comprehensive test should consider inclusion of manufacturer testing advice and will likely benefit from having the testing carried out by an experienced testing and commissioning engineer.

6.4 Selection of PMT Acceptance Criteria.

PMT Acceptance Criteria fall into one of two categories:

1. Recognized Engineering Standards, including Basis of Design (BOD)
2. Customer-focused

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

The objective nature of PMT Acceptance Criteria means that there is a wide range of measurable parameters that can be utilized: voltage, current, temperature, time, pressure, pressure difference, decibels, thickness, viscosity, etc. These acceptance criteria can be described as 'single parameter' criteria. 'Multiple parameter' criteria can also be specified, such as 'voltage drop per hour.'

Whilst there are usually recognized engineering standards criteria that can be adopted or adapted to describe a successful installation, it is sometimes necessary to create a custom engineering criterion or customer-focused criteria. For true PMT Acceptance Criteria, the criteria requirements should be objective in nature, not subjective.

Wherever possible, it is recommended that recognized engineering standards or BOD is adopted, though it is acceptable to supplement these criteria with customer-focused criteria as appropriate.

The following is a brief list of suggested aspects of engineered systems that may have a criterion applied to reduce the risk of failure or issues with the acceptability of a repair, replacement, alteration, integration, or extension to an asset or system.

- **Electrical:** harmonics, UPS performance, etc.
- **Mechanical:** vibration, capacity, etc.
- **Plumbing:** recovery time, flow, etc.
- **Construction:** finish, tolerances, etc.
- **Civil:** undulations, gradients, etc.
- **Life Safety:** audibility, sensitivity, time performance, etc.
- **Control:** fail safe response, correct 'system gain' and 'valve/damper authority,' etc.

6.4.1 PMT Acceptance Criteria – recognized engineering standards.

There are many government or industry body recognized testing standards for a wide range of engineering systems which, though not necessarily providing a compliance with a statutory requirement, do provide high quality instruction on how to test, the acceptance criteria and the thresholds that should be achieved.

International Organization for Standardization (ISO), British Standards, National Electrical Code (NEC), American National Standards Institute (ANSI), American Society of Tool and Manufacturing Engineers (ASTME), and other similar non-sector specific bodies provide good quality advice.

Adoption of BOD as the testing criterion provides a readily available standard but which relies on the availability of technical information from the time of construction or installation, or the modified installation. 'Basis of Design' is essentially stating that any repair, replacement, alteration, integration, or extension must meet the design intent of the original installation. This specification is limited by the quality of the available information.

6.4.2 PMT Acceptance Criteria – customer focused.

Customer-focused acceptance criteria should be technical, objective, and achievable and be based on real requirements. The aim of setting any acceptance criteria is to ensure a successful and high-quality repair, replacement, alteration, integration, or extension is achieved. It is possible that these requirements are subjective, though still technically critical to operation. For example, a repaired X-ray system in an airport shows the quality of image required for security operator/guard. Another example, 'the hot water storage calorifier needs to provide showering for 10 people every hour for two continuous hours.' Customer-focused criteria should also be accompanied with the test plan. There is a danger that these customer-focused criteria are unreasonable or greater than the existing installation and hence, care needs to be taken when writing these requirements. When writing the SOR the Writer must declare the required results from the testing in order to pass.

It is acceptable to seek the opinion of a potential installation contractor on what is the likely required, or commonly possible, performance criteria, though this needs to be done at an early stage. Requesting criteria advice from one or more of the potential installers is sometimes necessary for specialist systems, for example sullage treatment plant.

6.5 Procedure deviation from the PMT requirements.

In the example of creation of a meeting room, the value of the testing may be reviewed following a subjective assessment of the acoustic performance of the constructed structure. The sound isolation between the spaces may be considered acceptable following a subjective assessment by the key stakeholders, removing the need for objective testing.

Sometimes in-situ 'testing to best industry practices' can be difficult and expensive to carry out with limited benefit. An example of this is the replacement of an internal lighting system where the illuminance criteria is specified but can only be confirmed by measurement in the absence of daylight and internal obstructions. The specifier may consider if there is value in carrying out an illuminance measurement survey at nighttime or whether a computer simulation is acceptable proof of compliance. This scenario can apply to both internal and external lighting upgrades. Although there are industry-recognized lighting surveying methods, if a lighting survey is required, it may be sufficient to carry out a number of spot checks of illuminance values, in particular in areas where they are or perceived to be at low levels, to the satisfaction of the client and occupant stakeholders. Measurement becomes more complicated, and requires specialist equipment, if criteria other than 'horizontal planar illuminance' are to be measured and differences between the assumptions built into the computed illuminance and the actual environment are to be resolved.

6.6 Procedural relationships between stakeholders.

To help ensure that PMT plan and acceptance criteria are correct and appropriate, it is recommended that the person writing the statement of requirement consults widely, from front line staff to technical managers, and from operational stakeholders to health and safety representatives. This approach will contribute to addressing quality assurance requirements of the company and/or good practice. It is sometimes necessary to consult with external bodies, for example, the fire officer or potential suppliers/contractors.

PMT is usually witnessed by the client, or the client's representative and hence, the client needs to be familiar with the requirements, testing procedure, acceptance criteria, and thresholds in order to be able to sign an acceptance statement with authority and justification.

When on-site testing and commissioning is being carried out, it is recommended that the operations and maintenance staff attend. This is for their familiarization with the new equipment and their input to questions and challenges to the installers.

Setting the PMT Level can have a direct impact on who funds the repair, replacement, alteration, integration, or extension to the asset or system. If the cost of testing, combined with the cost of the parts and labor, exceeds the Inclusive Repair Limit (IRL), it is common practice that the client is responsible for work that exceeds the IRL.

6.7 PMT Test Plan and Procedure Quality Management.

Generally, PMT 'shall' be applicable where there is a legal, including environmental or performance requirements; or 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. The PMT standards document should be referred to.

The **PMT Test Plan Checklists** should be addressed as a minimum level of ensuring the quality of the PMT.

The requirements of the original 'Testing and Commissioning' procedures could form part of PMT, though may be overly complex for a simpler repair, replacement, integration, alteration, or extension.

A PMT Plan should respect the stakeholder relationships and dependencies with asset management, operations management, financial and performance management, supply chain management (inventory), business reputation, and Health and Safety.

The use of PMT Plan and Procedure needs to be effective and applicable; therefore, as stated in the PMT standards, must be written by a knowledgeable and technically competent requirements writer within an effective quality assured environment.

This PMT Plan and Procedure guidance presents the requirements writer with the opportunity to adopt the latest best practices in procuring services for the repair, replacement, alteration, integration, or extension to an asset or system.

PMT Plan and Procedure documents are dynamic documents and should be reviewed as part of a continuous improvement activity. This review should be in a frequency of 2 years as good practice, unless the client or organization has specific requirements for documents of this type. This suggested period is not to exclude adoption of improvements arising from continuous improvement opportunities that arise.

PMT Plan and Procedure documents should be managed through an information management system or Computerized Maintenance Management System (CMMS) such that all the stakeholders have access to the documents.

6.8 Application to soft services, non-engineering trades and planned maintenance.

PMT Acceptance Criteria is not particularly applicable to soft services as there is rarely any testing associated with soft services activities. Advice on cleaning standards is given in the janitorial sections of this guide and should be referred to as necessary.

Paint colors can be specified by a Reichs-Ausschuß für Lieferbedingungen und Gütesicherung (RAL) identifier. There are specific colors required for several engineering services; for example, in the UK, pipework conveying specific fluids must be painted a specific color. The painting of pipework is likely to fall on the engineering hard services provider and not the soft services provider.

Related to the quality of painting workmanship, adhesion of paint to a surface can be tested by an adhesion (or peel) test; although the assessment is somewhat subjective, the method is prescribed and repeatable.

Industrial coatings are more widely and thoroughly regulated in terms of quality of workmanship and would normally only feature in facilities management if painting repairs were being made to architectural features or industrial assets where the original coating had been applied in a factory environment to a specific standard. Achieving compliance for repainting work to specific standards designed for manufacturing quality control standards on aged metal surfaces may not be possible.

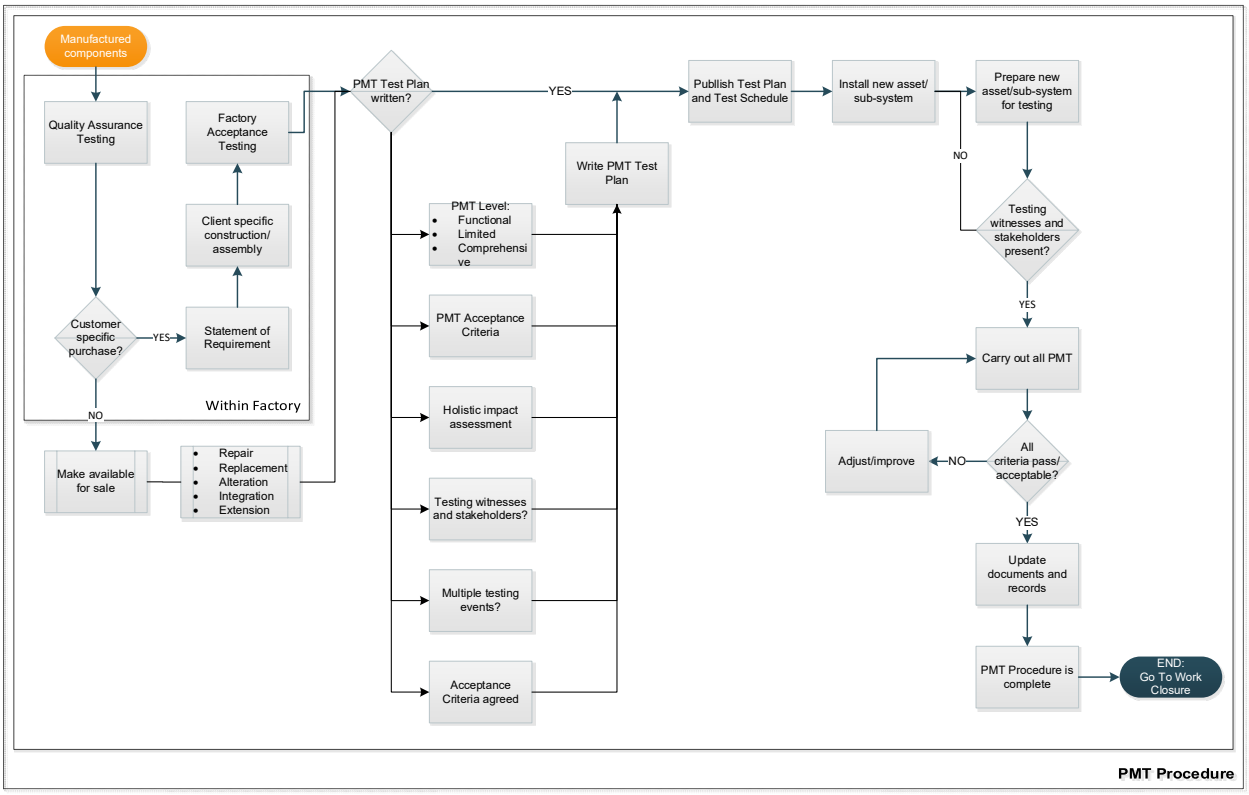
PMT may be applicable to certain planned maintenance activities. It is usual that planned maintenance contracts do not specify the technical performance of a system following replacement of a consumable item, such as an air handling unit air filter. Replacement of air filters, for example, is normally contractually required on a time-based frequency, not a pressure drop criteria. Normally, it is only when the client becomes responsible for the cost of a repair that the opportunity for setting a PMT Acceptance Criteria presents itself. PMT Acceptance Criteria comes into focus for planned maintenance when a predictive maintenance model is engaged.

7.0 ATTACHMENTS

Attachment 1- PMT Test Plan and Procedure Flow Chart
Attachment 2- EOM-ZM0-TP-000002- Post Maintenance Testing Template

Attachment 1- PMT Test Plan and Procedure Flow Chart

PMT Test Plan and Procedure flowchart



Attachment 2- EOM-ZM0-TP-000002- Post Maintenance Testing Template

PMT Test Plan checklists

- Pre-Test Plan writing checklist
- Test Plan writing checklist

These templates are intended to prompt the writer of the PMT Test Plan to consider the technical and non-technical resource and requirements perspective, including compliance, quality assurance, financial, information management, operational, stakeholder involvement, logistical, etc.

These templates should be altered to reflect the complexity of the writer's organizational environment and the particular PMT requirements.

PROJECT NAME:		ASSET ID:		REV.		
No.	**Test Plan headings**	**Statement**	**Detail**	**Writer check**		
				N/A	**YES**	**NO**
1.0	**PMT Pre-Test Plan writing checklist**					
1.1	Statement of Requirement (SOR).	• Not Applicable		☐	☐	☐
		• Agreed by stakeholders?		☐	☐	☐
		• Project approved?		☐	☐	☐
1.2	Factory Acceptance Testing (FAT).	• Not Applicable		☐	☐	☐
		• Testing criteria agreed?		☐	☐	☐
		• Test witnesses agreed?		☐	☐	☐
1.3	PMT Level.	• Functional		☐	☐	☐
		• Limited		☐	☐	☐
		• Comprehensive		☐	☐	☐
1.4	PMT Acceptance Criteria Category.	• Single parameter	Location, method, values	☐	☐	☐
		• Multiple parameter	Location, method, values	☐	☐	☐
		• Others, e.g., extreme	Location, method, values	☐	☐	☐
1.5	Holistic impact assessment.	• Repaired asset/system only		☐	☐	☐
		• Adjacent assets/systems	Drawings and diagrams	☐	☐	☐
		• Integrated systems		☐	☐	☐
1.6	Testing witnesses and stakeholders?	• None	Agreement to forward on report(s)	☐	☐	☐
		• External, specialists, etc.		☐	☐	☐
		• Internal, O&M, non-technical, etc.		☐	☐	☐
1.7	Multiple testing events?	• Duration cause?		☐	☐	☐

PROJECT NAME:		ASSET ID:		REV.		
		• Seasonal cause?		☐	☐	☐
		• Other causes?		☐	☐	☐
1.8	Acceptance Criteria agreed?	•		☐	☐	☐
		•		☐	☐	☐
		•		☐	☐	☐

No.	Reviewer's Comments	Resolution

Originator's Name/Signature and Date:	Checker's Name/Signature and Date:

PROJECT NAME:		ASSET ID:		REV.		
No.	**Test Plan headings**	**Statement**	**Detail**	**Writer check**		
				N/A	**YES**	**NO**
2.0	**PMT Test Plan writing checklist**					
2.1	Install new asset/ sub-system.	• Work Order number		☐	☐	☐
		• Pre-requisites, permissions	Risk Assessment/Method Statement (RAMS), Permit to Work (PTW), outage, access, overtime	☐	☐	☐
		• As Plan?	Risk and impact?	☐	☐	☐
2.2	Prepare testing.	• Test procedure	Calibrated tools	☐	☐	☐
		• Temporary equipment and modifications	Loads banks, utility supplies	☐	☐	☐
		• Isolations, mitigations, etc.		☐	☐	☐
2.3	Testing witnesses and stakeholders present?	• None	Agreement to forward on report(s)	☐	☐	☐
		• External, specialists, etc.		☐	☐	☐
		• Internal, O&M, non-technical, etc.		☐	☐	☐
2.4	Carry out PMT.	• No deviation(s)		☐	☐	☐
		• Minor deviation(s)	Assess impact	☐	☐	☐
		• Major deviation(s)	Consider retest	☐	☐	☐

PROJECT NAME:		ASSET ID:		REV.		
2.5	All criteria pass/acceptable?	• All fail	Root Cause Analysis. Cost.	☐	☐	☐
		• Minor fails	Conditional handover? Resolution timescale.	☐	☐	☐
		• Major fails	Investigation. Reschedule.	☐	☐	☐
2.6	Reduce/relax Acceptance Criteria	• Not permitted	Consequences	☐	☐	☐
		• Expected	Acceptable compromises	☐	☐	☐
		• Unexpected	Decision maker, escalation	☐	☐	☐
2.7	Maintenance requirements changed?	• No change		☐	☐	☐
		• Minor	Consumables, tasks, frequencies	☐	☐	☐
		• Major	Contract amendment, resources, skillsets	☐	☐	☐
2.8	Operations requirements changed?	• No change		☐	☐	☐
		• Minor	Training	☐	☐	☐
		• Major	New SOP/EOPs and training	☐	☐	☐
2.9	Document and records updating.	• Asset Register and Asset Management		☐	☐	☐
		• Manuals and drawings	Integrated into 'site' drawings	☐	☐	☐
		• Warranty	Managed through CMMS	☐	☐	☐

No.	Reviewer's Comments	Resolution

Originator's Name/Signature and Date:	Checker's Name/Signature and Date: