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Maintenance History Procedure

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1.0 PURPOSE

The purpose of this procedure is to guide the Entity client and maintenance contractor on how to build an effective database of maintenance history with the objective of improving decision making, asset behavior tracking and analysis, and compliance.

This procedure will also demonstrate the importance of keeping records and identify the potential benefits of aggregating equipment-related data to support the operational service life as well as help facilitate the replacement of equipment.

2.0 SCOPE

This procedure provides stakeholders with a methodology for identifying, gathering, storing and using Maintenance History.

This procedure recognizes that Maintenance History is relevant throughout the serviceable life of an asset, sub-system or system, from handover at the time of original construction or major rehabilitation to replacement arising from technological upgrade or expired service life. During this period, the maintenance history will be gathered from planned and unplanned maintenance activities.

The use of this procedure should complement and uphold the information outlined in the following related documents featured within other volumes of the National Manual of Facilities and Asset Management (NMA&FM):

- Asset Management and Condition Assessment
- Financial Planning
- Facility Surveillances
- Preventative and Predictive Maintenance Program
- Maintenance Management
- Equipment Troubleshooting
- Estimating Work
- Post Maintenance Testing
- Work Closeout
- Contracts Management

The information presented herein should be considered the minimum standard for Best Practice and may be adapted to meet the particular needs of an Entity, sector, contract or site. Implementation of this procedure will contribute to ensuring that the maintenance contract is operating and managed to good technical and operational standards.

The guidance provided herein is applicable across all sectors, various types of contracts, and planned maintenance operating models including multisite contracts, in-house and outsourced delivery models, and specialist environments.

It should be remembered that maintenance history data from unplanned maintenance activities resides within the scope of maintenance history management.

3.0 DEFINITIONS

Term	Definition
Corrective Maintenance	Refer to Volume 6 – Types of Maintenance
Information Management System	Commonly refers to an electronic file management and sharing system accessed from personal computers.
Infratech	The deployment or integration of digital technologies with physical infrastructure to deliver efficient, connected, resilient and agile assets
Intelligent Maintenance	Maintenance system that utilizes the assets' historical collected data in order to optimize the maintenance operations between planned and unplanned activities (data-driven approach).
Maintenance History	The aggregation of information, which may include technical and non-technical metrics, sufficient to form an understanding of an asset, subsystem or system over time
Maintenance Type	Refer to Volume 6 – Types of Maintenance
Maintenance Philosophy	A mix of strategies that ensure assets, subsystems, and systems operate as expected and when needed
Metric	An objective technical or non-technical measurement; for example (technical) temperature, voltage, (non-technical) cost, time
Planned Maintenance	Planned maintenance has two subcategories: preventative and predictive; Refer to Volume 6 – Types of Maintenance.
Predictive Maintenance	Refer to Volume 6 – Types of Maintenance
Preventative Maintenance	Refer to Volume 6 – Types of Maintenance
Success Factor	An element that is necessary for an organization or project to achieve its mission
Unplanned Maintenance	Refer to Volume 6 – Types of Maintenance. Has three subcategories: corrective, run to failure and emergency
Acronyms	
AMS	Asset Management System – a dedicated software application used to record and track an asset throughout its life cycle, from procurement to disposal
BMS	Building Management System
CMMS	Computerized Maintenance Management System
IMS	Information Management System
KPI	Key Performance Indicator
OEM	Original Equipment Manufacturer
OOH	Out of Hours
PDA	Personal Digital Assistant
RTF	Run-to-Failure; Refer to Volume 6 – Types of Maintenance
WMC	Work Management Center
WO	Work Order

4.0 REFERENCES

- 2015 International Facilities Management Association (IFMA), Facilities Management Professional (FMP), Chapter 3
- International Standards Organization ISO 55001 Asset management – Management Systems
- International Standards Organization ISO 41001 Facility management – Management Systems
- International Standards Organization ISO 14224 Petroleum, petrochemical and natural gas industries – Collection and exchange of reliability and maintenance data for equipment

5.0 RESPONSIBILITIES

Key personnel involved in this procedure are given here:

Role	Description
Entity Client	A senior manager responsible for delivering cost-effective, contract-compliant facilities management. This person is knowledgeable and competent in the technical and contractual aspects of the maintenance contract and senior enough to provide awareness to the most senior level of management within the client organization.
Maintenance Contractor	Responsible for identification of the types, sources, and methods used for gathering and managing the appropriate maintenance history, and for using this information to the benefit of the maintenance contract.
Work Management Center	Team/Office responsible for the management of work control. As the receiver of much of the Maintenance History information, this office is also likely to be responsible for populating the Asset Management System (AMS) in a timely and accurate manner.

6.0 PROCESS

6.1 Introduction

Maintenance History is defined as the collection of data, including technical and non-technical metrics, pertaining to a specific asset, subsystem, or system, over time. It is an essential part of maintenance operation that ensures equipment is operating at an optimal level, thereby prolonging the useful service life of the equipment.

Maintenance History is a key tool in assisting an Entity client and maintenance contractor in shifting from a reactive model towards an intelligent maintenance model that can benefit from continuous improvement.

An Entity should to consider the range of assets they are responsible for and the importance of those assets. For example, complex assets with a high-profile impact will justify a higher level of maintenance history management than a low-value, low-impact asset.

Compliance with this procedure requires that the Entity client and maintenance contractor apply the guidance provided herein and adapt the Maintenance History Procedure flowchart below to their particular situation:

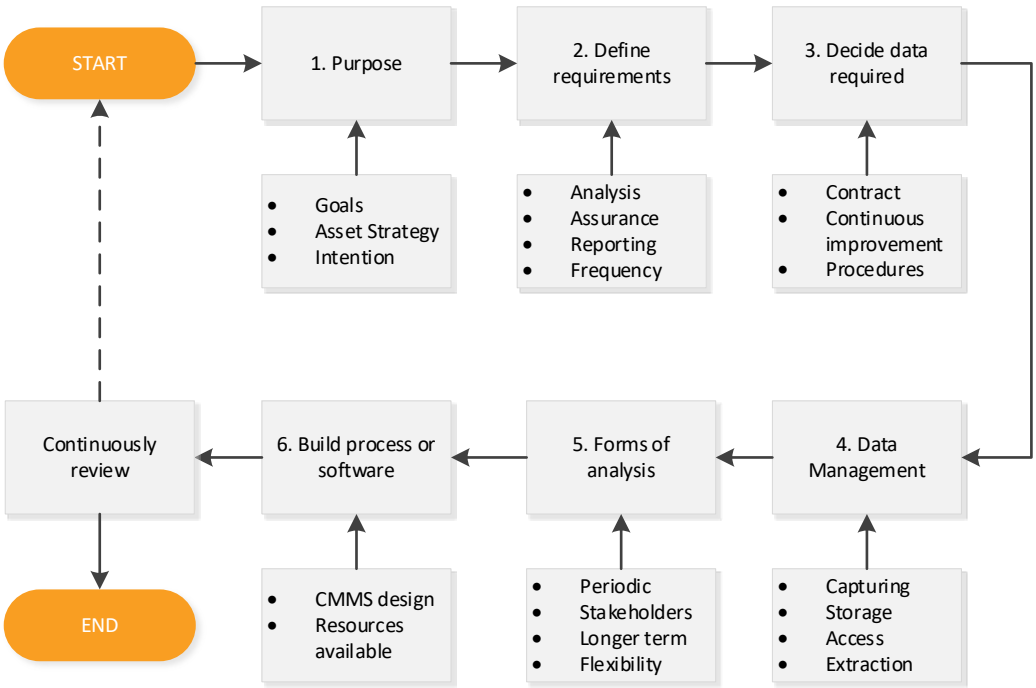

Figure 1: Maintenance History Procedure

The Maintenance History Procedure flowchart illustrates the sequence of steps related to the specifying of requirements through to the deployment stage. Each step is summarized here:

1. Purpose: the application of Maintenance History to assets is dependent on the complexity, risk and impact of the asset. For example, complex assets with a high-profile impact will justify a higher level of maintenance history management than a low-value, low-impact asset.
2. Define Requirements: the maintenance organization needs to have clarity of the purpose and uses of their Maintenance History reporting capability. Organizations need also to consider the skillsets and roles that will likely use the full range of Maintenance History. The range of Maintenance History requirements may include:
    a. Monthly KPI Reports of tasks against time
    b. Labor hours against staff member, task and asset
    c. Calibration maintenance against specific assets and tools
3. Decide data required: data is in several forms, for example, ‘hours’, ‘asset ID’, ‘Work Order number’. The selection of these will be decided by requirements from the contract, need for continuous improvement, procedures, productivity management, etc.
4. Data Management:
    a. Capturing: data may be gathered by installed monitoring systems such as Building Management Systems (BMS). Where this infrastructure is not installed, data gathering may be an instruction as part of a planned maintenance activity or an instruction separately under Facility Surveillance activities. Automatic transference of data to storage is limited to BMS and similar, most other transfer actions require human resource.
    b. Storage: refer to the section on Measurement and Recording. The storage location should be shared and the location suitable for data extraction and manipulation.
    c. Access: this applies to data saved within AMS, spreadsheets or similar. Not everyone needs to be able to edit the data and restrictions should be put in place, but able to be altered as necessary. For example, the Work Management Center (WMC) needs to be able to input Work Order data into the AMS but the Health and Safety, Quality and Environment Manager will probably only need to view the data without the ability to edit.
5. Forms of analysis: awareness of the variety of information needed is not easily predicable when the AMS is being configured, which is usually at the start of a new contract, and therefore flexibility of the system is a recommended requirement. History information will be needed in various forms and will either be needed on a periodic basis, short term or one-off. For example:
    a. Monthly repairs up to a certain monetary value
    b. Tasks against asset type(s) or group(s). This may be required as part of a time-limited response to an audit on maintenance compliance.
    c. A one-off enquiry to provide information that prioritizes a number of assets for capital project replacement may require the Maintenance History of unplanned maintenance costs.
6. Build process or software: If data is to be stored in the AMS then the requirement needs to provide for the extraction and manipulation of the stored data. If the data is to be gathered as part of a planned maintenance task or Facility Surveillance, the instruction has to be designed in to these activities. Refer to Maintenance Procedures Writers Guide and Facility Surveillances Procedure.

Maintenance philosophy can be defined as a ‘mix of strategies that ensures assets, subsystems and systems operate as expected’. Maintenance philosophy is illustrated in Figure 2. Maintenance history is a key tool in being able to deliver the most appropriate maintenance strategy for each Entity, site and maintenance contract. The expectation of the Expro approach to maintenance is that costs are optimized against uptime. This optimization is defined as intelligent maintenance.

The level of success achieved by the adoption of this procedure is measured by a periodic convergence of maintenance costs and operational downtime as illustrated in Figure 2 below.

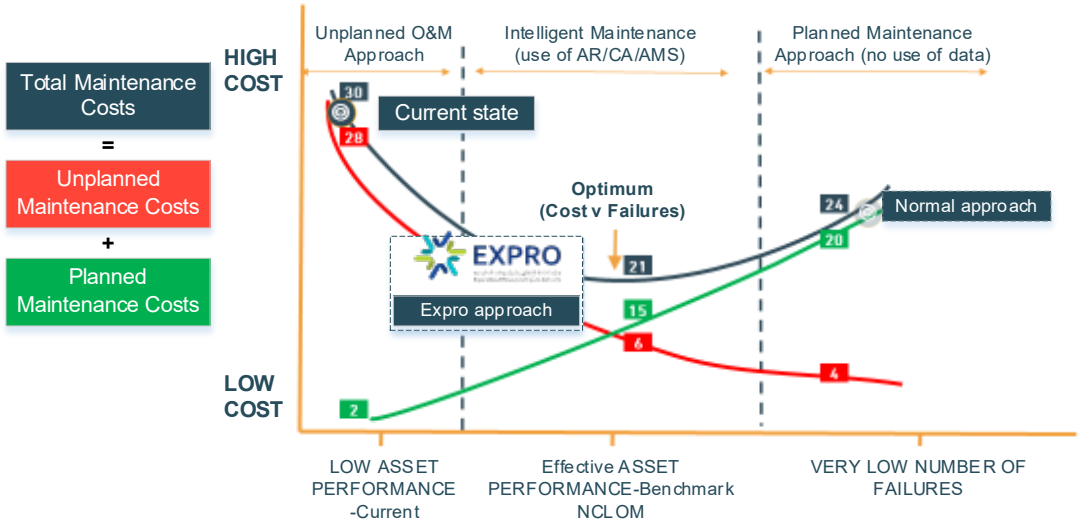

Figure 2: Maintenance Philosophies

For Intelligent Maintenance to be achieved, Maintenance History needs to be appropriate, accurate and available.

The effectiveness of maintenance history for a maintenance contract will only be limited by the availability of the resources required to achieve the level of information management required. The resources required include the instructions, recording media, skillsets and time needed to record the information, followed by the information management resources which will likely include the computerized technology and human resources for inputting and manipulating the recorded data.

Maintenance history needs to be managed to a high standard if the benefits are to be fully realized. Maintenance history should be managed in line with the standards defined in Section 4 of this document, particularly International Standards Organization ISO 14224 Petroleum, petrochemical and natural gas industries.

6.2 Definition of Maintenance History

Maintenance History is the aggregation of information such as, but not limited to:

- Time
- Duration
- Date
- Work Order numbers
- Work Order cost
- Work Order status
- Failure Code
- Technician
- Labor cost
- Material cost
- Purchase Order number
- Priority
- Condition score
- Temperature
- Voltage
- Response time

Maintenance history ranges from ensuring that all maintenance work is assigned a Work Order (WO) number and allocated time and personnel, to the way the maintenance work is tracked. Maintenance history can increase in scope to include recorded operating values, the quantity and cost of spare parts used, and asset condition score. Maintenance history can further increase in scope to provide long-term tracking of past work and the planning of future investment through data-led refining of the predicted life expectancy of the asset.

Maintenance history data is configured into information in a variety of formats and designs depending on the needs of the stakeholder. These designs can be predetermined for commonly used reports such as Key Performance Indicator (KPI) reports. For less common combinations of data, the format needs to be predefined and made available.

6.3 Management and Uses

Information that forms the maintenance history of an asset, subsystem or system is used by decision makers with the assistance of the Computerized Maintenance Management System (CMMS).

While CMMS is the best repository for information, it is not fully capable of extracting the data into a format that can be used in documents or reports. For example, while water temperature planned preventative maintenance Work Orders will be recorded in the CMMS in terms of date, time, technician, and location, the CMMS may not be able to record the actual water temperatures in such a way that this data can be extracted into a report for graphical analysis. These types of limitations depend on the specification of the CMMS.

Tasks that require the entry of data into text boxes rather than fields within the CMMS, are often carried out by the Work Management Center (WMC) if the Work Orders are paper-based.

Maintenance history is commonly used when compiling a KPI Report, which reports Work Order statuses against time targets. This type of report allows decision makers to consider the impact of KPIs on the contract and what mitigations may be appropriate. Maintenance history is also able to provide information not commonly used. For example, an auditor may need to review the consistency of application of a maintenance task against a type of asset.

Maintenance history is one group of questions that is essential in deciding whether a preventative or predictive maintenance type should be applied to an asset or asset group. It may be that the history is complete but concludes that the condition is poor with a high frequency of repairs in its past. Additionally, the history could have many blank entries, resulting from the required type of information not being available or recorded in the past. A typical timescale for good quality, appropriate maintenance history is three consistent years' worth of data.
Maintenance history is particularly important when used for predictive maintenance decision making. For example, deciding when the need for maintenance intervention is approaching is key to successful predictive maintenance.

6.4 Purpose of Recording Maintenance History

Decision makers have various motivations for needing to assess the information associated with assets, systems, or subsystems. Maintenance history may have elements of technical and non-technical metrics. For example, the frequency of unplanned maintenance and the associated labor resource cost may be needed by the Asset Management team when compiling a list of assets within a group of assets for an investment project.

Maintenance history that is provided in the form of a Work Order with a specified date/time, acts as the basis for key designs of KPI Reports.

The specific full-version documents relating to the subjects summarized below should be consulted to fully understand the purpose of maintenance history as it pertains to these procedures.

6.4.1 Asset Management and Condition Assessment

At the time of handover from construction, or taking on a new maintenance contract, the Asset Management team will focus on achieving a record of the baseline information on each asset.

This baseline will include:

- Date of purchase
- Date of delivery
- Date of installation
- Life expectancy
- Warranty details outlined in the maintenance contract, specifying if a third party will be maintaining the asset during the contract period
- Commissioning information, specifically technical data that indicates condition

As the contract progresses, the Asset Management team will focus on monitoring the condition of the assets through a combination of asset condition surveys and reviewing maintenance records and other sources of information.

6.4.2 Financial Planning

Financial planning can refer to capital investment and enhancing asset and contract performance, while minimizing maintenance costs.

The Asset Management team will require maintenance history to assist with decisions relating to asset capital investment. Part of this decision-making process will involve assessing the cost of planned and unplanned maintenance against the replacement cost of the asset. The frequency and cost of unplanned and corrective maintenance will be part of that decision-making calculation. The identification of the most appropriate assets for replacement will be important when limited capital investment funding is available and therefore maintenance history is a crucial input for ideal solutions.

Maintenance history can have a financial planning impact if a specific asset is frequently requiring Out-of-Hours (OOH) unplanned attendance. The solution to improving the maintenance of such an asset may be to increase the planned maintenance on that asset, which may require contract changes and asset condition adjustments. The combination of timing and frequency of unplanned maintenance provided by the maintenance history of an asset identifies and solves this type of situation.

6.4.3 Maintenance Management

Maintenance history can be as simple as providing the information that proves that the planned maintenance was carried out at the required frequency, confirmed by a report generated by the CMMS. This report will likely contain a Work Order number, a maintenance task title or identifier, task frequency, location identifier, and date. This type of maintenance history report allows the maintenance contractor to prove contract and statutory compliance.

Maintenance history can sometimes be called upon to provide evidence when a dispute or enquiry arises. For example, if the WMC or technicians have been attempting to gain access to a location to perform maintenance but they are repeatedly declined by the user or other stakeholder, this needs to be recorded. Failure to meet the timely delivery of the maintenance may be attributed to the stakeholder if the CMMS has been updated with the correct information. The occurrences of these types of operational and non-technical incidents form part of the maintenance history just as much as the technical information or data as these records can form part of the recording leading to deferred maintenance.

Preventative maintenance provides evidence in the form of structured data captures that is useful for the analysis of a piece of equipment's technical and financial integrity, productivity, condition, and compliance.

Predictive maintenance involves recording, analysis, and invasive maintenance. Maintenance history is an essential part of the recording and maintenance activities associated with predictive maintenance. The success of predictive maintenance relies heavily on the availability of good quality maintenance history that confirms the technical risks.

Unplanned, reactive maintenance provides high quality maintenance history data because it shows the real ability of the assets, sub-systems and systems to operate day-to-day. All instances of failure, including minor instances or instances that are unofficially reported, should be recorded to ensure that a comprehensive maintenance history database is compiled.

6.4.4 Work Control

Maintenance history is a key factor in effective troubleshooting. Assigning the correct failure code is essential for compiling accurate maintenance history and for analysis. A reliable database of maintenance history records all faults against all equipment and helps to distinguish isolated faults from those problems that are part of a longer term pattern of failure.

For estimating work techniques, the availability of applicable and accurate maintenance history data is essential. When deciding upon the replacement or purchase of a particular piece of equipment, maintenance cost-related data pertaining to one type of equipment can be compared against that of a different type of equipment to determine the most cost effective option. The costs associated with a particular asset should be assessed inclusive of the following:

- Planned maintenance cost.
- Breakdown cost
- Cost for hiring temporary resources.
- Fuel cost
- Parts cost

For documenting performance of work, in order to manage, measure and document the performance, a series of statuses within the AMS/CMMS should be used to enable accurate history information about all Work Orders. Examples of commonly used Work Order statuses are:

- In planning
- Scheduled
- Open
- Pending
- Complete
- Closed

The timestamp of when these statuses change, as well as the reason given, are key to maintenance history associated with documenting the performance of work.

For Post Maintenance Testing, recording the condition of an asset, sub-system or system is a key closing task in the procedure. This maintenance history forms the basis of the future renewal planning records managed under Asset Management.

A Work Closeout procedure checks the quality of the maintenance history information required to be provided by the technician to the Work Management Center for entering into the CMMS. Compliance with the Work Closeout procedure is therefore crucial to the success of the timely closing of Work Orders.

6.4.5 Contracts Management

The availability of maintenance history is valuable at the commencement and termination of a maintenance contract. For example, at the end of a contract, the maintenance history is evidence that the maintenance contractor has applied reasonable planned maintenance to an asset. The history of reactive maintenance can be an indication that either the planned maintenance has not been effective or the asset is of such poor condition that capital investment may be beneficial. At the commencement of a new contract, the maintenance history should be provided by the Entity client to allow the incoming maintenance contractor to determine the most appropriate maintenance type for that asset.

Contractually, maintenance history is usually the intellectual property of the Entity client or related stakeholder, and the extent, format and archiving system is usually defined in the contract.

6.5 Measurement and Recording

Depending on the type of information that forms the maintenance history, the location will differ. For example, technical information is measured locally at the point of delivery but may be recorded manually or remotely by fixed calibrated measurement sensors via the Building Management System (BMS).

The information that is normally recorded in to the CMMS usually involves manual inputting of the data. It is recommended that all information is stored in a location that is shared and subject to routine backing up, commonly by a computerized Information Management System (IMS). It is not recommended to record information on a desk top as they typically can only be accessed by one user. This is not Best Practice from a business continuity perspective.

Spreadsheets can be a good medium to store information as most team members have the skillset to manipulate the data into a variety of graphs and pie-charts with different axis titles suitable for the purpose and reader.

6.5.1 Recording Phases

Maintenance history is usually recorded from the time of construction, installation, testing, and commissioning phases through to the removal and disposal phases of the asset, subsystem or system. The information required to be recorded may vary during the life of the asset.

Only certain information is required for a specific phase or period of time, such as at the time of taking on a new maintenance contract. For example, where there is insufficient maintenance history available for the maintenance contractor to provide optimized Intelligent Maintenance, they will have to operate for a period of time on the default preventative maintenance frequencies recommended by the Original Equipment Manufacturer (OEM). Once a suitable amount of data has been collected, the maintenance contractor may relax the intervals between maintenance and can closely monitor the impact on the performance of the asset and the measured values. The relationship between the performance and the measured values is a key input in the decision making for predictive maintenance.

6.5.2 Recording Methods

The locally recorded information may be recorded manually on to a paper-based Work Order or electronically on to a Personal Digital Assistant (PDA) system. The task of observing and recording may be through planned or unplanned maintenance Work Orders, or under a Facility Surveillances instruction. Measuring data can be carried out by reading a gauge that is permanently attached to the equipment, or by a mobile tool such as a temperature meter. Non-technical information, such as date and time, are also recorded using fixed or mobile devices.

Infratech is the term used to describe the combining of infrastructure and technology to achieve a technical function such as monitoring. Continuous performance and condition monitoring of an engineered system can be carried out by permanently installed monitoring equipment that reports to a monitoring and recording system. The effectiveness of the automatic, remote monitoring equipment will depend partly on what reporting network and hardware is installed. It will most likely take the form of a BMS.

Reporting of the technical performance information that predictive maintenance is based on is often provided to the BMS by other hardwired or Wi-Fi medium.

Transferring the data from PDA to the CMMS can be immediate or at prescribed times and is commonly via the internet or a hardwired docking arrangement.

Facility surveillances is a flexible alternative to the more structured and formal methods of gathering data that forms part of maintenance history.

Maintenance history data is a valuable tool and can be used to measure performance which in turn allows for the planning of continuous improvement changes. Although date/time information is a commonly used axis on many graphs, the remaining information should be flexible in order to be configured in a variety of ways.

6.6 Analysis tools and techniques

This Maintenance History Procedure recognizes that analysis of the data is a key reason for ensuring that the procedure and associated practices are carried out fully. The preparation of the gathering, format, management and availability is key to meeting the requirements of the analysis activities, following that the entity should nominate the most appropriate analysis tool that suits and support the defined purpose. These analysis activities take several forms, for example:

- Failure Modes and Effects Analysis (FMEA)
- Root cause analysis
- Cause and Effect

When employing this Procedure for the specifying and management of a Maintenance History capability, the Entity and maintenance contractor should bear in mind the analytical steps that may be used with the data and information that has been gathered. Typical analysis steps include:

- Identify asset/facility maintenance trends
- Determine Analysis Tool
- Analyze
- Review results and produce action items
- Assign owners for action items
- Write analysis report
- Submit to decision maker