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Whitepaper # II:

INTEGRATION OF A MAINTENANCE MANAGEMENT MODEL (MMM) INTO AN ASSET MANAGEMENT PROCESS

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II.1. INTEGRATION OF A MAINTENANCE MANAGEMENT MODEL (MMM) INTO AN ASSET MANAGEMENT PROCESS

While execution of the activities of the processes of maintenance and reliability are basically technical actions, management of these processes are actions associated to administrative decisions, oriented to maximize the profitability of the asset, with the purpose of preserving and/or restoring the teams of production to conditions that allow them to meet with a function required during certain periods of time (Crespo, 2006, Parra and Crespo, 2015, Crespo et al., 2018).

Approximately 3 decades ago, organizations became aware that in order to manage maintenance and reliability properly it was necessary to include them in the general scheme of the organization and manage them in interaction with the other functions (Pintelon and Gelders, 1992). The challenge then consisted of integrating maintenance within the system of management of the company's assets. The desired picture was that, once reached such integration, the processes of maintenance and reliability received well-deserved importance and would be developed as one function of the Organization: generating 'products' to satisfy internal customers, yielding useful data and information and contributing to the fulfilment of the objectives of the organization. Thus the concept of "maintenance management system" was born in the 1980s and reliability, whose activities were aimed to benefit from business, rather than focus on them as in the past: as a cost center (Prasad et al., 2006).

Unlike the approach of the traditional management process of maintenance that has as an object of study the team only during their operational life, the model of optimization of management of asset, known as: "Asset Management", is a discipline that emerged at the end of the 1990´s and focuses on decision-making of all the life cycle of the physical asset from its creation or acquisition, use, maintenance and renewal or disposal (Crespo. 2006). For this, the management of asset links concepts and techniques of different fields, such as finance, engineering, technology, operations, etc.

II.2. GENERAL ASPECTS AND HISTORY OF ASSET MANAGEMENT

Obviously the efforts of organizations to improve the performance of their assets goes beyond the development of systems for the management of maintenance and reliability, it is also about optimizing different aspects that have to do with the life cycle of assets. However, the vision that incorporates the asset management process during its life cycle is extremely beneficial for optimize the maintenance of the assets. The activities of prevention and correction of failures for the improvement of the security of operation of the equipment is greatly influenced by a management linked to the design, construction, mounting, operation, maintenance and replacement of the equipment (Lopez et al., 2011 and Parra and Crespo 2015).

The enterprise asset management has been recognized as a discipline since the mid 1990´s, it brings together concepts and techniques from different fields, such as finance, engineering, technology, operations, etc.; and focuses on decision making throughout the full life cycle of physical assets, optimizing aspects of different natures on every occasion, but with a integrating vision throughout the life cycle.

The Institute of Asset Management (IAM), an independent and non-for-profit organization has been one of the main promoting bodies of this "crusade". IAM defines asset management as "the art and science of making the right decisions and optimizing the processes of selection, maintenance, inspection and renewal of assets" (IAM, 2010). It mentions also that a common goal is to minimize the cost of the total life of the asset, and also possibly enabling other critical factors such as risk or the continuity of the business, which must be considered objectively for decision-making.

The proposal of standard PAS 55 was a public specification aimed at optimizing the management of physical assets and infrastructure. The efforts to conceive it started in 1995 when a Committee of Managers, members of the Institute of management of assets and which integrated a variety of representatives of industry, Government and British regulatory bodies, gathered for the first time to define the direction that this standard would take. Their works, revision and publication, conducted through the British Standards Institute (BSI) took 9 years (BSI, 2010). First published in April 2004, it is to date, the main background of standard ISO 55000 (Reyes-Picknell, 2007). From 2006, the proposed standard PAS 55 gained recognition and spread its use in the industry when the Regulatory Bureau of Gas and Electric Power in the United Kingdom (UK Office of Gas and Electric Markets) strongly recommended its use in public companies that make up its network of operations. By 2008 most public enterprises of gas and electricity of United Kingdom met the requirements of the proposed standard PAS 55. Subsequently this trend also came to the areas of transport, management of public companies, food, pharmaceuticals, and chemicals, among others. And of course, also outside of the United Kingdom several companies took as a reference the proposed standard PAS 55 have increasingly appeared (Reyes-Picknell, 2007). In terms of its relevance and applicability, it is even possible to make the following analogy: PAS 55 is to asset management what ISO 9001 is to quality management or what ISO 14000 is to environmental management (Reyes-Picknell, 2007).

The proposal of PAS 55 standard defines asset management as " controlled and systematic practices and activities through which an organization optimally manages their assets, their associated performance, risks and expenses through their life cycle, in order to meet the strategic plan of the Organization" (PAS 22-1, 2004). PAS 55 can be applied to any sector of business that manages physical infrastructure and is independent of the function or type of asset. Some examples of companies where it has been applied successfully include roads, airports, trains and petrochemical complexes.

Based on Deming's cycle of planning, doing, checking and acting, this standard can be used also for various purposes: self-evaluations, benchmarking, and improvements in

planning, independent audits, certification, selection of contractors, demonstration of competence, etc. Organizations that have adopted the standard 55 PAS proposal reported significant improvements in cost and performance/service issues. PAS 55 provides a clear evidence of a proper management of asset to customers, investors, regulators and other interested parties.

Later in 2009, ISO Organization proposes the development of an asset management standard (initially based on the proposed standard PAS 55), known today as asset management standards of the series: ISO 55000, 55001 and 55002 (standards adopted from 2014 and whose certifiable standard is ISO 55001), these standards have become the international reference in the area of asset management (López et al, 2011). The design and implementation of a system of management of asset, in line with the 24 requirements of ISO 55001, is a very broad matter of discussion. This chapter describes in general the model developed by ISO 55001 and proposes a process of integration between the MMM (maintenance management model, proposed in Whitepaper I, see Figure 2.1) with the asset management model proposed by ISO 55000 (López et al, 2011).

II.3. GENERAL DESCRIPTION OF STANDARD OF MANAGEMENT OF ASSETS ISO 55000

This international standard provides a general vision of the systems of management of asset (i.e., systems of management for the handling of asset). It includes standards ISO 55000, 55001 and 55002. The target audience of this standard are those (ISO 55000):
─ Who are considering improving the chain of value of their organizations starting from their bases of asset?
─ Who are involved in the establishment, implementation, maintenance and improvement of a system of management of assets?
─ Who are involved in the planning, design, implementation and review of the activities of asset management, together with service providers?

The adoption of this set of international standards will enable an organization to achieve its objectives through the efficient and effective management of its assets. The implementation of an asset management system ensures that the achievement of those objectives is consistent and sustainable over time.

Standard ISO 55000 defines asset in the following way:

"An asset is an element, thing or entity which has a real or potential value to an organization. The value will vary for different organizations and their shareholders, and may be tangible or intangible, financial or non-financial"

The period that goes from the creation of an asset to the end of its life is called useful life of the asset. Useful life of the asset does not necessarily coincide with the period in which any organization maintains responsibility on it; rather, along its life useful, an asset can provide a real or potential value to one or more organizations, and the value of

the asset with regard to the organization can change throughout the useful life of the asset. Asset management allows an organization to recognize the need for and examine the performance of the assets and systems of assets at different levels. Likewise, it allows the application of analytical approaches to the management of an asset throughout the different stages of its cycle of life (which can start with the concept of the need for the asset until its elimination, including the handling of potential responsibilities subsequent to the elimination) (IS0 55000).

For standard ISO 55000, key factors that influence an organization to achieve its goals, are cited below:
─ Nature and purpose of the organization.
─ Its operational context.
─ Its financial restrictions and regulatory requirements.
─ The needs and expectations of the Organization and interested parties (stakeholders).

The organizations must keep an effective control and efficient policies of asset to generate value through the management of **risks** and opportunities, to achieve the balance of costs desired, the reduction of **risks** and the performance. The management of asset translates the objectives of the Organization into activities, plans and decisions related to the asset, using an approach based on **risks** (ISO 55000).

II.3.1. REQUIREMENTS OF THE ASSET MANAGEMENT MODEL BASED ON THE STANDARD ISO 55000

The standard ISO 55000 proposes a model of asset management based on 24 certifiable requirements. Below, the certifiable standard ISO 55000 requirements are quoted:

4. Context of the Organization
4.1. Understanding the Organization and its context
4.2. Understanding the needs and expectations of interested parties
4.3. Determining the extent of the asset management system
4.4. System of management of assets

5. Leadership
5.1. Leadership and commitment
5.2. Policies
5.3. Roles, organizational responsibilities and authorities

6. Planning
6.1. Actions to address the risks and opportunities in management system asset
6.2. Objectives for the management of assets and planning to achieve them

7. Support

7.1. Resources
7.2. Competencies
7.3. Awareness
7.4. Communication
7.5. Requirements of information
7.6. Documented information

8. Operation
8.1. Planning and operational control
8.2. Change management
8.3. Outsourcing

9. Performance evaluation
9.1. Monitoring, measurement, analysis and evaluation
9.2. Internal audit
9.3. Revision of the management

10 Improvement
10.1. Non-compliance and corrective action
10.2. Preventive action
10.3. Continuous improvement

In the entire version of the standard ISO 55000 proposal there are 24 requirements, which keep a logical order of elements in accordance with the common framework for quality processes: plan-do-check-act.

II.4. INTEGRATION OF THE MAINTENANCE MANAGEMENT MODEL (MMM) WITH THE ASSET MANAGEMENT STANDARD ISO 55000

Although there are no simple formulas for the implementation of an integral model of management of asset, nor fixed or immutable rules with validity and applicability for all the assets of production, the 24 requirements needed by the proposal of standard ISO 55000 can be covered by the integral Maintenance Management Model (MMM) proposed in the Figure 2.1. In the MMM, composed of eight phases, specific actions are described to follow in different steps of the process of management of maintenance that are integrated in a direct form within a process of management of assets (Parra and Crespo, 2015). As we have explained in chapter 1, the MMM offers a dynamic, sequential process and in a closed loop that tries to accurately characterize the course of actions to be carried out to ensure the efficiency, effectiveness and continuous improvement of the management of assets from the use and integration of techniques of engineering and maintenance management and reliability.

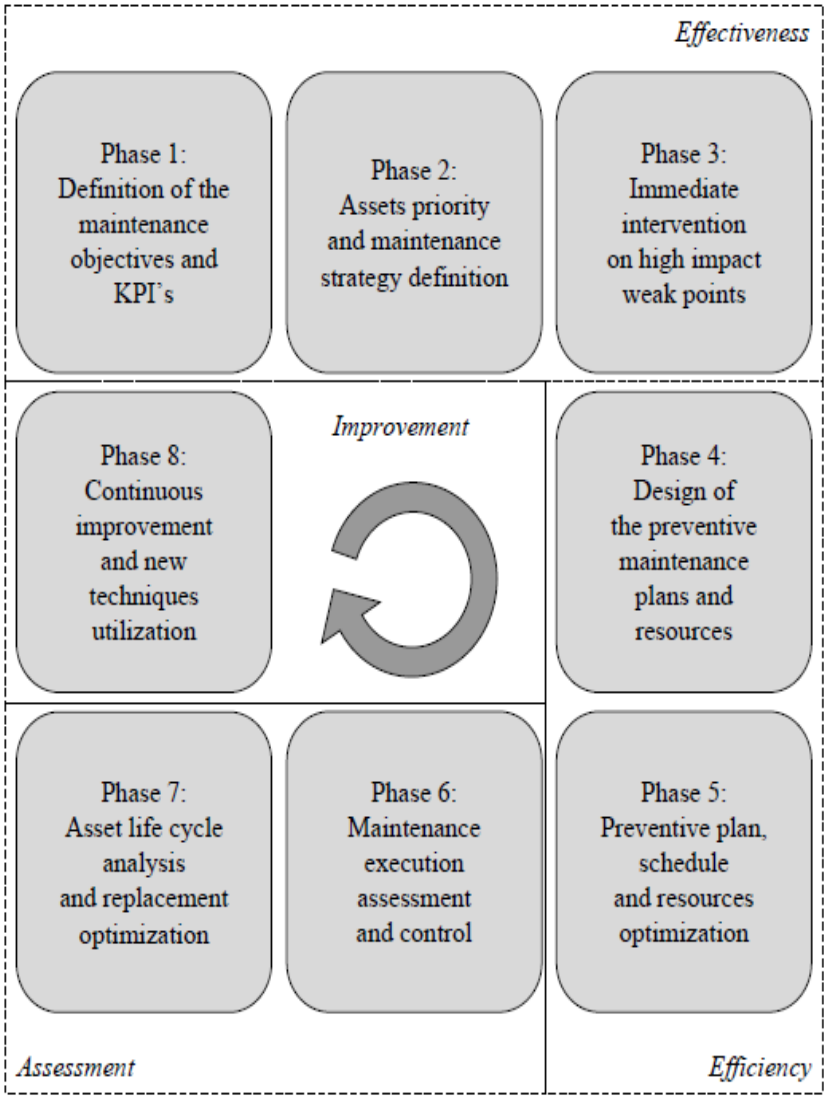

Figure 2.1. Maintenance Management Model (MMM) (Parra and Crespo, 2015)

In particular, below is shown (table 2.1), a basic relationship is made between the 8 phases of the model proposed and the general points of the standard ISO 55000, so that the gradual implementation of the generic model progressively covering the requirements of the standard ISO 55000 may be looked at. According to table 2.1, the activities to be developed within the 8 stages of the MMM can help organizations, to meet with the 24 requirements demanded by the standard ISO 55000 (taking as reference the standard UNE 16646: Maintenance within physical asset management, see Figure 2.2). The following describes in more detail the relationship between the phases of the MMM and the requirements of ISO 55000.

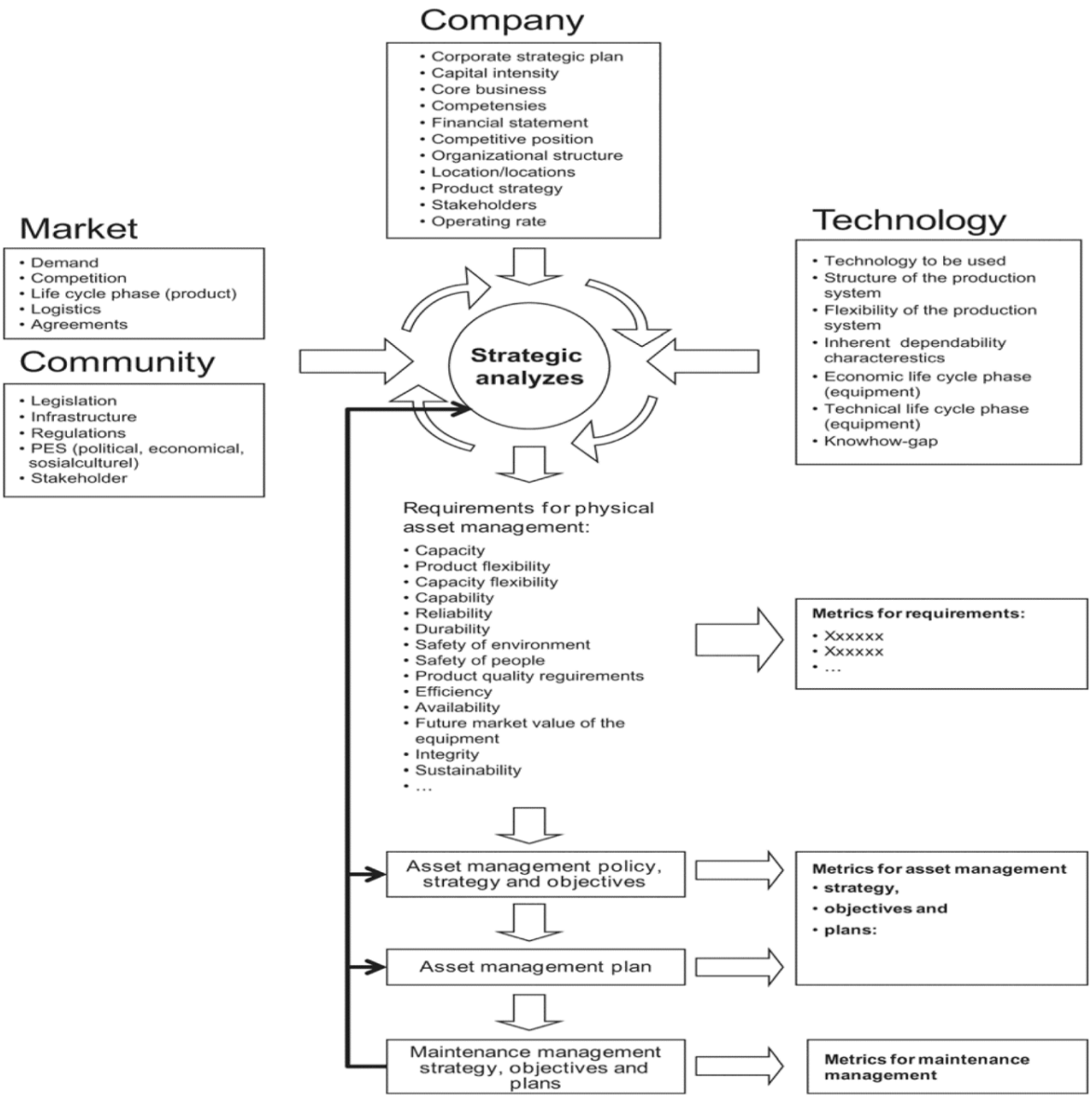

Figure 2.2. Interaction between organizational context, asset management system and maintenance management system (Standard UNE-16646)

ISO 55000 REQUIREMENTS	INTEGRATION OF THE PHASES OF THE MMM PROPOSED WITH STANDARD ISO 55000
4. context of the Organization 4.1. understanding the Organization and its context 4.2. understanding the needs and expectations of interested parties 4.3. determining the extent of the asset management system 4.4. system of management of assets 5. leadership 5.1. leadership and commitment 5.2. policies 5.3. roles, organizational responsibilities and authorities	Phase 1. Proposes the use of the scorecard (Balanced Scorecard – BSC), proposed by Kaplan and Norton, model that translates the mission of a business unit into its strategy in a set of objectives and quantifiable measures. By implementing the BSC, organizations get to: 1.Formulate policies and strategies for the operation and performance of the maintenance of assets throughout their lifecycle 2. Put into practice the strategies of maintenance and operation, which is translated into objectives at short, medium and long term. 3. Develop the plans of action. These are the means to get to the purposes stipulated in the objectives set out in step (2) 4. Establish leadership in the different processes to improve in all areas of the Organization 5. Review and periodically audit the performance of implemented strategies. Monitoring will be made and the casual relations between the measures will be investigated what will be validated at intervals previously established and plans of contingency will be defined Additionally in phase 1, the MMM model proposes that an cohesive organization is designed which supports the process of asset management and is able to implement a holistic process optimization based on the application of techniques of reliability and maintenance, with the assignment of roles, responsibilities, and definition of the leadership of all the activities to be developed during the lifecycle of the asset. Phase 2. Proposes the use of models of prioritization, which must comply and align with the expectations of stakeholders (interested parties) and at the same time, cover the legal requirements demanded by the environment of the asset
6. planning 6.1. actions to address the risks and the opportunities in the system of management of assets 6.2. objectives for the management of assets and planning to achieve them 7 support 7.1. resources 7.2. competencies 7.3. awareness 7.4. communication 7.5. requirements of information 7.6. documented information	Phase 2. Proposes at the beginning of a process of improvement, the development and the application of basic models of prioritization of assets based on the analysis of the risk factor (example: qualitative and technical matrix of risks AHP: Analytics Hierarchy, Process, etc.) Phase 3. Proposes the use of the methodology of root cause analysis (RCA) to assess the failures of major impact events, taking as a basis for the definition of solutions, the level of risk caused by failure events to be analyzed Phase 4. Proposes the use of methodology of reliability-centered maintenance (RCM) to optimize maintenance and operation depending on the level of risk plans that generate failures within the context of the operational modes Phase 5. Proposes the use of methods of optimization to be used in the programming and allocation of resources for maintenance and operations. Within the selected methods are the techniques related to processes such as risk analysis: theory of queues, Monte Carlo simulation and probabilistic techniques of point of order from inventory Additionally, at this stage, using continuous improvement methods is proposed in the programming, planning and allocation of resources for maintenance and operations, risk management-based. Phase 8. Proposes the use of the systems of information support (ERP, EAM, software of reliability, etc.), to manage and disclose all the documentation and information to be generated by the different assets in their processes of operation and maintenance. The information systems for the management of assets are key tools for their ability to support and facilitate their management, thanks to the transmission and processing of information at high speeds and quantities exceeding the organizations´ own borders and strengthening the convergence among sectors. The need for a correct implementation of the support for the management of information systems is the basis for the development of programs to improve reliability, maintenance and operations

Table 2.1. Relationship between the phases of the maintenance management model (MMM) proposed and the requirements of ISO 55000 (Parra and Crespo, 2015) (1/2)

ISO 55000 REQUIREMENTS	INTEGRATION OF THE PHASES OF THE MMM WITH THE STANDARD ISO 55000
8. operation 8.1. operational planning and control 8.2. change management 8.3. Outsourcing 9. evaluation of performance 9.1. monitoring, measurement, analysis and evaluation 9.2. internal audit 9.3. revision of the management	Phase 1. Proposes the use of the Balanced Scorecard-BSC table to measure and review the indicators of economic performance of the Organization and subsequently, integrate them with the technical indicators of operation and maintenance (technical indicators that are developed in phase 6). Additionally, in this phase 1, the use of audits of control and continuous improvement was proposed among which is found: MES (Maintenance Effectiveness Survey), QMEM (Qualitative Matrix of Excellent in Maintenance), etc. Phases 3 and 4. Propose the application of reliability as the RCA and the RCM methods that allow evaluating modes of failure and determine their causes. These methods help to determine the incidents and non-conformities, allow to evaluate the consequences that the failures can cause on safety, the environment and operations and additionally, these techniques propose procedures that help to define actions of improvement and control: corrective, preventive, of redesign and by condition Phases 5. Proposes the application of methods of optimization of maintenance and reliability engineering, which would help to define the processes of planning, programming, outsourcing and the level of training necessary to improve the management of assets in their lifecycle Phase 6. Offers a comprehensive process of measurement, analysis and evaluation of indicators of performance and improvement (indicators of probabilistic assessment: reliability, maintainability, availability, cost and risk) Phase 8. Proposes to establish a process of continuous improvement which should be able to register and to adjust to the constant changes related to techniques and emerging technologies in areas that are considered of high impact as a result of the studies carried out in the previous 8 phases of the proposed maintenance management model
10 improvement 10.1. non-conformity and corrective action 10.2. preventive action 10.3. continuous improvement	Phase 2. Proposes at the beginning of a process of improvement, the development and application of basic models of prioritization of assets based on the analysis of the risk factor (example: technical and qualitative risk matrix AHP: Analytics, Hierarchy, Process, etc.) Phase 3. Proposes the use of the methodology of analysis cause root (RCA: Root Cause Analysis) to evaluate them events of failures of greater impact, taking as base for the definition of solutions, the level of risk caused by them events of failures to be analyzed (processes of not conformity and actions corrective) Phase 4. Proposes the use of the reliability-centered (RCM) maintenance methodology, to optimize maintenance and operation depending on the level of risk plans that generate the modes of failures within the operational context (preventive action) Phase 5. Proposes the use of methods of optimization to be used in the programming and allocation of resources for maintenance and operations. Selected methods techniques include related processes such as risk analysis: theory of queues, Monte Carlo simulation and probabilistic techniques of point of order from inventory Phase 6. Proposes a holistic process of probabilistic evaluation of the indicators of: reliability, maintainability, availability, cost and risk. Additionally, in this phase a procedure is explained that allows to relate the indicators of reliability and maintainability, with decisions of optimization in the areas of maintenance and operation based on techniques of cost risk benefit analysis (continuous improvement) Phase 7. Proposes a process of cost analysis of life cycle that allows optimizing decision-making associated with the processes of design, selection, development and replacement of assets that make up a production system. The process of life cycle begins with the definition of the different tasks of production for the preliminary design. Then activities are developed such as: plan of production, layout of plant, selection of equipment, definition of processes of manufacturing and other similar activities. Subsequently, prior to the design phase logistics is considered. This phase involves the development of the necessary support for the design and the different stages of production, the possible user support, maintenance plan intended for the use of the asset and the process of divestiture of assets (continuous improvement) Phase 8. Proposes establishing a process of continuous improvement which must be capable of reviewing and evaluating the technical and economic performance of the Organization in a continuous way

Table 2.1. Relationship between the phases of the maintenance management model (MMM) proposed and the requirements of ISO 55000 (Parra and Crespo, 2015) (2/2)

According to table 2.1, out of the 24 requirements defined by the standard ISO 55000, the Maintenance Management Model (MMM) can help to align with the demands of the requirements expected by this standard. It is important to understand that the fundamental objective of the MMM is to provide a path that helps to order and optimize the key processes of maintenance management, not to fall into the error of confusing the MMM and use it as a guideline for the implementation the ISO 55001 standard (Parra and Crespo, 2015, Crespo, et al., 2018). Finally, the MMM can help organizations to improve their technical processes (effectiveness) and maximize the profitability (efficiency) of assets throughout their useful life cycle.

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