



### Research Article

## DEVELOPING THE WIREMAN MODEL FOR ASSESSING MAINTENANCE MANAGEMENT AND TRANSCENDING IT TO THE HIGH LEVEL OF A TECHNICAL ORGANIZATION

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### ABSTRACT

The first step in establishing any kind of system in the field of maintenance is creating an assessment model for the existing status of the organization. Considering these models being numerous, the conditions dominant upon each organization demands existence of ethnic models. The objective of this research is determining the assessment factors based on the components of maintenance management along with developing Wireman Model in 8 industries of holding companies with high level of technology. In order to do this a checklist consists of two parts of systematic and technical requirements was prepared based on environmental situation of the company. After several systematic review cycles, the reviewed components were based as the foundation of an ethnic model. Data aggregation was performed using the primary checklists which have been scored based on Cramer's rule. Among the calculated scores, the least amount belongs to "maintenance based on RCM reliability" with 27 and "predictive maintenance" with 33. In fact the results indicate a gap between the existing circumstances and that which is expected. Also, despite existence of quality management system in Pilot Industries, 37.7 standard deviation which is high, does not hold a desirable status which could indicate lack of effectiveness of audits based on ISO9001:2008 in the field of maintenance.

**Keywords:** Maintenance- assessment-Wireman model.

### 1. INTRODUCTION

In today swift alterations (including daily development of industries, increment of universal competition, increment of activities and duties of the organizations) organizations would be successful which would adapt themselves with these alterations and have the required power for fulfilling the expectations of the industries. On one hand the significant of the maintenance and its direct and indirect effects upon the durability and profitability of the industrial, productive or even service organizations is undeniable; since, paying a great deal of attention to the science of

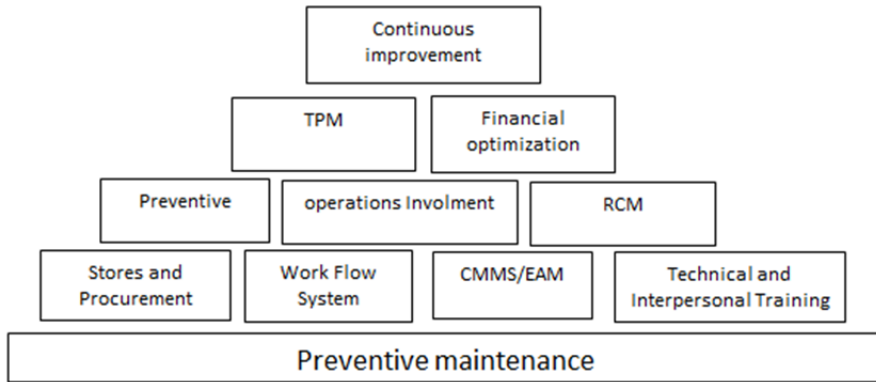
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maintenance for fulfilling the expectations of the industries is essential. Identifying and maintaining the factors effective upon the organization decision making, plays a significant role in applying and improving the maintenance management. In order to do so, a profound analysis of the maturity level of the organization is required. This analysis is performed for answering two basic questions: "how is the current situation of the organization in the field of maintenance management?" and "what should be done for improving the current situation of the organization in the field of maintenance management?"

Considering what was stated and the route map of the target organization, performing self-assessment and systematic audits are among the significant tools in improvement and growth of the industries in the field of maintenance, the current research has proceeded to identify and extract the effective factors in testing the maintenance management status with the objective of testing the organization current status in the field of maintenance. After localization of the effective components in the field of maintenance, eventually in two topics named systematic and technical requirements 21 components has tested the current status of the organization in this field; consequently the model presented in this research can be considered the creative aspect of the job, as in addition to being new, localization of the extracted components is among the points that nothing similar to it was found. This essay is being followed with research literature related to maintenance model. After that the third part explains research methodology. Eventually the gained results would be discussed and propositions would be presented for future researches.

## **2. FUNDAMENTALS AND LITERATURE OF THE RESEARCH**

In recent decades the significance of maintenance management has increased in a way that up to today official and various standards and documents have been published for making the process of maintenance more effective and transcendent. For example, maintenance excellency of America, has designed the five-level pyramid of improvement of the maintenance in which 300 requirements have been considered for improving the maintenance. [6] and [12]. Considering existing variability, electing the accurate standard or presented requirements is significant here based on which the audition would be performed and the route map of improving system would be determined. Wireman suggests step by step performance of the activities in order to make sure about performance of all of the functions of the maintenance management. The general frame of this model is shown in image (1). He believes that prior to moving on from the first step to the next level which is executing CMMS (Computerized maintenance management system ), a fundamental program for preventive maintenance of PM should exist [7]. Also, we require a "notice letter issuance" system. Prior to execution of maintenance based on RCM ( Reliability-Centered Maintenance) reliability and predictive maintenance programs a maintenance system would be essential. The next level of establishment process in maintenance activity would be consist of operators and normal staff. It is worth mentioning that Total Productive Maintenance ( TPM ) programs in 1980, had been an innovation. These programs include management plans that emphasize operator involvement in normal maintenance activities; consequently in case TPM would be placed in an appropriate position, it would extremely assist operator's participation, normalization of optimization techniques and composition of the maintenance organization structure.

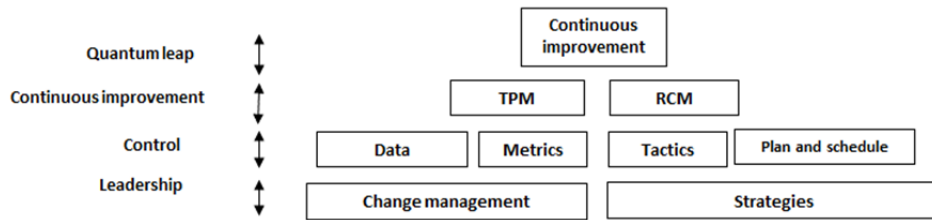


**Image 1.** Maintenance frame based on Wireman model

One of the most well-known checklists of the maintenance system audition of the organizations properties is Terry Wireman's property management checklist. This checklist includes 16 parts and each part includes 10 questions. These 16 parts have been presented in table (1).

**Table 1.** 16 parts of the Wireman checklist

<b>Wireman checklist assessment</b>	<b>part</b>
Maintenance organizations	1
Maintenance Training	2
Maintenance Work Flow	3
Maintenance timing and programming	4
Preventive maintenance	5
Maintenance purchasing and inventory	6
Maintenance automation	7
Facilities involvement	8
Maintenance system report	9
Predictive maintenance	10
Reliability engineering	11
Maintenance general activities	12
Financial optimization	13
Continuous improvement of observing properties	14
Maintenance contracts	15
Document management	16

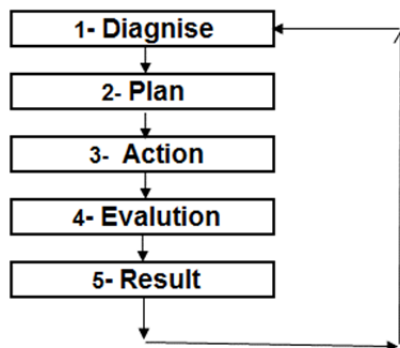


**Image 2.** Maintenance Framework according to Campbell

Campbell proposes an official structure for effective maintenance management as well. [2] [4]. The process of Campbell's suggestion, begins with expanding the strategy for each property of the organization. [3] This strategy has been designed completely coherent with a business plan. It specifies aspects related to human resource for creating required cultural alterations simultaneously. Campbell suggests execution of RCM [9] and TPM [15] methods which are very successful in this field. He suggests using open technics of process engineering for improving the leap between the steps of maintenance frame and suggested maintenances. This frame is depicted in image (2). John Campbell proposes Uptime model. This model has been established in more than 1000 industrial assemblies in the world. The huge amount of successful establishments and performed reforms have made the mentioned model the most powerful one in the field of physical properties management [12]. In Iran, various industries have been common in the mentioned field among which we can refer to Ministry of Defense and Ministry of Oil. In order to improve existing systems along with the common procedures at the Ministry of Defense and the Ministry of Oil, strategic document of maintenance management has been codified. This document has been taken of the developed patterns of the world that have been localized and codified strategically. One of the strategies of maintenance transcendence of the oil industry, is codification of the physical properties management system.

In order to do so administrative assistant of the Oil Ministry has codified this document on 2014/5/26. According to Oil Ministry maintenance management manual document and ISO 55000 [3] , the manual has a coherent structure compatible with 9001 [5] ISO quality management, 14001 environment and 18001 hygiene security and could be integrated with these systems. In this manual we could refer to Terry Wireman Models, reliability pyramid and John Campbell for choosing a physical properties management model; however, considering the mentioned criteria only John Campbell Model holds all of the basic criteria.

### 3. RESEARCH METHODOLOGY



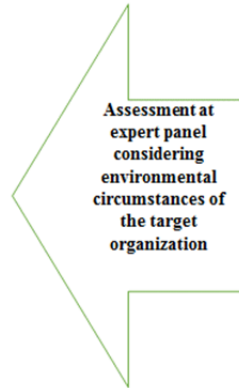
**Image 3.** The process of action research

In the current research, analysis of the existing concepts in the field of maintenance management, has been performed based on qualitative method. The aggregated data in this research are based on subjects that have been saved in the form of archived registrations and depicted in the form of scientific essays in databases. In the next stage in order to organize and data analysis case study method has been applied. In order to confirm the identified factors, strategic committee was held consisted of the experts of that field and the factors were discussed in several sessions. Afterwards, it was endeavored to present a model for target organization in the maintenance field using factors confirmed by the experts. The primary presented model was assessed in the experts committee during a brainstorm. Eventually, a checklist compatible with the circumstances of the target organization, was codified for the primary assessment of the pilot industry. For deeper discussions among the experts in the maintenance fields, action research along with expert panel have been applied. The significant point in all of the expert panels is consensus of the experts. By consensus, it means reaching an agreement regarding an idea and identification of the differences. The other point is analyzing the results of the data. The current research has two main parts of designing and assessing the model. Considering prior experiences and backgrounds in the target organization, for the first part "action research" and for the second part "survey research" was considered appropriate. In the process of action research, the researcher himself researches and performs the data simultaneously. Action research means committed or practical research; since each research that would be performed for creating social alterations particularly ideology specific to the researcher, is different from operational and practical researches. The first stage of the action research is confronting an unclear issue with identifying the issue, the second stage is evaluation and the last is the result [16]. The mentioned stages are depicted in image (3).

The researchers have assessed the industries studied in this research through five stages and at each stage have reviewed and expanded the primary checklist. After the assessments performed by the maintenance experts eventually a comprehensive checklist was provided considering the circumstances of the target organization. The process of creation of this checklist is depicted in image (4). In table 2, Wireman checklist has been compared to oil industry property management strategic statute; afterwards, based on the expert's opinion, a primary checklist was codified for assessing the existing status. The provided checklist included 107 questions with overviews presented in table 2. After strategic comparisons to Wireman checklist through tables (1, 2, 3), 8 industries were utilized in assessing the existing status. Eventually considering the score obtained from the checklist, the understudy industries were scored in 4 different grades as in table (4).

**Table 2.** 16 parts of the Wireman checklist

Primary checklist of the target organization :Table (2 )	row
structuralizing	1
Instruction and culture-building	2
Documentaries control	3
Management commitment	4
Maintenance policy	5
Maintenance objectives	6
Planning maintenance activities	7
Management review	8
Identifying and grading facilities	9
Competence, instruction and awareness	10
Supplying purchase resources	11
Knowledge management	12
Internal audition	13
Performance management and optimizing concentration	14
staff	15
Safety, environmental circumstances	16
Maintenance, displacement and stocking	17
RCM reliability engineering	18
PM preventive maintenance	19
Proactive maintenance	20
Autonomous maintenance	21
Qualitative maintenance	22
PDM	23
TPM	24



**Table 3.** Advantages of target organization checklist in comparison to Wireman checklist

The high degree of popularity of the checklist among maintenance managers	1
Compatibility of the checklist with management systems dominant on the industries of the organization	2
Inserting security points in the checklist	3
Using scoring system and ethnic grading	4
Standardization process has been considered in the checklist	5
Commitment of senior management is clearly visible in the checklist	6
Emphasis on culture building and instruction	7
The route map of industry development has been cleared in the checklist	8
Emphasis of the checklist on being process-oriented	9
PDCA cycle and constant improvement is quite visible in the checklist	10
Considering early retirements, knowledge management has been considered in the checklist	11

### 3.1. Scoring and calculating assessment checklist score in the field of maintenance

This checklist has two X and Y columns. According to the observer, in case the questions in the checklist would be practical regarding the under assessment industry, number 1 would be registered in column X and otherwise, 0 would be registered. In case 1 would be dedicated to the checklist question, the way that the industry would answer the question would be assessed. As it is depicted in table (4), column Y would be completed.

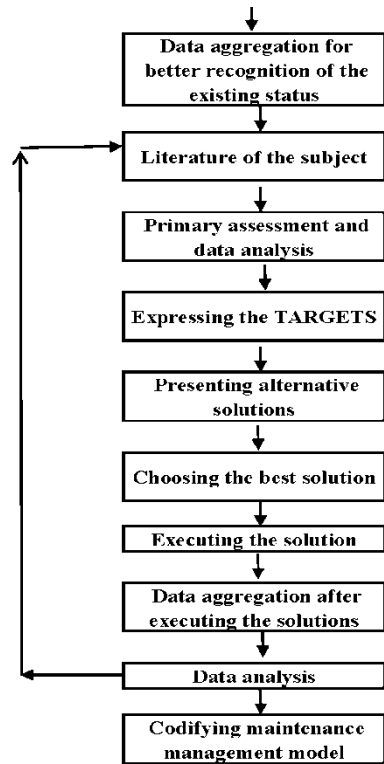


Image 4. Providing the checklist of the current checklist

Table 4. the way of scoring column Y

Negative Score	compatibility	observations
0	appropriate	The under-assessed industry has completely fulfilled the requirements of the checklist
1	More action will be needed	The under-assessed industry has not completely fulfilled the requirements of the checklist
2	basic actions is needed	The under-assessed industry has only fulfilled half of the requirements of the checklist
3	It does not exist	The under-assessed industry has not fulfilled the requirements of the checklist at all

It is worth mentioning that regarding the questions that 0 has inserted in their X columns, there is no need for completing column Y, as the mentioned question has not been practical regarding that industry.

Calculating scoring and grading:

Assessment score

$$= \left( \frac{\sum 3X - \sum Y}{\sum 3X} \right) \times 100$$

$$X = \begin{cases} 0 \\ 1 \end{cases}$$

0=in case the mentioned question would not be practical in the desired industry

1= in case the mentioned question would be practical in the desired industry

Y: totality of the negative marks

The assessed score in weighted coefficient related to structuring axis has been (10%), Training (10%) and requirements of the maintenance statute of the target organization (80%) and the totality of these scores indicates the degree of improvement of that industry based on the legislated agenda of that industry. In the next stage the grade of the assessed industry would be extracted based on table (5).

**Table 5. Grading the industries**

grade	Final score of the checklist
A <sup>+</sup>	100-90
A	89-80
B	79-60
C	59-30
D	29-

The last step of the assessment process is determining the assessed industry. Categorization of the industries in various grades along with the obtained score of the assessment is depicted in table (6). Although the results can be an accurate estimation of predicting the level of the ability of the industry in the field of maintenance management, the effects of other environmental and cultural variables on the final judgment of the level of the organization maturity and its abilities should not be overlooked; as these effective factors could cause deviation in accurate identification of the grade of the industry.

### 3.2. Planning and Establishment of Improvements

Most of the organizations are not able to achieve all the desirable potentials at once. As it was stated before, some of the factors are dependent upon the other ones; consequently, each organization requires its particular planning in order to improve and grow.

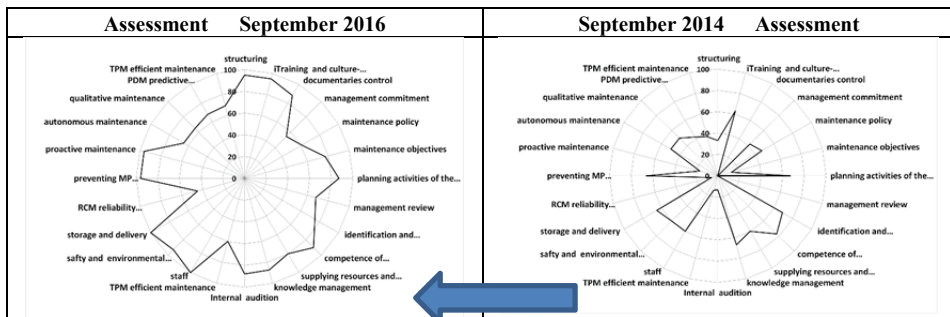


**Table 6.** The Results of systematic assessment of pilot industry and developing them in the field of maintenance management

Result of assesments				
Sept. 2015		Sept. 2014		
GRADE	%RESULT	GRADE	%RESULT	pilot
<b>C</b>	<b>54</b>	<b>B</b>	<b>65</b>	Indusry 1
<b>D</b>	<b>24</b>	<b>C</b>	<b>56</b>	Indusry 2
<b>C</b>	<b>45</b>	<b>B</b>	<b>77</b>	Indusry 3
<b>D</b>	<b>27</b>	<b>B</b>	<b>69</b>	Indusry 4
<b>C</b>	<b>31</b>	<b>C</b>	<b>44</b>	Indusry 5
<b>C</b>	<b>29</b>	<b>C</b>	<b>34</b>	Indusry 6
<b>C</b>	<b>57</b>	<b>C</b>	<b>48</b>	Indusry 7
<b>C</b>	<b>38</b>	<b>D</b>	<b>29</b>	Indusry 8
<b>38</b>		<b>53</b>		<b>Average</b>
<b>12.61</b>		<b>17.02</b>		<b>Deviation</b>

Documents and proofs that have not been seen in the organizations can be indicative of lack of existence of assessment factors at the organization and introduce recoverable points for moving toward improvement route. After providing improvement plans, organization should proceed to establish them according to the timetable. In fact, these plans and activities of the organization, have the objective of developing the grade. It should be noted that proceeding toward execution of the activities inserted in the questionnaire, can itself be executed in the form of an improvement project. Based on performed plans and in a PDCA cycle and after 5 periods of industries assessments, by comparing the amount of the industries grows for one of the pilot industries in 2014 and at the end of 2016, the radar chart has changed in the form of image (5) which indicates growth and improvement of the industries in the field of maintenance management. Eventually the route map was designed in a way that the under-assessment industries entered the stage of systematic audits and integrated procedure with other management systems after several assessment periods. This way, these audits themselves would follow the regulations of certification bodies based on issuance of conformity or nonconformity instead of scoring.

**Image 5.** Comparison of the degree of the growth of industry in the field of maintenance management of one of the pilot industries



#### 4. DISCUSSION AND CONCLUSION

In maintenance management system, an appropriate checklist is highly significant as effective establishment of a maintenance management system is dependent upon creating an accurate recognition of the current situation. As the results of the research indicate, acquired checklist is highly popular in the expert panel considering the situation of the target organization. After executing this checklist, the average of the acquired score for the target organization indicates lack of desirable situation. Additionally, despite the quality management in all of the holding companies, the systematic requirements part of the checklist does not have an appropriate status which can be confirmative of the lack of effectiveness of these systems. The significant advantages of the target organization checklist in comparison with the Wireman checklist which was assessed in the expert panel includes:

- 1-popularity degree and high acceptance of the checklist among the maintenance organization managers
- 2-compatibility of the checklist with management systems dominant upon the holding industries of the organization
- 3-using scoring system and local grading that has been experienced in the industries before
- 4-considering knowledge management in the checklist due to premature retirements
- 5-considering standardization approach in the checklist
- 6-specification of the industries transcendence route map in the checklist
- 7-considering senior management commitment in the checklist
- 8-considering PDCA cycle and continues improvement
- 9-including safety points in the checklist
- 10-emphasizing upon culture-building and instruction
- 11-emphasizing upon process-orientation

After execution of the documented checklist, the gained results of the current status of the industries in the field of maintenance were classified as the followings:

1-In this research, assessment factors in the components of maintenance management were assessed systematically considering literature review and analysis of the particular situation of the target organization in a team work process consisted of maintenance experts in a form of a checklist compatible with management systems dominant upon target organization. The results indicate development of the defined components. The mentioned components became the base of a local model in the field of maintenance management. The first edition of this model named maintenance requirements was required along with a PDCA cycle for improving the holding companies of that organization.

2-The average of the industries assessment in 2014 has been about 20 in the target organization and dispersion has been 1.26 which indicates inappropriateness of the organization status among with considerable dispersion in the pilot industries in the field of maintenance.

3-Considering the fact that it has been 10 years since the establishment of ISO 9001: 2008 standard quality management system in pilot industries acquiring insufficient score in systematic departments is unexpected and requires more coordination among audition institutes in more effective audition performance including maintenance requirements document audition of the target organization as an outer organization document.

4-One of the future threats in the field of maintenance considering retirement of most of the maintenance experts is lack of registering their experiments in the form of knowledge management models. As it is clear in the chart, the score of this factor has been registered 64 out of 100 for the organization that needs urgent reaction.

5-In this assessment, related grade was determined for 8 pilot industries considering the acquired score and the execution of the improvement program for developing the grade in future audition that is being repeated every three months was required in the form of PDCA cycle.

6-Considering the review of the literature in the field of maintenance and its compatibility with management systems and the target organization situation, the prepared checklist was not confronted any resistance from the senior managers and the maintenance staff in the stages of execution, assessment and improvement.

7-In the form of a proposition, after the primary assessments and acquiring sufficient score out of the prepared checklist, we could proceed to access a maintenance management model compatible with the crisis in the level of a technological organization through a research essay.

## REFERENCES

- [1] Wireman T, (2005) Developing performance indicators for managing maintenance. New York: Industrial Press. 2nd ed
- [2] Campell JD, Jardine A, (2001) Maintenance excellence . New York:Marcel Dekker
- [3] ISO 55000, 55001, 55002.
- [4] Crespo Marquez, A, (2007) The maintenance management Framework. Models and methods for complex systems maintenance. London: Springer Verlag
- [5] ISO 9001:2008
- [6] EN 13306:2010, Maintenance Terminology. European Standard. CEN (European Committee for Standardization), Brussels.
- [7] Palmer RD, (2005) Maintenance Planning and Scheduling Handbook, 2nd Edition (McGraw-Hill Handbooks) [2 ed.]
- [8] Pintelon LM, Gelders LF, (1992) Maintenance management decision making. European Journal of Operational Research, 58: 301–317.
- [9] Moubray J, (1997) Reliability-Centred Maintenance (2nd ed.). Oxford: Butterworth-Heinemann.
- [10] Campbell JD, (1995) Uptime. Strategies in excellence in maintenance management.
- [11] Maintenance Management Strategic Statute of Ministry of Defense.
- [12] Oil Industry Physical Assets Management Strategic Statute.
- [13] Comparative Study of the Various Facilities Maintenance Strategies with the Objective of Identifying the Strategy Compatible with Sensitive Industries, Prepared by: Ehsan Shahin-Assistant Professors: Dr. Mohammad Hossein Karimi Govareshaki, Seyyed Javad Hosseini 2014-2015, Defense Industries Research Institute, Field of Organization Innovation and Defense Management, Operation Management Research Group.
- [14] Maintenance Quality Management, Saeed Ramezani and Ali Akber Barzegar 2011.
- [15] Translated by: Ali Haj Shirmohammadi, TPM Maintenance-First Edition Fall 1998, Industrial Management Organization.

- [16] Qualitative Research Methodology in Management: a Comprehensive Procedure-  
Translated by: Dr. Hassan Danayi Fard, Dr. Mehdi Alvani, Dr. Adel Azar, second edition:  
Fall 2013 Saffar publication.