The Missing Tool for Maintenance and MRO Inventory Control

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EMERSON

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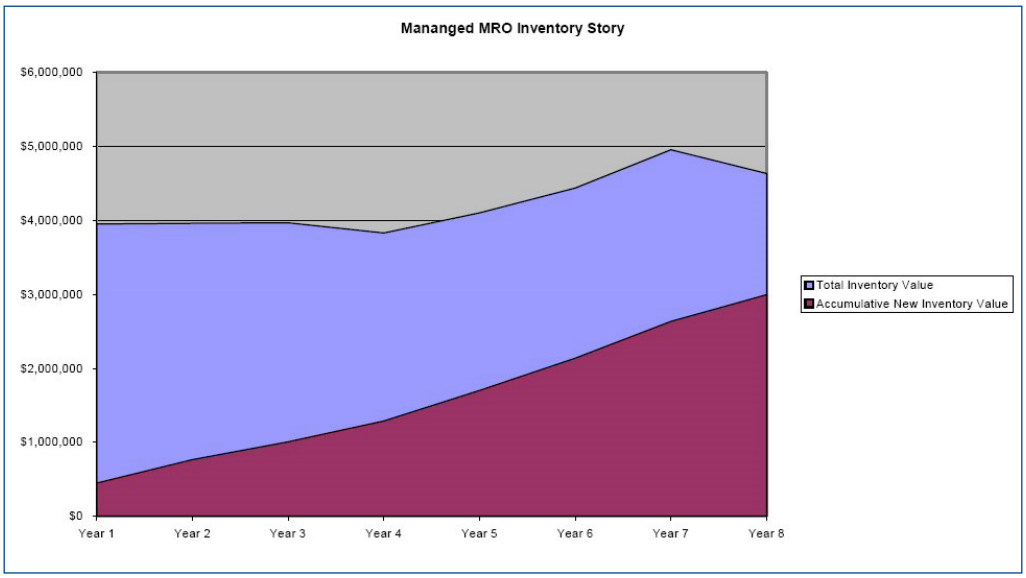
BOMs – A Maintenance & MRO Inventory Savings Model

Emerson has performed hundreds of plant assessments in a wide range of industries, including Chemical Processing, Heavy Metals, Pharmaceuticals, Power Generation and a wide variety of Light Manufacturing. During the course of these assessments, Emerson came to the conclusion that a consistently missing maintenance best practice is the availability of accurate Bill of Materials for plant equipment. Only a handful of plants visited by Emerson have complete Bill of Materials available, which incorporated the majority of the spare parts in their MRO inventory. Not surprisingly, these plants are also considewred pacesetters in their respective industries.

The focus of this report is on the differentiators that separate these few pacesetters from their competitors. The following chart depicts the results possible when complete BOMs are in place. The chart is based on real data from a mid-western refinery that was undertaking many capital improvement projects during the eight-year time span requiring the addition of numerous spare parts to support new equipment. The chart shows that in spite of a large increase in the accumulative value of new spare parts, the overall effect on the total inventory value was negligible. While other practices such as regular evaluation of inventory levels using an EOQ and order point model and the daily practice of ABC cycle counting contributed to the control of the total inventory value, the primary reason for the results depicted in the chart were because of accurate and complete BOMs. The spare parts for old equipment removed from service were easily and safely deleted from inventory because the plant use of every stocked spare part was known.



BOM Definitions

There are many different names tied to the lists of parts that are carried in an MRO inventory to allow the proper maintenance of a plant's equipment. To avoid confusion in our discussions, the following definitions are provided for clarification of the terms we will use:

- **OEM BOM:** The complete listing of all components used by the original equipment manufacturer to build a piece of equipment.
- **Work Order BOM:** The listing of materials required to accomplish the work described in the job plan.
- **MRO BOM:** The listing of components the equipment owner has determined are necessary to maintain the equipment.
- **Stocked Parts:** The components that are listed on a MRO BOM and are carried in inventory.
- **Non-stocked Parts:** The components that are listed on a MRO BOM and are ordered on request only.

The MRO BOM will be our primary topic of discussion.

Industry Pacesetters Have BOM Goals

In the area of MRO BOMs, Emerson research has determined that the differentiator between pacesetters and the rest of the pack is that the pacesetters have clearly defined goals plant personnel involved with MRO BOMs are working towards. In fact, one interesting point is that comprehensive MRO BOMs tend to only exist in pacesetter plants. The following are the most commonly occurring goals the pacesetters have achieved or are working towards:

- All stocked spare parts and desired non-stocked parts are assigned to MRO BOMs on all applicable equipment. New equipment is addressed procedurally.
- When the initial MRO BOM project is complete, spare parts that have not been linked to equipment are removed from the MRO inventory.
- Some form of best practice analysis method(s) is used when developing MRO BOMs.

Industry Pacesetters have a Best Practice BOM Strategy

The following strategies differentiate pacesetters:

- Pacesetters use a standard methodology to build MRO BOMs. This methodology is ingrained in the plant culture and fosters using consistent procedures so that the right parts are stocked to support plant production and cost control goals. Emerson has found that standard methodologies typically include the following practices:
  - Formal analysis is performed to identify critical wearable parts. This analysis is performed at a minimum on all equipment categorized as critical to the plant's operations. The results from this analysis become the main driver for MRO BOM development for critical equipment. Equipment deemed less important to the plants' operations will have wearable parts identified by using less intensive analysis.
  - Prior to building equipment specific MRO BOMs, lists (or templates) of typical wearable parts are built for each equipment class (if component failure and cost analysis determines spare parts are required) present at the plant. In addition, a maintenance factor is assigned to each equipment class that ranks the tendency of the particular class of equipment to require maintenance.
  - The equipment class MRO BOM templates are used as the "standard" to be modified as required to fit individual equipment requirements.

- After the individual MRO BOMs are created, formal analysis is performed to assign initial stocking levels based on:
  - Part critical
  - Equipment criticality
  - Equipment class maintenance factor
  - Usage exposure (The number of times the part is listed on plant BOMs)

- Each plant has at a minimum one MRO BOM champion. Larger plants may have specialists for some of the maintenance crafts. For example different people may be responsible for overseeing the BOMs required for rotating equipment and instrumentation. The MRO BOM Champion coordinates all spare part requirements and spare part stocking levels. The position ensures that the assignment of existing spare parts to BOMs is completed. In addition, the position is responsible for prioritizing and guiding the movement of all existing equipment through plant MRO BOM methodology. Finally the position is responsible for ensuring that MRO BOMs for deleted equipment are removed and the spare parts are removed from stock or their inventory levels are adjusted to fit new service requirements.

Typical Best Practice MRO BOM Processes

The following tasks, listed chronologically, make up the typical MRO BOM project at a pacesetter plant:

- Equipment population is accurately cataloged & classed
- Equipment classes identified & assigned
- Equipment class maintenance factors assigned
- Equipment criticality assigned
- BOM templates developed for appropriate equipment classes
- BOM development plan in place based on criticality & maintenance factors
- New equipment add process in place

Typical BOM Structure

The following list depicts all of the elements that can be found in a MRO BOM. Not all elements have to be present, but large MRO BOMs for complicated equipment will typically use Assemblies and Sub-Assemblies to break the BOM into more manageable views with a goal of reducing craft time locating the needed parts.

- Equipment
  1. Assembly
     2. Sub-Assembly
        3. BOM Record Identifier
           4. Inventory Description
              5. BOM Description
                 6. Inventory OEM Part Number
                    7. BOM Item, Drawing or Reference Number
                       8. Overhaul Quantity

Typical BOM Element Definitions

- **Assembly or Sub-Assembly:** Actual spare part or dummy BOM record to which other spare parts are attached. Typically used to logically breakdown large BOMs
- **BOM Record Identifier:** The unique record key consisting of the equipment and inventory record identifiers
- **Inventory Description:** The description contained in the spare part's inventory record
- **BOM Description;** Alternate or additional description describing function of spare part on the equipment
- **Inventory OEM Part Number:** Original equipment manufacturer part number
- **BOM Item Number:** Item, reference or drawing number relating the spare part to its location on the OEM BOM
- **Overhaul Quantity:** Number of times the spare part is used in the equipment or assembly

Potential MRO Inventory Savings

Emerson has found that the savings potential is based on the extent to which best practices are followed in these areas:

- Inventory Control
- BOMs
- Maintenance Reliability
  - PM/PdM
  - Recurring Problem Solving

Emerson research on best practices in industry plants, including power generation, has further found that the typical possible savings are in the range of 20% to 50%. Again, the savings potential depends on the current best practices in place.

Distribution of Potential MRO Inventory Savings

The savings distribution can best be described as a cylinder divided according to the following formula:

- **Maintenance Reliability (30%):** The following assumptions were derived from a NPRA study for the refining industry but are applicable to any heavy industry.
  - **PM/PdM (15%):** Savings derived over time by reducing equipment failures which in turn results in reduced part usage and gradually allow lower spare part stocking levels.
  - **Recurring Problem Solving (15%):** Savings derived over time by root cause failure analysis and the implementation of solutions discovered as a result of reliability centered maintenance (RCM). The solutions result in reduced part usage and gradually allow lower stock levels.
- **MRO BOMs (30%):** This assumption was made from Emerson research & assessment results. Being the focus of the report, this subject is discussed in greater detail in the next section.
- **Inventory Control (40%):** This assumption is also from Emerson industry research. This area of savings results from the implementation of basic inventory management methodologies. It includes procedures such as security, cycle counting, order quantity and order point modeling, accurate descriptions and tracking key performance indicators.

Plant Savings from MRO BOMs

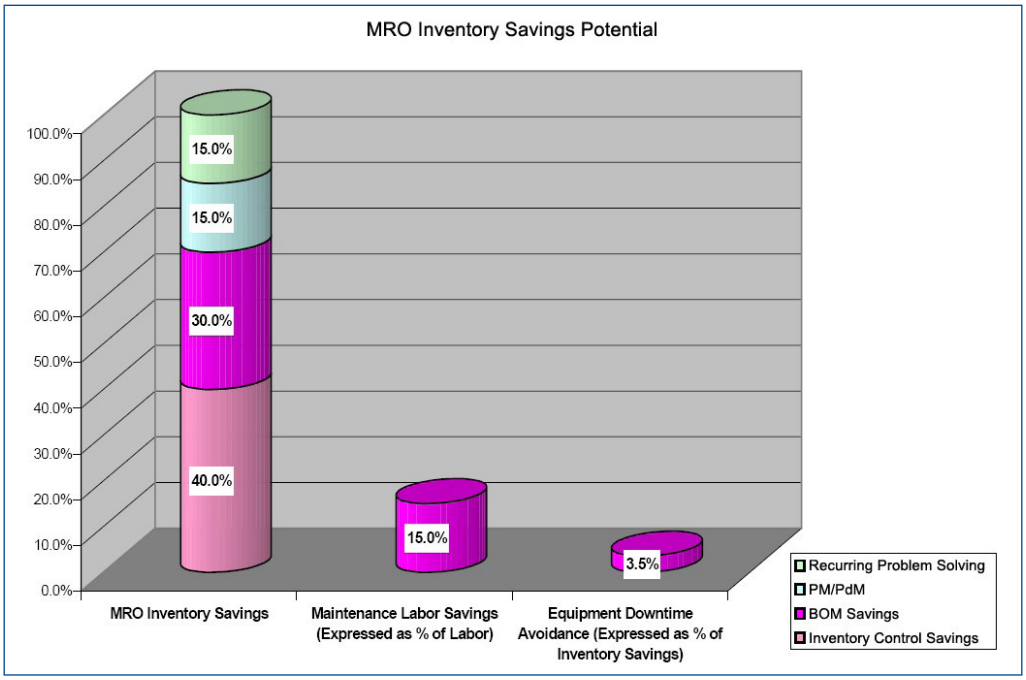
Emerson has previously stated that a maximum savings equal to 50% of the MRO inventory value is possible. The actual potential percentage of savings is based on the current state of the plant's MRO BOM program, the current level of MRO inventory management and the sophistication of the maintenance reliability program at the plant. Emerson research indicates that MRO BOMs are on average 30% of the total savings value. The direct inventory savings come from eliminating spare parts no longer supporting plant equipment, reduction of spare part stocking levels because total potential need for each spare part is now known and can be more accurately forecast and from the elimination of duplicate spare parts as a result of the MRO BOM building process.

In addition, MRO BOMs result in other plant savings in areas such as maintenance labor and the reduction of equipment downtime. Maintenance labor savings of up to 15% are possible. These saved hours can be "banked" in the PM/PdM program, which will result in even greater savings over time. The labor savings are a result of the decrease in time spent identifying and locating parts needed for equipment repair. Emerson assessments have found that 10% to 25% of a craftsman's time is spent obtaining parts. BOMs will largely eliminate this waste and will also allow for in-plant deliveries by the storeroom in large plants because visual identification of the spare part by the craftsmen is no longer required.

Another area of savings is from equipment downtime avoidance. Emerson has benchmarked this savings at 3.5%. This savings is normally calculated based on the value of lost production. However, since the focus of this report is on MRO inventory supply chain and not maintenance reliability the savings percentage and formula has been tied to the MRO inventory value. The savings come from the fact that required spare parts are quickly located thus reducing the mean time to repair.

Another area of cost avoidance results from installing the correct spare part and not just one that fits. Accurate MRO BOMs add quality assurance to the maintenance repair process by significantly reducing the possibility of installing the wrong part and possibly causing early and potentially catastrophic failure of the equipment. This is extremely important in highly regulated industries such as nuclear power and pharmaceuticals.

The following chart depicts the savings available by instituting a variety of maintenance best practices including BOMs.



Your Total Potential BOM Savings

To quantify the potential savings gained by having a "pacesetter" BOM program, Emerson has developed a MRO Inventory Savings Model in an Excel spreadsheet. The spreadsheet requires the input of your total plant maintenance costs, MRO inventory value and plant maintenance labor costs in the BOM Input sheet. In addition, you will be asked to benchmark the status of your BOM program using the BOM Survey sheet. Using the data you provide, the spreadsheet will calculate and display the total potential savings possible in the Case Study $ Savings Calculations & Results work sheet portion of the model. Data entry instructions are provided and explanations are contained in many of the survey question cells of the spreadsheet.

A sample of the calculator input and output screens are displayed in the appendix attached to this document.

Investment cost to gain the MRO BOM portion of the MRO Inventory Savings

To assist you in estimating the investment required to obtain the savings possible from a "pacesetter" MRO BOM program, Emerson suggests the following thumb rules, which can be used to calculate the man-hours need to build the individual MRO BOMs:

- Assume 40% of plant equipment is critical to the process and will require BOMs
- Assume average 2 to 4 hours per BOM developed
- Assume one developed BOM can be copied to 2 to 5 pieces of equipment (dependent on plant equipment commonality)

Finally, assume that while labor savings will begin immediately, MRO inventory value savings will take two to five years to accrue once the MRO BOMs are in place.

Appendix A

BOM Savings Calculator Sample

Emerson BOM Survey Input Screen Sample

The survey below reflects the state of typical BOM programs at plants Emerson visited:

Inventory Savings Model — BOM Survey			Shade indicates input point	
MRO Inventory Improvement Areas			Use "clear content" when changing any checkbox selections	X
Area	Survey	Survey Characteristic		
BOMs	Which characteristic best describes the current status of your BOM program?	All spare parts and appropriate consumables have been assigned to all appicable BOMs	Check only one box.	
		All spare parts are assigned to BOM but many times only to the equipment BOM the part was originally put in stock for		
		Many, but not all, spare parts are assigned to BOMs		
		A few spare parts are assigned to BOMs		X
		No BOMs		
BOMs	Which characteristic best describes your use of a special BOM description (overriding the items inventory description) field that describes the use of the part in the specific application?	All applicable BOM records enhanced	Check only one box.	
		Many BOM records enhanced		
		A few BOM records enhanced		
		No BOM records enhanced		X
BOMs	Which characteristic best describes your use of the BOM field (or fields) that can be used to store specific drawing numbers, item numbers, or reference numbers that reflect a parts use or location on the applicable equipment's exploded parts drawing view?	All applicable BOM records enhanced	Check only one box.	
		Many BOM records enhanced		
		A few BOM records enhanced		
		No BOM records enhanced		X
BOMs	Which characteristic best describes your population of the "overhaul quantity" or "quantity of the part used" field on the application BOM records	All applicable BOM records enhanced	Check only one box.	
		Many BOM records enhanced		
		A few BOM records enhanced		X
		No BOM records enhanced		
BOMs	Which characteristic best describes the status of your program to identify all your OEM substitutes and assign them to BOMs in place of the OEM part?	All appropriate OEM substitutes identified and assigned	Check only one box.	
		Many appropriate OEM substitutes identified and assigned		
		A few appropriate OEM substitutes identified and assigned		X
		No appropriate OEM substitutes identified and assigned		

Emerson BOM Survey Results Screen Sample

The table below reflects the survey results of typical BOM programs at plants Emerson has visited:

Inventory Savings Model — BOM Survey Results				
Survey Questions	**MRO Inventory Savings**	**Maintenance and Storeroom Labor**	**Equipment Downtime**	**Possible Point**
BOM Program Status	0	0	0	16.0
	0	0	0	12.0
	0	0	0	8.0
	4	4	4	4.0
	0	0	0	0.0
Use of special BOM description field		0	0	2.0
		0	0	1.0
		0	0	0.5
		0	0	0.0
Use of optional BOM fields		0	0	2.0
		0	0	1.0
		0	0	0.5
		0	0	0.0
Use of overhaul quantity field		0	0	2.0
		0	0	1.0
		0.5	0.5	0.5
		0	0	0.0
Use of OEM substitute	0			6.0
	0			4.0
	2			2.0
	0			0.0
Total Points from Survey	6	4.5	4.5	
Maximum Possible Points	22	22	22	
% of Maximum Possible Points	27%	20%	20%	

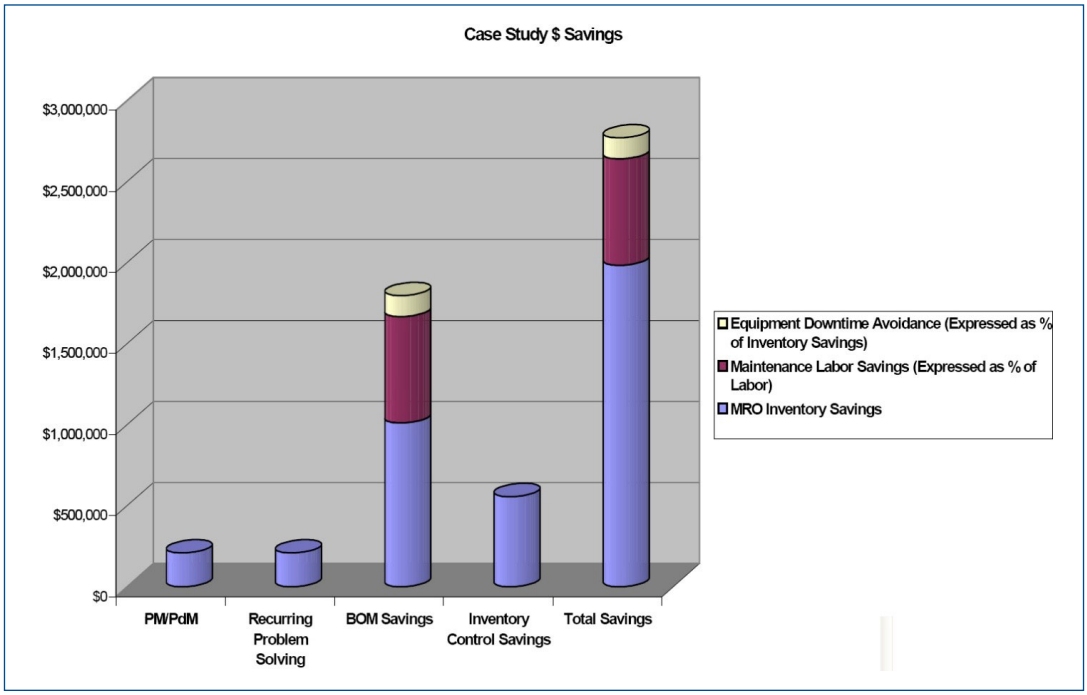
Emerson BOM Savings Calculations Sample

The table below reflects the savings potential based on the model calculations. Note that the savings presented because of PM/PdM, Recurring Problem Solving and Inventory Control Savings have been inserted as an example to support the presented case study and are not actually part of the model calculations.

Inventory Savings Model — $ Savings Calculations from BOM Survey					
Case Study Inputs					
	Case Inputs	**Case Adj Inputs**			Shade indicates input point
Total Annual Maintenance	$ 10,000,000	$ 10,000,000			
Total MRO $	$ 4,633,306	$ 4,633,306			
Total Maintenance Labor $	$ 5,500,000	$ 5,500,000			
Base Savings Benchmarks					
	Maintenance Reliability		**BOM Savings**	**Inventory Control Savings**	
	PM/PdM	**Recurring Problem Solving**			
MRO Inventory Savings	15.0%	15.0%	30.0%	40.0%	
Maintenance Labor Settings (Expressed as % of Labor)			15.0%		
Equipment Downtime Avoidance (Expressed as % of Inventory Savings)			3.5%		
Case Study Saving Percentages Adjusted by BOM Survey Answers					
	Maintenance Reliability		**BOM Savings**	**Inventory Control Savings**	
	PM/PdM	**Recurring Problem Solving**			
MRO Inventory Savings	4.5%	4.5%	21.8%	12.0%	
Maintenance Labor Settings (Expressed as % of Labor)			11.9%		
Equipment Downtime Avoidance (Expressed as % of Inventory Savings)			2.8%		
Case Study Saving Percentages Adjusted by BOM Survey Answers					
	Maintenance Reliability		**BOM Savings**	**Inventory Control**	**Total Savings**
	PM/PdM	**Recurring Problem Solving**			
MRO Inventory Savings	$ 208,499	$ 208,499	$ 1,010,903	$ 555,997	$ 1,983,897
Maintenance Labor Settings (Expressed as % of Labor)			$ 656,250		$ 656,250
Equipment Downtime Avoidance (Expressed as % of Inventory Savings)			$ 128,995		$ 128,995
Totals	$ 208,499	$ 208,499	$ 1,796,149	$ 555,997	$ 2,769,143

Emerson BOM Savings Graph

The graph below reflects the savings potential based on the model calculations:



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