Preventive Maintenance

Cement Industrial Framework

CIF-PL-MN01

LafargeHolcim

Description

- Preventive Maintenance establishes cost-effective maintenance tasks carried out at predetermined intervals to check the current physical condition, to reduce probability and/or impact of a failure in operation, or to maintain a desired level of performance of the equipment.

  This process is based on the Maintenance management concept defined by Maintenance Management System.

Objectives

- Increase equipment availability and performance by knowing the equipment condition and reduce probability of unexpected failures through avoid the occurrence of technical incidents during operation
- Maintain equipment available to perform the main and secondary functions
- Improve scheduling of repairs and reduce overall operating costs
- Contribute to the inventory levels optimization through better planning and usage of existing stock
- Level and stabilize workforce workload
- Reduce needs for major repairs by attending minor issues as quick as possible

Key Performance Indicators

- Meantime between failures MTBF [h],
- Net availability NAI [%]
- Maintenance Cost [RC]
- PMR % [%]
- PMR Efficiency [%]
- PMR not performed [#]

1. Objectives

Preventive Maintenance are cost-effective maintenance tasks carried out at predetermined intervals to check the current physical condition, to reduce probability and/or impact of a failure in operation, or to maintain a desired level of performance of an equipment.

Preventive maintenance objectives are:

- Increase equipment availability and performance by knowing the equipment condition and reduce probability of unexpected failures through avoid the occurrence of technical incident during operation.
- Maintain equipment available to perform the main function and secondary functions in a desired state
- Maintain equipment safety (worn parts are early identified and replaced).
- Improve scheduling of repairs and reduce overall operating costs (less unexpected works).
- Contribute to the inventory levels optimization through better planning and usage of existing stock
- Level and stabilize workforce workload.
- Reduce needs for major repairs by attending minor issues as quick as possible.

Preventive Maintenance is a key component on any successful Maintenance strategy in LafargeHolcim.

2. Applicability

Preventive maintenance is applicable to all areas of production facilities (integrated cement plants and cement grinding units, Alternative Fuel facilities), being kept up to date based on regular program review and optimization according to equipment and plant demands.

The ownership and responsible to implement it is the Preventive Maintenance management role

3. Prerequisites for implementation

3.1 Processes

- CIF Plant organization
- CIF Integrated people development
- CIF Production planning
- Annual Master Schedule
- CIF Work order system
- CIF Maintenance Cost Management
- CIF Equipment Replacement Strategy

3.2 Tools and systems

- LafargeHolcim Asset Code System (ACS)
- Critical Equipment definition
- Computerized Maintenance Management System (CMMS) - SAP Plant Maintenance (SAP PM) module with SAP Maintenance standard customization or equivalent integrated Enterprise resource planning solution (ERP) replicating the SAP Maintenance standard requirements

4. Process description

Preventive maintenance program is subdivided in two types - running or stopped preventive routines - given by the equipment situation required to perform the specific task.

This process is based on the Maintenance management concept defined by Maintenance Management System.

4.1 Annual Master Schedule

The starting point for planning and scheduling of preventive and corrective maintenance activities is the Annual Master Schedule for equipment stops. This is the agreement between maintenance, production and

sales departments that establishes the equipment stops schedule and it is the base for maintenance plans for each area. Annual Master Schedule is agreed and approved by the plant manager.

The Annual Master Schedule for equipment stops matrix summarizes the days of the week when the main equipment for each area are stopped for maintenance and frequency of these stops during the full year. Typical stoppage frequency for main equipment is two weeks. This will be balanced by alternate the stops with other lines of same area. For example Cement Mill 1 is planned to be stopped on the week 1, Cement Mill 2 on the week 2, and so on.

This matrix gives maintenance the possibility to ensure that all areas can visualize the relevant maintenance activities as well as to see the people's availability for foreseen training or other events.

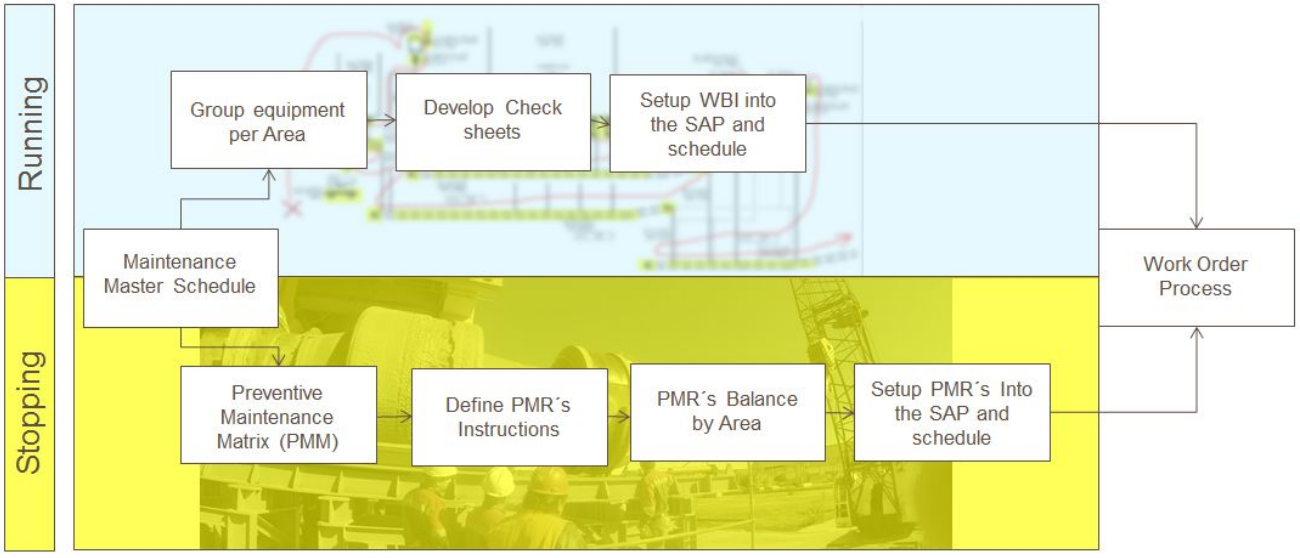

Fig 1. Preventive maintenance program development process from Annual Maintenance Master Schedule to work order automatic generation

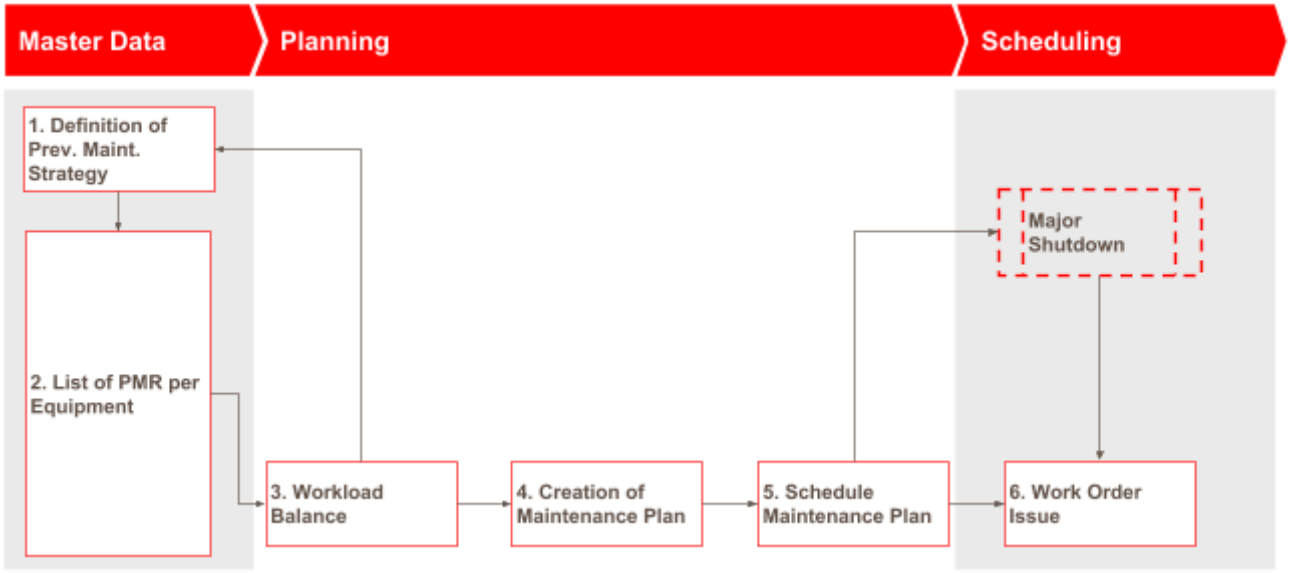

Fig 2. Preventive maintenance program development process show the flow and steps to set up in CMMS system

4.2 Running inspections

Running inspection program include the routines of Walk-by inspection (WBI), Lubrication routines and all advanced Condition monitoring (CM) like vibration, thermography and online electrical motor diagnostic, which requires the machine in running condition. Lubrication routines and related condition monitoring are described in the CIF - Lubrication excellence.

4.2.1 Check Sheets developing

WBI technique uses the human senses to monitor the condition of the equipment and detect damages in progress. All the issues found during the WBI execution which can be easily solved at the moment by the inspector have to be fixed at this moment instead of creating a notification. Next are few examples of such tasks:

- adjust skirt of belt conveyor,
- tight loose fixation bolts of covers or guards (Consider risk assessment),
- align belt conveyor,
- fix sensors supports.

Such tasks must be executed only if all potential risks generated by execution near or on a running equipment are mitigated and all applicable safety rules are applied.

4.2.2 Condition monitoring

Advanced condition monitoring uses specialised instruments to quantify and trends variables depending of the technique like vibration in order to take decision at the right time. The minimum instruments which must be available for the inspector are:

- vibropen,
- Infrared Thermometer,
- adjustable wrench,
- screwdrivers,
- flexometer,
- multimeter,
- camera.

The sequence to design each program is the same and steps are shown below.

- Define the targeted plant area to be included into the routine.
- List each machine / equipment from the respective area into the WBI template and ensure to include all the equipment which is operating during the inspection.
- List for each machine / equipment all parts to be inspected or collection point.
- Define for each part listed the tasks and parameters to be performed.
- Define the optimum sequence (shortest) route to cover selected area starting in the farthest point and upper level.
- Name the route according to the Functional Location of the Area; example: xx361 Walk by inspection Raw Mill Area
- Update your WBI checklist according with the defined walking route

4.3 Stopped Inspections

4.3.1 Preventive Maintenance Matrix

After establishing the Annual Master Schedule it is needed to define the Preventive Maintenance Matrix (PMM). This is the guide to determine the techniques of the task and to keep under control the program.

Each machine or equipment must have its own routines by specialty except certain exceptions which will be grouped in order not to generate too many work orders, the exception are:

- Auxiliary Dust collector for deducting points on belts, bucket elevator, air slides, hoppers, transfer points.,
- Group of screw conveyors or air slide in the same circuit like bag house, silo feeding system,
- Weight feeders for the same process and area which are on a radius of 200 mts,
- Instrumentation and sensors from the same process or equipment like preheater tower, mills, etc.,
- Family motors for Megger (50-250 hp) and EMD (>250 hp),
- Transformers and Motor Control Central (MCC).

A specific Annual Master Schedule for the plant is the main input for the entire program and some guides must be considered:

- Take the WBI matrix of the listed equipment expanded to theirs components
- Define the different techniques to be applied to each element of the machine.
- The ABC criticality of the equipment is considered to define the cost effective technique to be applied. On the selection of the technique it must be considered as well the impacts of the potential failure to be detected in terms of product quality, environmental and safety.
- Condition of each equipment must be checked through at least in one inspection routine

4.3.2 Define the PMR instruction for equipment

Preventive maintenance routines (PMR) are a set of instructions and or decisions performed activities according with a specific technique at predetermined intervals designed to optimize the maintenance in terms of equipment downtime, cost and labour.

The PMR instructions must contain the following information:

- Tools and materials
- Safety instruction for LOTOTO, also include the warnings in between the activities where risk are present at the moment.
- Technical information of what to inspect, adjustments and specifications.
  The source of technical details are contended on:
  - Manuals of equipment manufacturer (OEM manuals)
  - Plant records
  - Equipment history
  - Personal knowledge
  - Best practices through the group
  - Failure Mode Effect Analysis (FMEA)
  - Operating context
- Manage the disposal materials and clean the area
- Test and/or Condition to deliver the equipment to the process
- Frequency, duration and man power.

4.3.3 PMR balancing

After defining the instructions, frequency, duration and working hours on the individual PMR it is required to consolidate them in a single matrix. The next step is to distribute the working hours per week for each area in order to have an even workload distribution.

A large and unbalanced database of the equipment will require a high volume of administrative work as many of the work orders created systematically by the system need to be reprogrammed manually. A well balanced PMR program will require a minimum intervention from planner to schedule the automatic generated preventive maintenance work orders.

Next steps show the way to get a balanced PMR program.

- List of equipment already defined in the PMM
- List PMR’s for each equipment and define the execution frequency (maintenance packages). The execution frequency should be multiple of the maintenance shutdown frequency.
- Define the duration and the workforce requirement to perform each activity
- Distribute the PMR’s in a period of one year as minimum
- Adjust the sequence of the PMR’s in order to balance the workforce requirement
- Verify that the activities from different specialties will not block between them and won’t generate hazards for workers

4.3.4 Setup the PMR´s into the CMMS system

Based on the the workload balance results, each PMR is uploaded in the CMMS system with the next contend:

- establish a maintenance strategy in CMMS which is driving the frequencies of the inspection and also the parameters of inspection like days, hours, millimeters, production, etc.,
- establish PMR task list with corresponding instruction, required trade, working time, duration and

frequency,
- Maintenance Item defining be the content of the work order header,
- Maintenance plans that allow the automatic creation and scheduling of the work orders by the system.

4.3.5 Create work orders and handle

After the PMR´s have been set into the CMMS system, work order are automatically created according with the defined schedule and handled as described in the CIF Work order system.
The added value of a preventive maintenance program is to detect failures of the equipment components before equipment functional failure and to establish the process to manage the findings. All findings during the PMR execution must result in creation of maintenance requests to initiate the creation of the work order to correct the failure.

4.4 Continuous Improvement

PMR´s effectiveness must be evaluated in terms of scope, content, quality and execution frequency targeting the continuous improvement of the preventive maintenance program considering the feedback from execution and equipment performance.
This process will address:
- Full PMR´s review must be done in a yearly basis
- Over and under maintenance:
- Work order planned and not executed (too many work orders)
- Work orders done but systematically nothing found during inspections (too high frequency),
- Machine fail on constant basis in the period between to execution of planned inspections(too low frequency),
- Work order / inspection target does not cover the root cause of failure - not able to identify the potential failure - PMR content review
- Work orders / inspection covers the root cause of failures but does not identify the issue in due time - execution quality
- Execution time and number of people required
- Planning accuracy is low and highly influencing the schedule process and resource allocation.

5. Maturity Elements

Element	Emerging level	Requirements for Basic level	Requirements for Advanced level	Requirements for Excellent level	Measured by
Annual Master Schedule	●Not all the requirements described for basic level are fully implemented or some of them are missing	●Annual Maintenance Master schedule Matrix (MMS) exist and is agree by Production, Maintenance and and Plant Managers ●MMS shows a year calendar for plan stoppages	●MMS is review and update weekly according with market demand	●Maintenance Budget is aligned with MMS	
Preventive Maintenance: Running inspection Strategy	●Not all the requirements described for basic level are fully implemented or some of them are missing	●Implemented WBI Routes for each speciality: Mechanic, Electric, Lubrication, Production ●WBI has detailed parameters for	●WBI are performed by production people ●Visual aids are in place to facilitate the inspection with parameters	●Collected information through WBI can be tracked by data collector or hand held tools	●Maintenance KPIs (Maintenance Management system)

		the inspection like limits or expect values ● Post it into the CMMS. and created in automatic way by the system ● Corrective maintenance is driven by inspection results through notification ● Prioritization mechanism to the notification result from the WBI is in place	● The effectiveness of the WBI is tracking and updated ● Vibration Routines are in place		
Preventive Maintenance: Stopped inspection Strategy	● Not all the requirements described for basic level are fully implemented	● Implemented PM Routines / Key PMRs and condition Monitoring PMR´s for different specialities: Mechanic, Electric, Lubrication ● Safety risk assessment is incorporated into PMR´s ● Workload PMRs balanced for PM Routines / Key PMRs, Lubrication, Spare Parts but not at the full resources maximum availability ● PMR´s belongs to the database on CMMS and are scheduled and launched automatically ● PMR´s instructions contend full information:Tools & Material, Technical specification, Safety issues, Environmental actions ● Corrective maintenance is driven by inspection results through notification	● PM and condition monitoring tasks are aligned throughout the plant in order to avoid duplications ● Wherever possible Condition Monitoring tasks replaced the time based activities (meters) ● Equipment Risk assessment is incorporated into all preventive activities ● Formal process to update preventive maintenance strategy, at least once per year ● Condition monitoring matrix, PMRs kept updated	● Implementation of meter based preventive tasks (wear ratio, tones produced and cost ownership considered..) ● Implementation of RCM (Reliability Centered Maintenance), a specific maintenance strategy on each of the assets of the plant ● Maintenance Strategies are optimized so that the plant functionality is maintained using various techniques	● Maintenance KPIs ● MTBF ● Availability

6. Support for Implementation

The implementation of the key topics is done using a standard methodology described by the CIF roll-out methodology. The following information gives specific guidance for the implementation.

Implementation step	Duration, Timeline	Resources (people, training, equipment)	Reference documents and tools to be used
Develop and implement basic preventive maintenance program (Running Condition) ● Define equipment maintenance to include into WBI strategy, and build routines, validate (including plant cross dpts.) and implement basic preventive maintenance program including safety risk assessment into preventive work plans *Prerequirements:* ● *Preventive maintenance management role in place covering maintenance inspections, lubrication and condition monitoring* ● *Preventive maintenance function as part of maintenance organization* *Deliverables:* ● *WBI routes, spare parts PMRs.* ● *Lubrication activities* ● *Vibration Routines*	2 months	CMM System (computerized Maintenance Management System) Manufacture Manuals to define parameters Alarm list from CCR Measuring Tools	Condition Monitoring Matrix, Lubrication Chart Template,
Develop and implement basic preventive maintenance program (Stopping Condition) ● Define equipment maintenance strategy according with Condition Monitoring Matrix, and build, validate (including plant cross dpts.) and implement basic preventive maintenance program including safety risk assessment into preventive work plans ● PMR´s have a detail instruction contend (Tools, Material, safety warnings, procedures with technical specifications) *Prerequirements:* ● *Preventive maintenance management role in place* ● *Preventive maintenance function as part of maintenance organization* *Deliverables:* ● *Equipment key PMRs. Workload balance (including WBI, key PMRs, parts PMRs, Lubrication activities)*	2 months	CMM System Manufacture Manuals to define parameters Alarm list from CCR	Condition Monitoring Matrix, Workload Balancing
Basic Preventive Performance tracking ● Implement basic preventive maintenance performance indicators (MAX: inspection compliance, effectiveness, CMMS)	1 month	CIP (for coaching), Plant maintenance users	Tableau (MAX), QlikView PMMc (Plant Maintenance Management cockpit) (CMMS)

Deliverables: ● *Performance reports to support maintenance performance analyze*			
Develop and implement advance preventive maintenance program (Running Condition) ● Implement on the field visual aids with specific limits to help to perform the WBI ● Train Production People to perform WBI and track effectiveness with the usage of Work Order System. ● Implement vibration Program and Oil analysis ● Thermography inspections ● Kiln inspection through Tom-Tom Tools *Deliverables:* ● *Visual aids in place.* ● *Oil Analysis program* ● *Vibration Routines* ● *Thermography routines*	3 Months	Train Production People in mechanical basics Oil Analysis template with limits Vibration Data Collector Thermography camera Tom-Tom Tools	Condition Monitoring Matrix,
Develop and implement Advance preventive maintenance program (Stopping Condition) ● Define equipment maintenance strategy according with Condition Monitoring Matrix, and build, and implement Condition Monitoring inspection including safety risk assessment. ● Track and update existing PMR´s through FMEA and RCFA *Prerequisites:* ● *Basic preventive maintenance program* *Deliverables:* ● *Equipment NDT, EDM, wear measurements PMRs and include into Workload balance*	6 months		Condition Monitoring Matrix, FMEA, RCA, Pareto
Meter based preventive Maintenance ● Preventive maintenance meter based for key equipments in order to better predict failures and optimize equipment maintenance strategy *Prerequisites:* ● *Meters definition,* ● *Preventive maintenance strategy optimized, for targeted equipments,* ● *TIS implemented and linked with CMMS,* ● *Condition monitoring matrix updated.* *Deliverables:* ● *Key equipments with preventive maintenance plans triggered by meters through TIS link.*	6 months	TIS CIP (for coaching), Plant maintenance user's, Local site IT support	CMMS, TIS, Condition monitoring matrix
Implement failure prediction analysis ● Advanced readings analysis to predict in advance equipment failures and prepare solutions to ensure high	12 months	CIP (for coaching), Plant maintenance users	CMMS, Data collection sheets, Trends analysis tools

equipment availability and avoid unexpected incidents. *Prerequisites:* ● *Meter based preventive maintenance* *Deliverables:* ● *Failures prediction much in advance to provide planning process proper engineering or adequate solutions to keep equipment availability at desired level*			
Reliability Centered Maintenance (RCM) implementation ● Integrates Preventive and Predictive Maintenance, Predictive, Repair (also called reactive maintenance), and Proactive Maintenance to increase the probability that a machine or component will function in the required manner over its design life-cycle with a minimum amount of maintenance and downtime *Prerequisites:* ● *Preventive and Predictive Maintenance (CBM) program,* ● *Proactive Maintenance strategies,* ● *Real Time monitoring (performance data)* *Deliverables* ● *RCM program*	12 months	CIP (for coaching), Plant maintenance users	RCM methodology

7. Document management

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Validated by	CIP Standards & Tools		
Revisions	**Version**	**Date**	**Main changes**
	Beta	03.03.17	
	1.0	12.04.17	Content alignment and formatting
	1.1	30.03.18	Content review