هندسة صناعية ــ الفرقة الرابعة

مادة: الاساليب المتقدمة فى الصيانة

الحل النموذجى امتحان نهاية الترم ــ للعام الجامعى ٢٠٠٩/٢٠١٠

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a) Maintenance Management is a powerful systematic methodology to maximize the facility effectiveness and improve the maintenance resource productivity, through optimizing maintenance policies for the critical equipment.
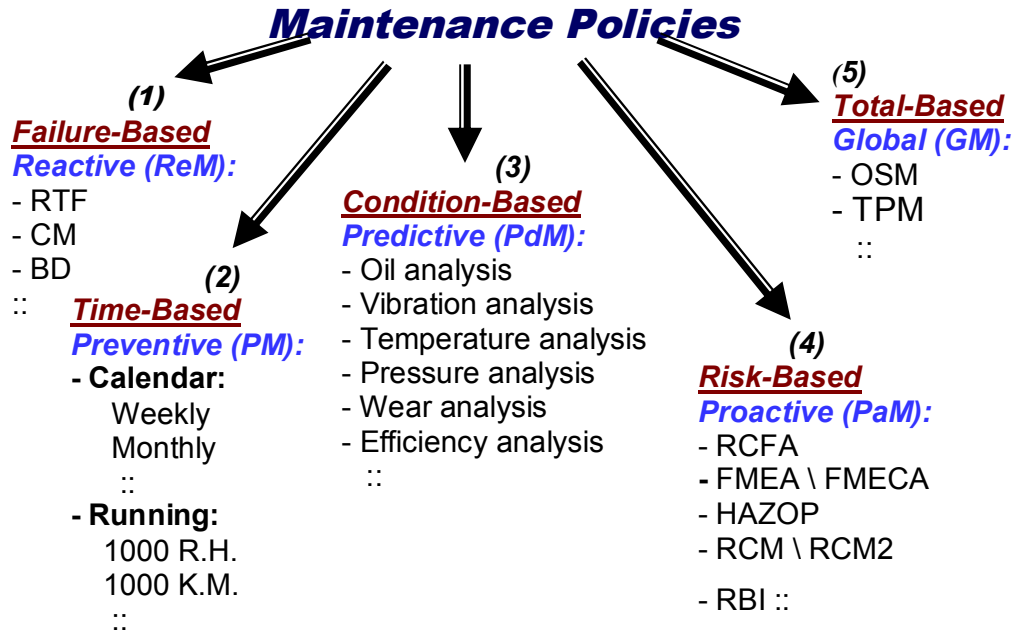
Definitions:

Methodology	A total view approach = Good communication (Maintenance, Process, HSE, Inventory, Resource, etc.)
Systematic	Documented rule-based = Codes & Standards
Powerful	Applicable and flexible = Organization structure & Team approach
Effectiveness	Utilization + performance + efficiency
Resource	Materials, manpower, tools, equipment, subcontractors, and cost
Productivity	Resource utilization and efficiency
Policy	Certain rules and program for long term
Maintenance Policy	Failure-based, time-based, condition-based, and risk-based
Criticality	Effect on HSE, Process, Standby and Cost

b) *Level of RCM Application:*

- *Plant*
- *System*
- *Sub-system*
- *Component- Assembly*
- *Part*

c)*Maintenance Policies:*
The policy is a certain rule-based for long term according to the
working conditions.

Maintenance Policies

(1)
Failure-Based
Reactive (ReM):
- RTF
- CM
- BD
::

(2)
Time-Based
Preventive (PM):
- **Calendar:**
    Weekly
    Monthly
    ::
- **Running:**
    1000 R.H.
    1000 K.M.
    ::

(3)
Condition-Based
Predictive (PdM):
- Oil analysis
- Vibration analysis
- Temperature analysis
- Pressure analysis
- Wear analysis
- Efficiency analysis
    ::

(4)
Risk-Based
Proactive (PaM):
- RCFA
- FMEA \ FMECA
- HAZOP
- RCM \ RCM2
- RBI ::

(5)
Total-Based
Global (GM):
- OSM
- TPM
    ::

d)

Facility (System level)	Equipment	Criticality (HSE, Process, etc.)
Air system	Compressor	C
Water system	Centrifugal Pump	B
Oil system	Centrifugal Pump	A
Steam system	Centrifugal Pump	A
Fire-fighting system	Centrifugal Pump	A
Power generation	Diesel	A

Q2

a) The size of maintenance labor force

PM level	Frequency	PM type	Maintenance duration	No. of workers	Man-day Per PM type
Y- Level 1	1	Shutdown	14 day	20	280*1=280
S- Level 2	1	Shutdown	7day	15	105*1=105
3M-Level 3	2	Shutdown	4day	10	40*2=80
M- Level 4	8	Running	2day	8	16*8=128
W- Level 5	36	Running	5hours	2	10*36/24=15
D-Level 6	317	Running	1hours	2	2*317/24=27

Annual PM man-day per diesel = 635
Total PM annual man-day required= 2540
The size of PM labor force = 8 workers
The size of CM labor force= 380*4/ 330= 5 workers
Total labor force = 13 workers

b)Average equipment availability =
Active operating time / Total time
= (365 – 44) / 365 = 87.9 %

c) **The average down time per year**

PM Type	Annual Frequency	Duration (day)	PM Downtime (day)
Y	1	14	14*1=14
S	1	7	7*1=7
3M	2	4	4*2=8
M	8	2	-
W	36	5/24	-
D	317	1/24	-

PM downtime per diesel	29

Average down time = 29 + 15 = 44 day/year per diesel
Annual downtime cost losses = 44 * 4 * 1000 = $ 176000

d)Annual maintenance cost

PM Type	Annual Frequency	Cost $1000	Spare parts PM Cost $1000
Y	1	10	10 * 1= 10
S	1	8	8 * 1 = 8
3M	2	5	5 * 2 = 10
M	8	-	
W	36	-	
D	317	-	

Annual spare parts PM per diesel =	28
Total annual spare parts PM cost =	28 * 4 = 112

The average annual spare parts CM cost =
$$\$ 12000 * 4 = \$ 48,000$$

Annual spare parts maintenance cost =
$$112000 + 48000 = \$ 160,000$$

Annual labor cost =
13 workers * 330 day/year * $ 10 per man-day= $ 42,900

Annual direct maintenance cost = $ 160000 + $ 42000
$$= \$ 202000$$

Overhead cost = 25 % direct cost

Annual maintenance cost = $ 202000 * 1.25 = $ 252500

Annual maintenance cost = $ 252500

Basic Annual PM Plan

Eq. code	Month #											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
DG1	Y	M	M	3M	M	M	S	M	M	3M	M	M
DG2	M	M	M	M	Y	3M	M	M	S	M	M	3M
DG3	M	3M	M	M	M	M	M	3M	Y	M	S	M
DG4	S	M	M	3M	M	M	M	M	M	3M	M	Y

Q3

The yearly PM programs information for a production line in a shop are as follows:
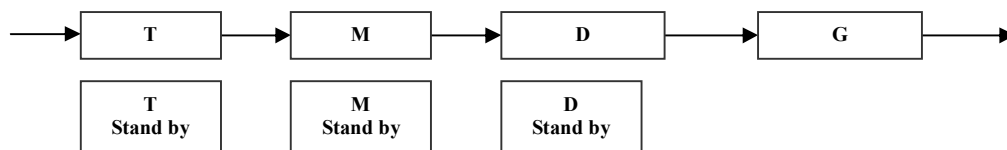
M/c Type	No .of Machines	Down Time CM (day/year)	PM levels per Machine					
			10 days		6 monthly		yearly	
			Man	Day	Man	Day	Man	Day
Turning	2	24	2	1	4	2	5	4
Milling	2	16	2	1	-	-	4	3
Drilling	2	10	2	1	4	2	-	-
Grinding	1	8	-	-	3	2	3	3

M/c Type	PM Spar parts and materials cost (L.E)		
	10 days	6 monthly	yearly
Turning	300	1000	2000
Milling	600	-	4000
Drilling	500	1600	-
Grinding	-	1000	2000

Working conditions:
-Production & maintenance 52 week/year, 6day/week, two shifts
- Manpower 45 week/year, 6day/week, one shift
-Average labor rate is 15 L.E/man-hour
- Average other costs are 25 % direct maintenance cost
- Average CM spare parts costs are 15% PM spare parts costs
- Average CM manpower are 30% PM manpower
- Average down time cost rate is 100 L.E/machine-hour

a) The size of maintenance labor force for turning machine

PM level	Frequency	Maintenance duration	No. of workers	Man-day Per PM type
Y- Level 1	1	8 day	10	80*1=80
S- Level 2	1	2day	4	8*1=8
10D-level 3	36.3	day	2	3

The size of labor force for turning = 91*2/312= 0.584

The size of maintenance labor force for milling machine

PM level	Frequency	Maintenance duration	No. of workers	Man-day Per PM type
Y- Level 1	1	3 day	4	12*1=12
S- Level 2	1	-	-	-
10D-level 3	36.3	day	2	3

The size of labor force for turning = 15*2/312= 0.096 = 1 workers

The size of maintenance labor force for drilling machine

PM level	Frequency	Maintenance duration	No. of workers	Man-day Per PM type
Y- Level 1	1	-	-	-
S- Level 2	1	2	4	8
10D-level 3	36.3	day	2	3

The size of labor force for turning = 11*2/312= 0.07 = 1workers

The size of maintenance labor force for grinding machine

PM level	Frequency	Maintenance duration	No. of workers	Man-day Per PM type
Y- Level 1	1	3	3	9
S- Level 2	1	2day	3	6
10D-level 3	36.3	2day	2	3

The size of labor force for turning = 18*1/312= 0.057 = 1 workers

Q4:

Policy	CM units	PM Units	CM Cost	PM cost	DT cost	Total Cost	Best
RTF	3 * 3	-	27000	0	93750	120750	-
Annual	2 * 3	1 * 3	18000	9000	62500	89500	-
6 Monthly	1 * 3	2 * 3	3000	18000	31230	52238	-
4 Monthly	0	3 * 3	0	27000	0	27000	x
3 Monthly	0	4 * 3	0	36000	0	36,000	-