PM-Scope Optimization — which failure modes preventive maintenance should control

Menu: System ▸ PM-Scope Optimization…

Part 1 — What the function does

What it calculates. A machine has a list of failure modes. For each mode you know, from one year of records, the total downtime it caused, the number of failures and the cost of one preventive visit that would prevent it. PM-Scope Optimization answers one question: which failure modes should preventive maintenance (PM) control, so that the yearly cost of maintenance plus breakdowns is lowest? ReliaEn ranks the modes by their mean downtime per failure (MDT) and builds five control levels, from the narrowest scope to the widest:

Level	Controls the failure modes with
Class I	MDT above the first threshold (9 hours unless you change it)
Class II	MDT above the second threshold (5 hours)
Class III	MDT above the third threshold (3 hours)
Class IV	MDT above the fourth threshold (1 hour)
Class V	every mode

For each level ReliaEn calculates:

Result	How ReliaEn sets it
Maint/yr	The predicted PM visits per year, $\chi^2(\text{conf}, 2n + 2) / 2$ pooled over the n failures the level controls, × the sum of the controlled modes' costs per visit
Breakdown/yr	The production lost by every mode the level leaves uncontrolled: its expected failures per year $\chi^2(\text{conf}, 2r + 2) / 2$ × its MDT × the production loss per hour
TOTAL/yr	Maint/yr + Breakdown/yr; the lowest total marks the optimal level ★

The report names the optimal level, the modes it controls, its total, what it saves against the cheapest level that controls a different set of modes, and the equipment mean time between failures (MTBF) at that scope.

From which data. One worksheet row per failure mode in four columns: the mode identifier, the total downtime in hours, the number of failures, and the maintenance cost per visit. The form adds the operating hours per year, the production loss per hour, the prediction confidence and the four MDT thresholds.

When an engineer uses it. Once a year, from the year's maintenance records, to decide which modes go into the PM plan.

When not to use it.

Situation	Use instead
The PM interval or the overhaul grouping of the chosen scope	Model the equipment structure on System ▸ RBD Canvas (chapter 4.1); the report's last line points there
The replacement age of one component with a fitted life distribution	The age-replacement card of Life Data ▸ Time Dependence ▸ Weibull (2P) distribution… (chapter 2.6)
Ranking failure modes by severity, occurrence and detection	System ▸ FMEA Study… (chapter 4.2)

A mode with a safety or environmental consequence	Put it under PM whatever this report says: PM-Scope Optimization prices production loss only

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Part 2 — The example's input data

Setting. A production line runs 8,760 hours a year and loses 10,000 baht for every hour it stands still. Its maintenance records of last year list twelve failure modes, A to L. The maintenance planner keeps the defaults: confidence 60% and thresholds 9, 5, 3 and 1 hours.

Mode	Downtime (h)	Failures	Cost per visit (baht)
A	22	5	5,000
B	55	12	8,000
C	72	9	2,500
D	48	12	5,500
E	125	9	8,000
F	155	7	5,000
G	195	11	1,500
H	219	30	8,500
I	157	45	12,000
J	150	90	12,500
K	60	65	5,500
L	37	40	9,850

Input	Value
Operating hours / yr	8760
Production loss / hr	10000
Prediction confidence %	60
Class I — MDT > … Class IV — MDT >	9, 5, 3, 1
File in the worked-example zip	5-PM-Scope/Example-1.csv - the twelve modes in four columns

The data in the worksheet, as the pictures of Part 3 show it:

	A	B	C	D	① E	② F	③ G	④ H	I
1					A	22	5	5000	
2					B	55	12	8000	
3					C	72	9	2500	
4					D	48	12	5500	
5					E	125	9	8000	
6					F	155	7	5000	
7					G	195	11	1500	
8					H	219	30	8500	
9					I	157	45	12000	
10					J	150	90	12500	
11					K	60	65	5500	
12					L	37	40	9850	
13									

The example data in the worksheet

- ① Column E: the mode identifiers, A to L.
- ② Column F: the downtime hours.
- ③ Column G: the failure counts.
- ④ Column H: the cost per PM visit.

Part 3 — How to use it, step by step

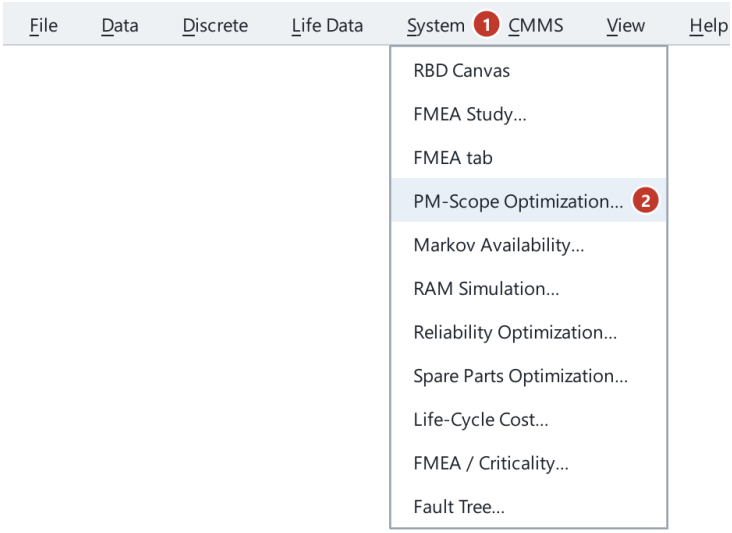
1. **Put the twelve modes into the worksheet.** Import 5-PM-Scope/Example-1.csv with File ▸ Import Data (Excel / CSV / JSON)..., or type the rows into four columns. The pictures of this chapter show them in columns E to H.

	A	B	C	D	① E	② F	③ G	④ H	I
1					A	22	5	5000	
2					B	55	12	8000	
3					C	72	9	2500	
4					D	48	12	5500	
5					E	125	9	8000	
6					F	155	7	5000	
7					G	195	11	1500	
8					H	219	30	8500	
9					I	157	45	12000	
10					J	150	90	12500	
11					K	60	65	5500	
12					L	37	40	9850	
13									

Step 1 — the data in the worksheet

- ① Column E: the mode identifiers, A to L.
- ② Column F: the downtime hours.
- ③ Column G: the failure counts.
- ④ Column H: the cost per PM visit.

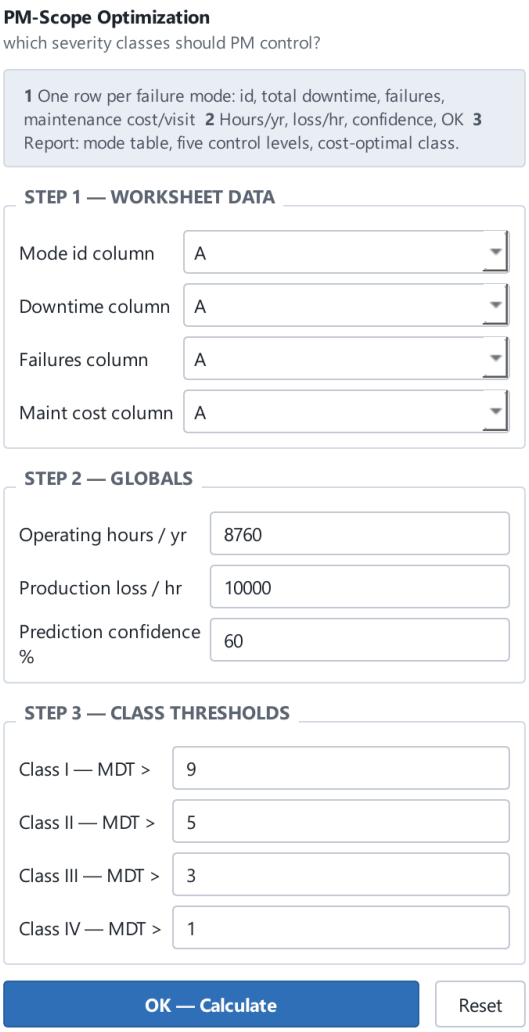
2. **Choose System ▸ PM-Scope Optimization…** in the menu bar. The form PM-Scope Optimization opens in the left panel.



Step 2 — the menu path

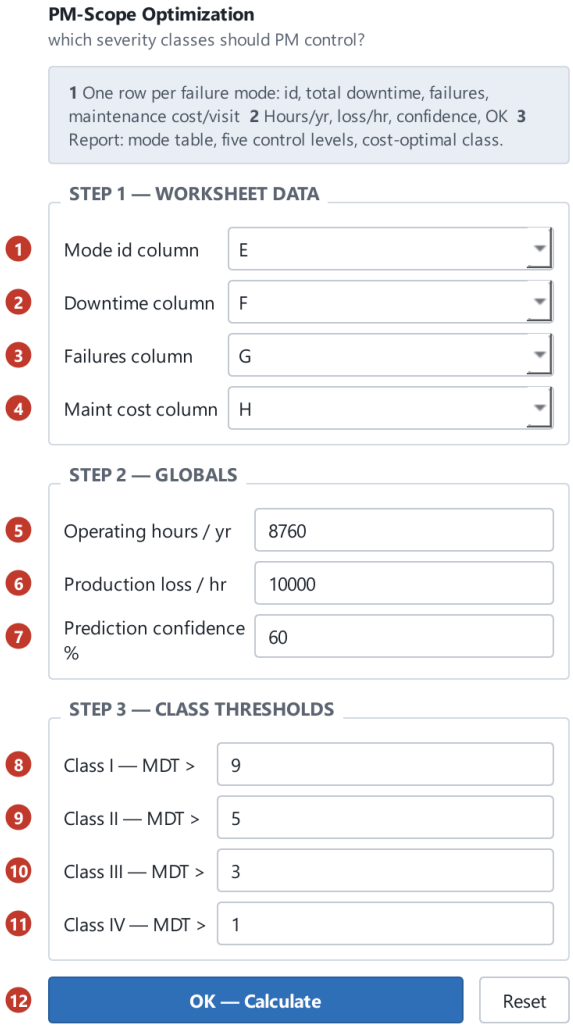
- ① System: the menu.
- ② PM-Scope Optimization…: the entry to click.

The form as it opens, before any box is set:



Step 2 — the form as it opens

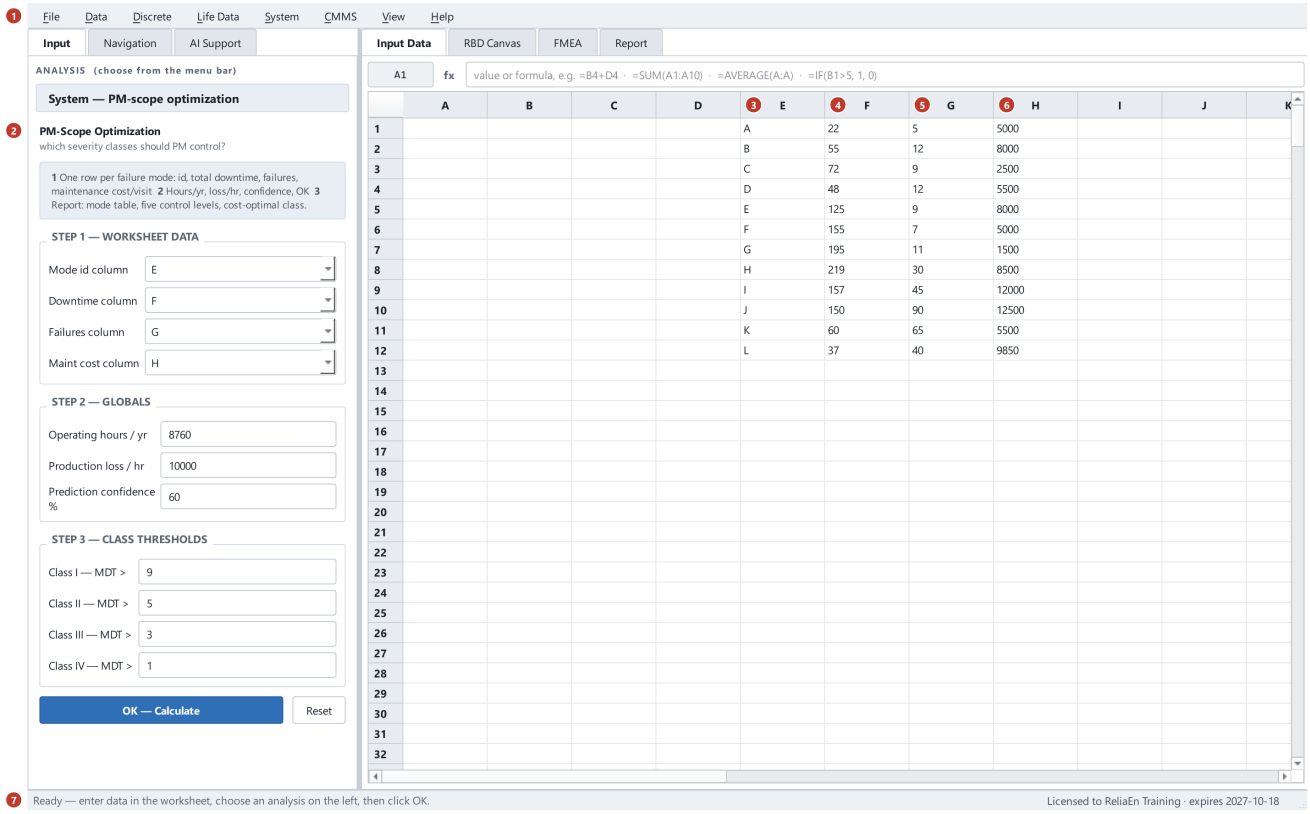
Steps 3 to 13 set the form's boxes, marked ① to ⑪ in the picture; ⑫ is the button of step 14:



Steps 3 to 13 — the form set for this example

3. ① **In Mode id column, choose E**, the column of the mode identifiers. A row with a blank identifier is skipped.
4. ② **In Downtime column, choose F.** Each downtime must be greater than 0.
5. ③ **In Failures column, choose G.** Whole numbers, 1 or more.
6. ④ **In Maint cost column, choose H.** The four columns must be different.
7. ⑤ **Check that Operating hours / yr reads 8760.**
8. ⑥ **Check that Production loss / hr reads 10000.**
9. ⑦ **Check that Prediction confidence % reads 60.**
10. ⑧ **Check that Class I — MDT > reads 9.**
11. ⑨ **Check that Class II — MDT > reads 5.**
12. ⑩ **Check that Class III — MDT > reads 3.**
13. ⑪ **Check that Class IV — MDT > reads 1.** The four thresholds must fall from Class I to Class IV.

14. **Click OK — Calculate** at the foot of the form (② in the picture below). ReliaEn calculates and shows the report.



Step 14 — the window just before OK

- ① The menu bar: File, Data, Discrete, Life Data, System, CMMS, View, Help.
- ② The form, set as in steps 3 to 13; OK — Calculate at its foot.
- ③ to ⑥ Columns E to H: the four columns the form reads, 12 values each.
- ⑦ The status bar: Ready — enter data in the worksheet, choose an analysis on the left, then click OK. and Licensed to ReliaEn Training · expires 2027-10-18.

Part 4 — The report, card by card

INPUT DATA

1	Failure modes	12
2	Operating hours / yr	8760
3	Production loss / hr	10,000
4	Prediction confidence	60% (expected failures = χ^2(conf, 2r+2)/2)
5	Class thresholds (MDT >)	9 / 5 / 3 / 1 / all

Input data

- ① Failure modes 12: the modes ReliaEn read from the worksheet.
- ② Operating hours / yr 8760.
- ③ Production loss / hr 10,000: baht per hour of lost production.
- ④ Prediction confidence 60% (expected failures = χ^2(conf, 2r+2)/2): the confidence and the formula it enters.
- ⑤ Class thresholds (MDT >) 9 / 5 / 3 / 1 / all: Class V controls every mode.

These are your data and settings as ReliaEn read them. If one differs from your records, a column or a box of the form is set wrong.

RESULTS

1	Optimal control level	Class II
2	Modes controlled	C, E, F, G, H
3	Total cost / yr at the optimum	7,418,537
4	Saving vs the next-best level	1,848,170
5	Equipment MTBF at the optimal scope	127.4

Results

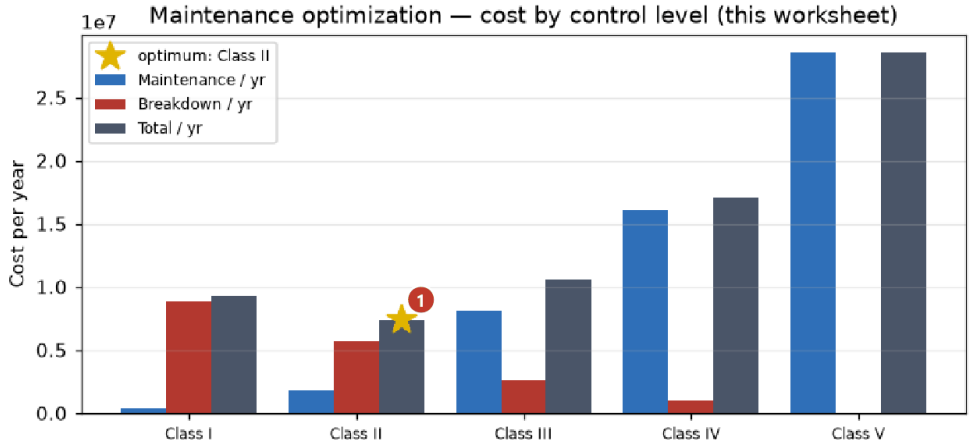
- ① Optimal control level Class II: the level with the lowest total cost per year.
- ② Modes controlled C, E, F, G, H: the modes PM controls at that level.
- ③ Total cost / yr at the optimum 7,418,537: maintenance plus accepted breakdowns, baht per year.
- ④ Saving vs the next-best level 1,848,170: against Class I, the cheapest level that controls a different set of modes.
- ⑤ Equipment MTBF at the optimal scope 127.4: the operating hours divided by the predicted PM visits of the five controlled modes, about one visit every 127.4 hours.

INTERPRETATION

1 Controlling Class II (preventing the breakdowns of C, E, F, G, H) costs 1,753,281/yr in maintenance and leaves 5,665,256/yr of accepted breakdown losses — total 7,418,537/yr, the minimum across the five levels. Controlling less leaves expensive breakdowns; controlling more buys prevention that costs more than the losses it removes.

Interpretation

- ① Controlling Class II (preventing the breakdowns of C, E, F, G, H) costs 1,753,281/yr in maintenance and leaves 5,665,256/yr of accepted breakdown losses — total 7,418,537/yr, the minimum across the five levels. Controlling less leaves expensive breakdowns; controlling more buys prevention that costs more than the losses it removes.



Interactive Plot

Cost by control level

- ① The point optimum: Class II: where the falling breakdown cost and the rising maintenance cost give the lowest total.

FAILURE MODES — PREDICTED YEAR (THIS WORKSHEET)

1 Expected failures/yr = $\chi^2(60\%, 2r+2)/2$ — the course's realistic-case prediction; production lost = expected downtime × 10,000/hr.

2 Mode	3 MDT	4 r	5 Expected fail/yr	6 MTBF	7 Production lost/yr	8 Maint cost/visit
A	4.40	5	6.29	1,392.3	276,844	5,000
B	4.58	12	13.59	644.6	622,849	8,000
C	8.00	9	10.48	836.2	838,055	2,500
D	4.00	12	13.59	644.6	543,578	5,500
E	13.89	9	10.48	836.2	1,454,956	8,000
F	22.14	7	8.39	1,044.1	1,857,734	5,000
G	17.73	11	12.55	697.8	2,225,335	1,500
H	7.30	30	32.09	273.0	2,342,605	8,500
I	3.49	45	47.40	184.8	1,653,718	12,000
J	1.67	90	93.10	94.1	1,551,666	12,500
K	0.92	65	67.74	129.3	625,297	5,500
L	0.93	40	42.30	207.1	391,304	9,850

Failure modes — predicted year (this worksheet)

- ① Expected failures/yr = $\chi^2(60\%, 2r+2)/2$ — the course's realistic-case prediction; production lost = expected downtime × 10,000/hr.
- ② Mode, ③ MDT, ④ r: each mode's identifier, its mean downtime per failure and its failures in the recorded year. Mode A: 4.40 hours, 5 failures.
- ⑤ Expected fail/yr: next year's predicted failures, 6.29 for mode A.
- ⑥ MTBF: the operating hours divided by them, 1,392.3 for mode A.
- ⑦ Production lost/yr: what the mode costs left uncontrolled. The largest: H 2,342,605 and G 2,225,335.
- ⑧ Maint cost/visit: the cost of one PM visit for the mode.

CONTROL LEVELS — THE OPTIMIZATION TABLE (THIS WORKSHEET)

① ★ Class II minimizes the total. Cost/visit is the SUM of the controlled modes' maintenance costs; visits/yr uses the POOLED χ^2 prediction over the controlled failures (course conventions).

② Level	③ Controls	④ n	⑤ MTBF	⑥ Cost/visit	⑦ Maint/yr	⑧ Breakdown/yr	⑨ TOTAL/yr
⑩ Class I	E, F, G	27	301.9	14,500	420,791	8,845,916	9,266,707
⑪ Class II ★	C, E, F, G, H	66	127.4	25,500	1,753,281	5,665,256	7,418,537
⑫ Class III	A, B, C, D, E, F, G, H, I	140	61.0	56,000	8,046,775	2,568,267	10,615,042
⑬ Class IV	A, B, C, D, E, F, G, H, I, J	230	37.4	68,500	16,065,680	1,016,601	17,082,281
⑭ Class V	A, B, C, D, E, F, G, H, I, J, K, L	335	25.7	83,850	28,536,619	0	28,536,619

⑮ Next step (course pp. 45–47): model the chosen scope's equipment STRUCTURE on the RBD Canvas — series/parallel arrangement decides the PM interval and overhaul grouping.

Control levels — the optimization table (this worksheet)

- ① ★ Class II minimizes the total. Cost/visit is the SUM of the controlled modes' maintenance costs; visits/yr uses the POOLED χ^2 prediction over the controlled failures (course conventions).
- ② to ⑨ The columns: Level, Controls, n, MTBF, Cost/visit, Maint/yr, Breakdown/yr, TOTAL/yr.
- ⑩ Class I: E, F, G · 27 · 301.9 · 14,500 · 420,791 · 8,845,916 · 9,266,707.
- ⑪ Class II ★: C, E, F, G, H · 66 · 127.4 · 25,500 · 1,753,281 · 5,665,256 · 7,418,537.
- ⑫ Class III: A, B, C, D, E, F, G, H, I · 140 · 61.0 · 56,000 · 8,046,775 · 2,568,267 · 10,615,042.
- ⑬ Class IV: A to J · 230 · 37.4 · 68,500 · 16,065,680 · 1,016,601 · 17,082,281.
- ⑭ Class V: every mode · 335 · 25.7 · 83,850 · 28,536,619 · 0 · 28,536,619.
- ⑮ Next step (course pp. 45–47): model the chosen scope's equipment STRUCTURE on the RBD Canvas — series/parallel arrangement decides the PM interval and overhaul grouping.

Part 5 — How to interpret the results

What to put under PM. Class II ★: modes C, E, F, G and H, the five with a downtime per failure above 5 hours. No other scope costs less than its 7,418,537 baht a year - 1,753,281 baht of PM visits and 5,665,256 baht of breakdowns accepted on the other seven modes.

How sure the choice is. The next scope, Class I (E, F and G only), costs 9,266,707 baht a year: 1,848,170 baht more. A saving that large means the choice does not hang on a rounding; a small saving would mean two scopes cost nearly the same and other reasons could decide.

Why not more, why not less. Controlling less leaves expensive breakdowns: at Class I mode H alone still loses 2,342,605 baht a year - 30 failures of 7.30 hours each. Controlling more buys prevention that costs more than the losses it removes: Class III costs 10,615,042 baht a year, and controlling every mode, Class V, 28,536,619 baht.

What the equipment MTBF means. At Class II the equipment's mean time between failures is 127.4 hours: the operating hours divided by the predicted PM visits of the five controlled modes.

What the result is not. It prices production loss only. A mode with a safety or environmental consequence goes under PM whatever its cost. The scope says which modes to control, not how often: model the chosen modes' structure on the RBD canvas to set the PM interval and group the overhauls.