Complete data — the constant failure rate, the mean life and their bounds

Menu: Life Data ▸ Estimate Failure Function ▸ Complete data…

Part 1 — What the function does

What it calculates. Every unit on test, or in service, has failed, and each unit's age at failure is known. The function estimates the **constant failure rate** $\hat{\lambda}$ and the **mean time to failure** (MTTF), puts two-sided chi-square (χ^2) confidence intervals on both, and gives the age by which one unit in ten has failed and how long a unit can run at each target reliability. Every result is a closed formula; you can repeat each number with a calculator and a χ^2 table.

What ReliaEn prints	What it tells you
$\hat{\lambda}$ = r / TTT	Failures per unit of operating time: the failures r divided by the total time on test TTT
$\widehat{MTTF}$ = 1 / $\hat{\lambda}$	The mean life of a unit
λ and MTTF intervals	The range that holds the true rate and the true mean life at your confidence level
B10 life and **SERVICE INTERVALS**	The age by which 10% of units fail, and the longest run that keeps each target reliability from 95% down to 5%

From which data. The failure ages of a group of like units, all of which failed, in one worksheet column, one row per unit, every age above 0 and in one unit of operating time (hours, cycles or kilometres).

When an engineer uses it. When the failure rate is constant with age (no wear-out, no early failures) and the numbers feed a commitment: a spares budget, a warranty reserve, an availability claim. Check the constant rate first (Life Data ▸ Goodness of Fit Testing…) if you are not sure of it.

When not to use it.

Situation	Use instead
The test stopped at a fixed time with units still running	Life Data ▸ Estimate Failure Function ▸ Time-censored data…
The test stopped at the r-th failure	Life Data ▸ Estimate Failure Function ▸ Failure-censored data…
Parts wear out and you want a replacement age	Life Data ▸ Time Dependence ▸ Weibull (2P) distribution…
One repairable system fails again and again	Life Data ▸ Estimate Failure Function ▸ Repairable unit data…

Part 2 — The example's input data

Setting. Eight controller boards on an accelerated-duty bench; each one runs until it fails. Their ages at failure are in operating hours. The reliability engineer wants the boards' failure rate and mean life with honest bounds before setting the spares budget.

Input	Value
Failure ages, operating hours (8)	120, 250, 340, 480, 610, 745, 900, 1150
File in the worked-example zip	2-Complete-Data/Example-1.csv — one column, heading Failure times, 8 rows
Confidence % (two-sided)	95 — the value the form opens with

	① A	B
1	120	
2	250	
3	340	
4	480	
5	610	
6	745	
7	900	
8	1150	
9		

The example data in the worksheet

- ① Column A: the 8 failure ages, one per row, in operating hours.

Part 3 — How to use it, step by step

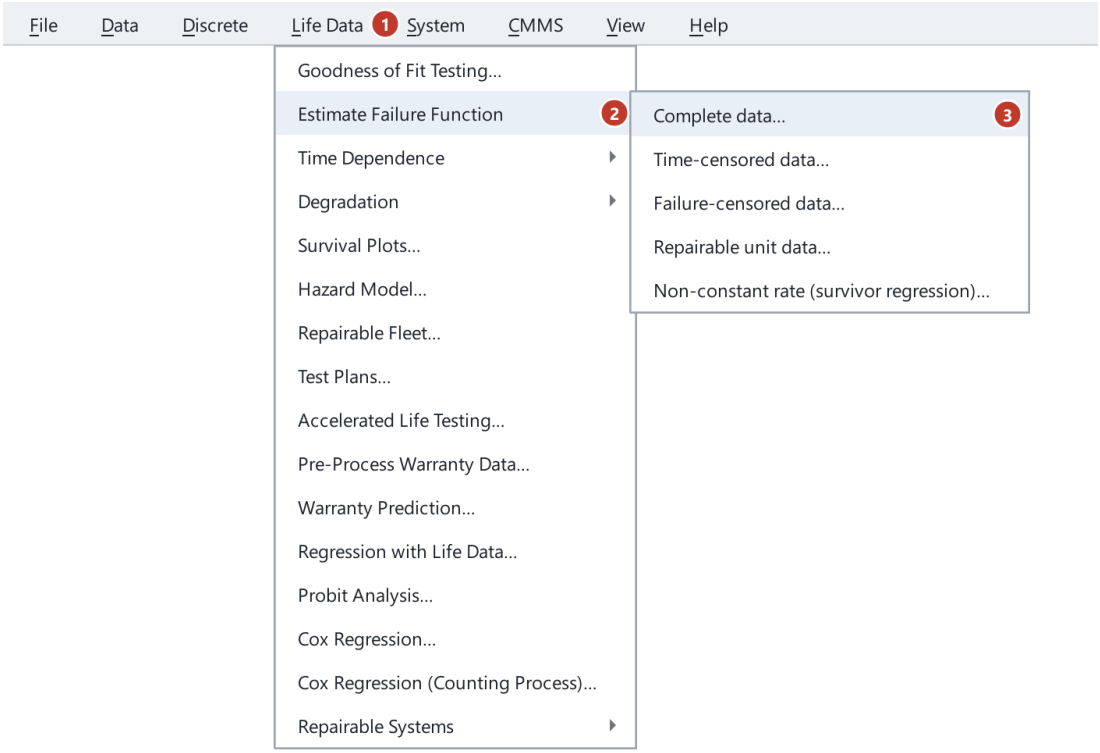
1. **Put the failure ages in column A.** Copy the 8 values of Example-1.csv that stand under its heading Failure times into column A of the worksheet, starting at row 1.

	① A	B
1	120	
2	250	
3	340	
4	480	
5	610	
6	745	
7	900	
8	1150	
9		

Step 1 — the failure ages in column A

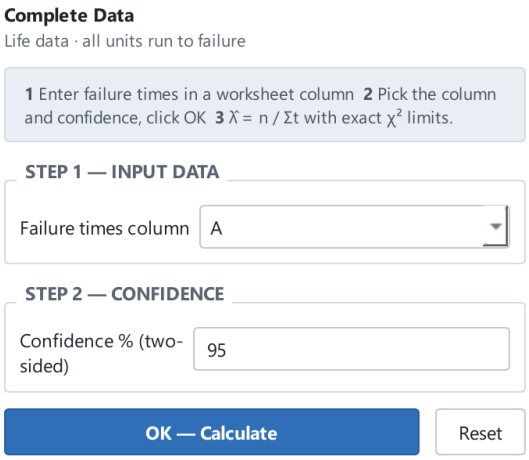
- ① Column A: the 8 failure ages, 120 to 1150.

2. **Choose Life Data ▸ Estimate Failure Function ▸ Complete data...** in the menu bar. The form Complete Data opens in the left panel.



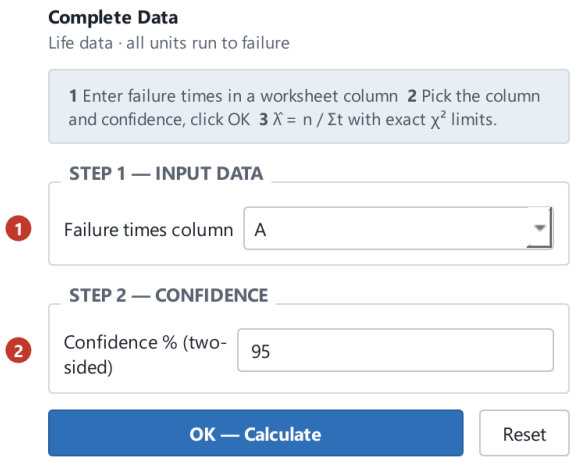
Step 2 — the menu path

- ① Life Data: the menu.
- ② Estimate Failure Function: the submenu.
- ③ Complete data...: the entry to click.



Step 2 — the form as it opens

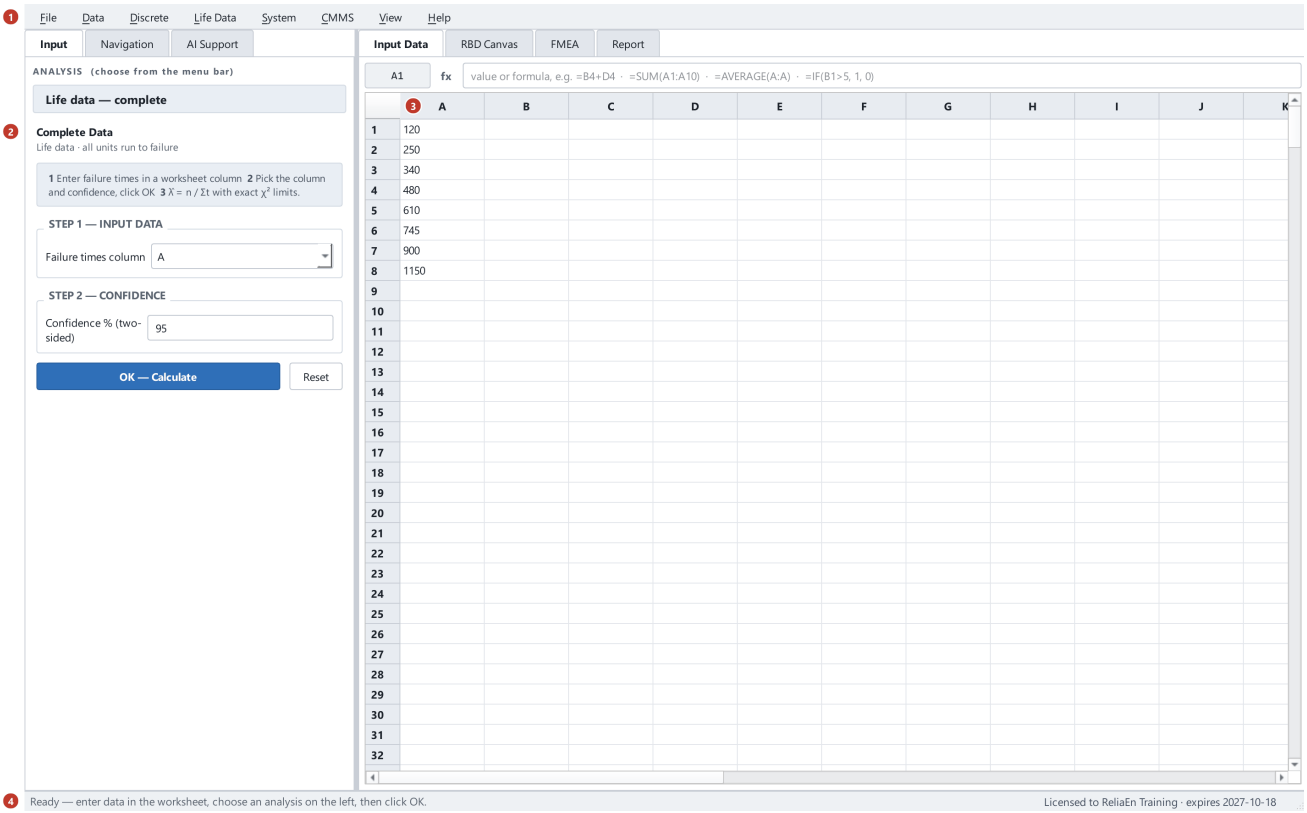
Steps 3 and 4 set the form's two boxes, marked ① and ② in the picture:



Steps 3 and 4 — the form set for this example

3. ① **In Failure times column, choose A.** This is the column that holds the failure ages.
4. ② **Check that Confidence % (two-sided) reads 95.** The confidence level of every interval in the report, on the rate and on the mean life.

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



Step 5 — 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 and 4; OK — Calculate at its foot.
- ③ Column A: the 8 failure ages.
- ④ 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

Life Data — Exponential (Complete data (all units failed))

2026-10-30 10:27:54

λ̂ = r / TTT ; χ² confidence limits

The report's head

- The title Life Data — Exponential (Complete data (all units failed)), the date and time of the run, and the method in one line: λ̂ = r / TTT ; χ^2 confidence limits.

INPUT DATA

1	Data situation	Complete data (all units failed)
2	n — units on test	8
3	r — failures	8
4	TTT — total time on test	4595
5	Confidence level	95% (two-sided)

Input data

- ① Data situation Complete data (all units failed): the kind of data ReliaEn used.
- ② n — units on test 8: the units in the data. Check n first: a blank cell is skipped, and n would then be lower than the rows you entered.
- ③ r — failures 8: for complete data every unit failed, so r = n.
- ④ TTT — total time on test 4595: the sum of the eight ages, in operating hours.
- ⑤ Confidence level 95% (two-sided): the level set in step 4.

RESULTS

1	λ̂ = r / TTT	0.00174102
2	MTTF̂ = 1 / λ̂	574.375
3	λ 95% CI	[0.00075165, 0.00313878]
4	MTTF 95% CI	[318.596, 1330.41]
5	B10 life	60.5164

Results

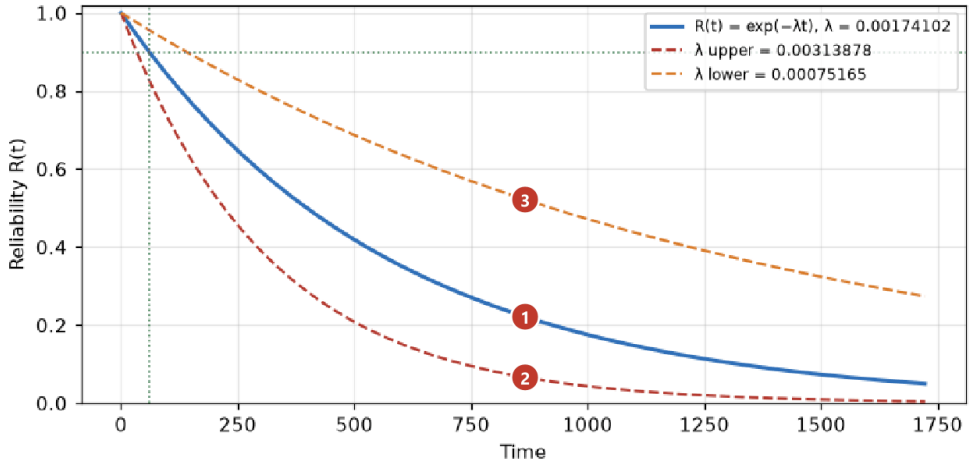
- ① λ̂ = r / TTT 0.00174102: 8 failures in 4,595 hours, about 1.7 failures per 1,000 operating hours.
- ② MTTF̂ = 1 / λ̂ 574.375: the mean life of a board, in operating hours.
- ③ λ 95% CI [0.00075165, 0.00313878]: the range that holds the true rate with 95% confidence.
- ④ MTTF 95% CI [318.596, 1330.41]: the same statement for the mean life - each end is the reciprocal of the other interval's opposite end.
- ⑤ B10 life 60.5164: one board in ten has failed by this age.

INTERPRETATION

1 The exponential model estimates a failure rate of λ = 0.00174102 per unit time (MTTF = 574.375). With 95% confidence the true MTTF lies between 318.596 and 1330.41. 10% of the population is expected to fail by t = 60.5164 (B10). Exact χ^2 limits per the censoring type were used (2r dof).

Interpretation

- ① ReliaEn's sentence: The exponential model estimates a failure rate of λ = 0.00174102 per unit time (MTTF = 574.375). With 95% confidence the true MTTF lies between 318.596 and 1330.41. 10% of the population is expected to fail by t = 60.5164 (B10). Exact χ^2 limits per the censoring type were used (2r dof). The rate, the mean life and its interval, B10, and the χ^2 rule (2r degrees of freedom).



Interactive Plot

Reliability against operating time

- ① R(t) = exp(−λt), λ = 0.00174102: the share of boards still running at each operating time, at the estimated rate.
- ② λ upper = 0.00313878: the curve at the upper rate - the cautious one, falling fastest.
- ③ λ lower = 0.00075165: the curve at the lower rate. The true curve lies between ② and ③ with 95% confidence.

SERVICE INTERVALS — OPERATING TIME TO STAY AT OR ABOVE TARGET RELIABILITY

1 Model: Exponential(λ = 0.00174102) — service before the unit accumulates this much operating time to keep reliability at or above the target.

2 Target R	3 Operating time t
95%	29.5
4 90%	60.5
85%	93.3
80%	128.2
75%	165.2
70%	204.9
65%	247.4
60%	293.4
55%	343.4
50%	398.1
45%	458.6
40%	526.3
35%	603.0
30%	691.5
25%	796.3
20%	924.4
15%	1,089.7
10%	1,322.5
5%	1,720.7

SERVICE INTERVALS — operating time to stay at or above target reliability

- ① Model: Exponential(λ = 0.00174102) — service before the unit accumulates this much operating time to keep reliability at or above the target.
- ② Target R: the reliability to keep, from 95% down to 5%.
- ③ Operating time t: the longest run that keeps it, t = −ln(R) / λ̂.
- ④ The 90% row: to keep the reliability at or above 90%, a board may run 60.5 hours - B10, rounded.

PREVENTIVE-MAINTENANCE OPTIMIZATION — NOT APPLICABLE

1 β = 1 — the exponential model is memoryless: a serviced machine is statistically identical to a repaired one, so preventive replacement cannot reduce failures (D23/D25). If wear-out is suspected, fit the Weibull model instead.

Preventive-Maintenance Optimization — not applicable

- ① β = 1 — the exponential model is memoryless: a serviced machine is statistically identical to a repaired one, so preventive replacement cannot reduce failures (D23/D25). If wear-out is suspected, fit the Weibull model instead. Under a constant rate a used board is as good as a new one, so the report computes no replacement age.

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The report's foot

- ① The licence line Licensed to ReliaEn Training · RL-2026-0017: the licence the report was made under.

Part 5 — How to interpret the results

The decision. The best estimate of a board's mean life is 574.375 operating hours ($\hat{\lambda}$ = 0.00174102 failures per hour), but eight failures only place it between 318.596 and 1330.41 hours at 95% confidence. For a commitment - the spares budget, a warranty reserve - plan with the conservative end: the upper rate 0.00313878 per hour, which is the same statement as the lower mean life 318.596 hours. $\hat{\lambda}$ is the most likely value, not a promise.

How much the data can tell. The upper rate is about four times the lower one. The width of the interval depends only on the number of failures: with more failures it narrows. If the interval is too wide to decide on, collect more failures; more calculation does not narrow it.

What follows for maintenance. One board in ten has failed by 60.5164 hours (B10). The service-interval table gives the longest run that keeps each target reliability, 60.5 hours for 90%. These rows assume the constant rate. Under a constant rate a used board is as good as a new one, so replacing boards early buys nothing - the report says so on its last card. If you suspect wear-out, test the constant rate (Life Data ▸ Goodness of Fit Testing…) or fit the Weibull model.