Regression with life data — which conditions change life, by how much, and the life at a new condition

Menu: Life Data ▸ Regression with Life Data...

Part 1 — What the function does

What it calculates. Units do not all run under the same conditions: some run hot, some carry a higher voltage or load, some come from another supplier. From one worksheet row per unit - its time to failure or its running time without failure, a censor flag, and up to three covariates (the measured conditions of that unit) - ReliaEn fits a life regression by maximum likelihood: ln T = b0 + b1·g(X1) + b2·g(X2) + b3·g(X3) + error, where each g is the transform you choose (x, ln x or 1/x) and the error follows a Weibull or a lognormal distribution with one common shape.

What ReliaEn prints	What it tells you
Common shape (β or σ) with its SE	The scatter of life around the regression line
Coefficients: each b with its SE, a likelihood-ratio test and a verdict	Which condition really changes life in this data, and how strongly
Life at X*: B10 with its interval, B50, MTTF, R at the mission time	The life to expect under the condition you type
A **caution** line for each X* outside the tested range	Where the prediction is an extrapolation
A residual probability plot	Whether the chosen distribution and transforms fit

From which data. One row per unit: the time, an optional censor flag (empty or 0 = failed, 1 = still running), and one to three covariate columns.

When an engineer uses it. When the units ran under different recorded conditions and the questions are which condition matters, and what life to expect at a new one.

When not to use it.

Situation	Use instead
A designed accelerated test with a named life-stress model	Life Data ▸ Accelerated Life Testing... (chapter 2.18)
No life distribution is to be assumed; the hazard ratio of each covariate is wanted	Life Data ▸ Cox Regression... (chapter 2.23)
Only the count failed at each stress level is known	Life Data ▸ Probit Analysis... (chapter 2.22)

Part 2 — The example's input data

Setting. A capacitor supplier tested 21 capacitors at 200 V, 300 V and 400 V until every one failed. The design runs them at 100 V, and the engineer wants to know how voltage changes their life and how many survive 20,000 hours at 100 V.

Voltage	Failure times, hours (7 at each voltage)
200 V	3307.5, 6396.5, 3219.0, 10708.2, 4269.6, 2217.4, 5292.2
300 V	253.6, 133.8, 991.2, 571.5, 732.3, 279.4, 1150.5
400 V	946.4, 539.0, 189.8, 271.1, 549.1, 1318.2, 609.5

Input	Value
Censor-flag column	none - every capacitor failed
Life distribution / X1 transform	Weibull / ln x (the inverse power model)
X1* (new condition) / Mission time t / Confidence %	100 / 20000 / 95
File in the worked-example zip	2-Regression-With-Life-Data/Example-3.csv — columns Time and X1 voltage, 21 rows

	① A	B	② C	D
1	3307.5		200	
2	6396.5		200	
3	3219.0		200	
4	10708.2		200	
5	4269.6		200	
6	2217.4		200	
7	5292.2		200	
8	253.6		300	
9	133.8		300	
10	991.2		300	
11	571.5		300	
12	732.3		300	
13	279.4		300	
14	1150.5		300	
15	946.4		400	
16	539.0		400	
17	189.8		400	
18	271.1		400	
19	549.1		400	
20	1318.2		400	
21	609.5		400	
22				

The example data in the worksheet

- ① Column A: the 21 failure times.
- ② Column C: the voltage of each capacitor. Column B stays empty: it is where censor flags would go.

Part 3 — How to use it, step by step

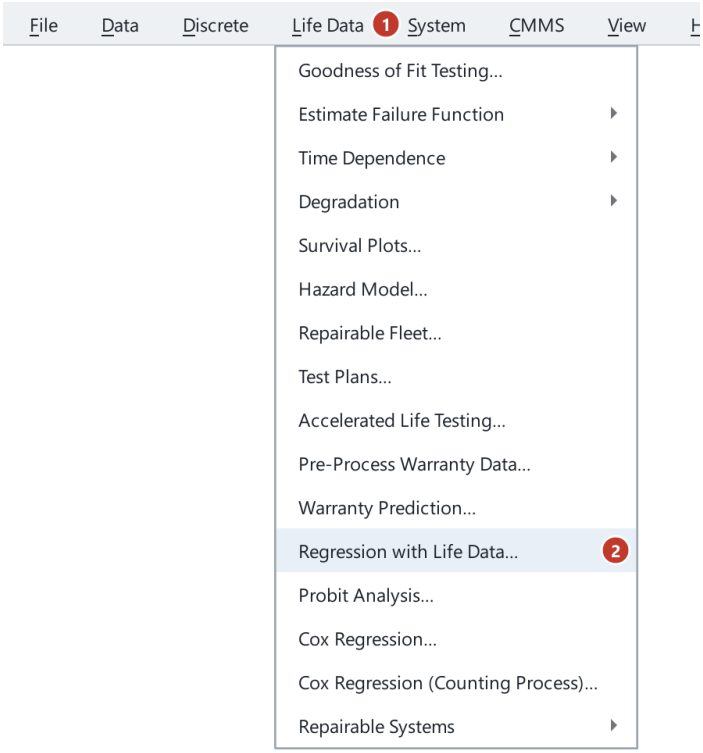
1. **Put the times in column A and the voltages in column C.** Copy the 21 values of Example-3.csv under its heading Time into column A and those under X1 voltage into column C, starting at row 1. Column B stays empty: it holds censor flags, and every capacitor failed.

	① A	B	② C	D
1	3307.5		200	
2	6396.5		200	
3	3219.0		200	
4	10708.2		200	
5	4269.6		200	
6	2217.4		200	
7	5292.2		200	
8	253.6		300	
9	133.8		300	
10	991.2		300	
11	571.5		300	
12	732.3		300	
13	279.4		300	
14	1150.5		300	
15	946.4		400	
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17	189.8		400	
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19	549.1		400	
20	1318.2		400	
21	609.5		400	
22				

Step 1 — the times in column A, the voltages in column C

- ① Column A: the 21 failure times, 133.8 to 10708.2 hours.
- ② Column C: the voltage of each capacitor - 200, 300 or 400.

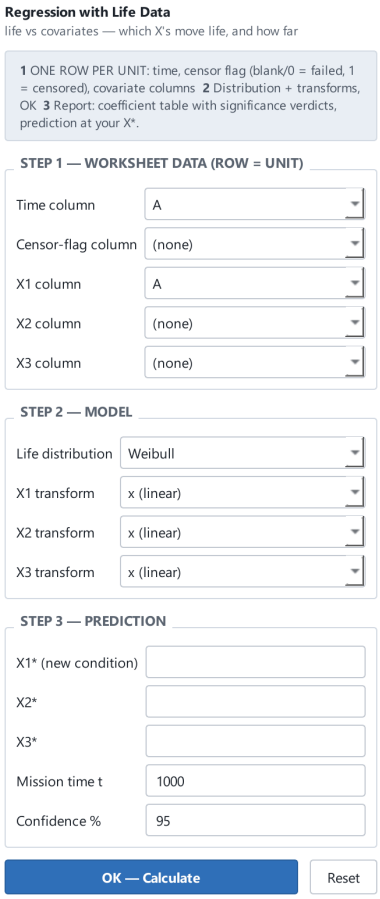
2. **Choose Life Data ▸ Regression with Life Data...** in the menu bar. The form Regression with Life Data opens in the left panel.



Step 2 — the menu path

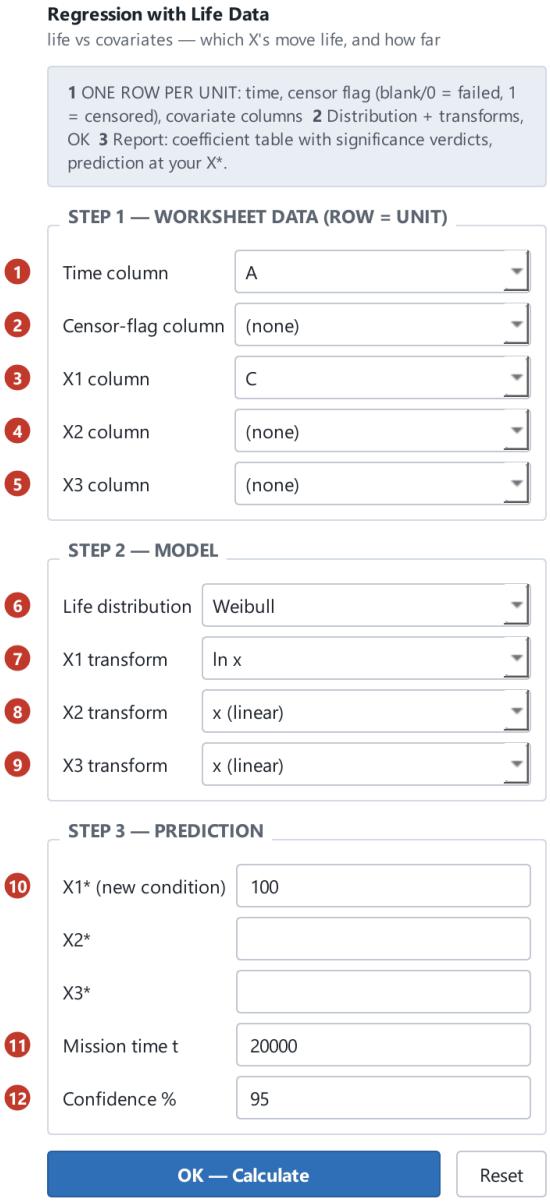
- ① Life Data: the menu.
- ② Regression with Life Data...: the entry to click.

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



Step 2 — the form as it opens

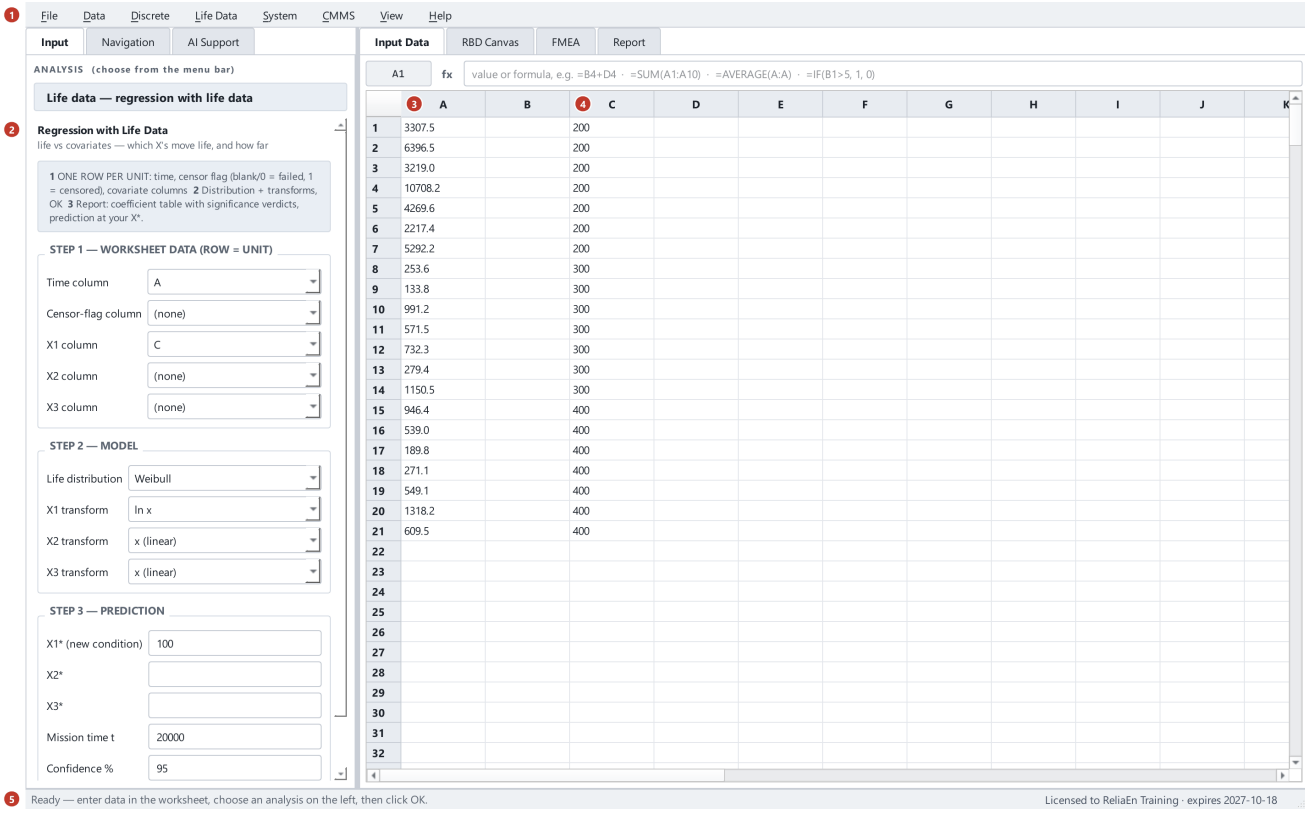
Steps 3 to 14 set or check the form's twelve boxes, marked ① to ⑫ in the picture:



Steps 3 to 14 — the form set for this example

3. ① **Check that Time column reads A.**
4. ② **Check that Censor-flag column reads (none).** Every capacitor failed.
5. ③ **In X1 column, choose C.**
6. ④ **Check that X2 column reads (none).**
7. ⑤ **Check that X3 column reads (none).**
8. ⑥ **Check that Life distribution reads Weibull.**
9. ⑦ **In X1 transform, choose ln x.** Voltage enters as its logarithm: the inverse power model.
10. ⑧ **Check that X2 transform reads x (linear).**
11. ⑨ **Check that X3 transform reads x (linear).** The X2 and X3 transforms are unused here.
12. ⑩ **In X1* (new condition), type 100.** The design voltage.
13. ⑪ **In Mission time t, type 20000.** It opens at 1000.
14. ⑫ **Check that Confidence % reads 95.**

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



Step 15 — 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 14; OK — Calculate at its foot.
- ③ Column A: the failure times.
- ④ Column C: the voltages.
- ⑤ 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 — Regression with Life Data

2026-11-04 08:33:01

ln T = b0 + Σ bj·g(Xj) + β·ε (weibull)

The report's head

- The title Life Data — Regression with Life Data, the date and time of the run, and the model in one line: ln T = b0 + Σ bj·g(Xj) + β·ε (weibull).

	INPUT DATA	
	Data	this worksheet — 21 failures / 0 censored, 1 covariate(s)
2	Model	ln T = b0 + Σ bj·g(Xj) + β-scaled Weibull error
3	Transforms	X1: ln x

Input data

- ① Data this worksheet — 21 failures / 0 censored, 1 covariate(s).
- ② Model ln T = b0 + Σ bj·g(Xj) + β-scaled Weibull error.
- ③ Transforms X1: ln x.

	RESULTS	
1	Common shape β	1.5111 (SE 0.2538)
2	Life at X* — B10	8,631.1 [2,844.6, 26,187.9] (95% CI)
3	Life at X* — B50 / MTTF	30,025.1 / 34,514.6
4	R(20000) at X*	0.6872

Results

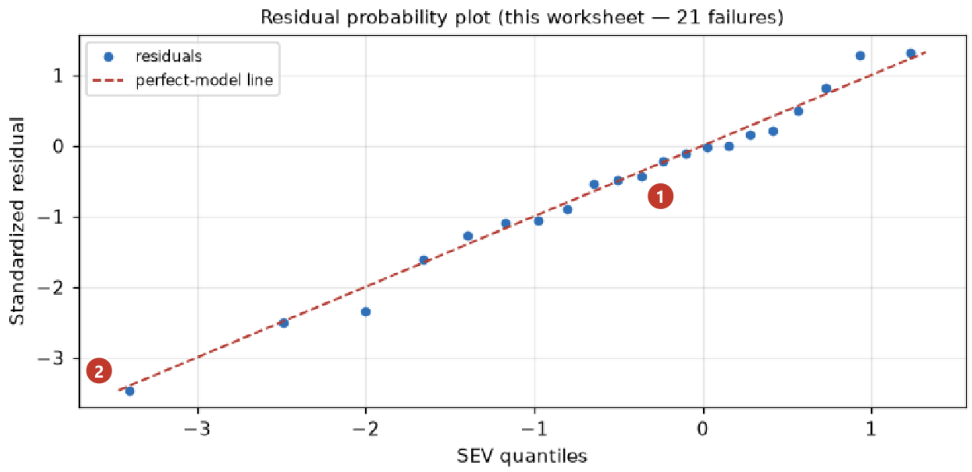
- ① Common shape β 1.5111 (SE 0.2538).
- ② Life at X* — B10 8,631.1 [2,844.6, 26,187.9] (95% CI): at 100 V.
- ③ Life at X* — B50 / MTTF 30,025.1 / 34,514.6.
- ④ R(20000) at X* 0.6872.

INTERPRETATION

1 Each coefficient moves LOG-life: bj > 0 means larger g(Xj) lengthens life multiplicatively (life × e^bj per unit of g). The LR verdict column is the honest filter — a covariate that fails it is noise dressed as a slope; refit without it before believing predictions.

Interpretation

- ① ReliaEn's reading: Each coefficient moves LOG-life: bj > 0 means larger g(Xj) lengthens life multiplicatively (life × e^bj per unit of g). The LR verdict column is the honest filter — a covariate that fails it is noise dressed as a slope; refit without it before believing predictions.



Interactive Plot

Residual probability plot (this worksheet — 21 failures)

- ① residuals: the 21 standardised residuals on the extreme-value grid of the Weibull.
- ② perfect-model line: points close to it support the Weibull and the ln x transform.

COEFFICIENTS (THIS WORKSHEET — 21 FAILURES / 0 CENSORED, 1 COVARIATE(S))

1 LR = 2·Δloglik dropping the term, ~ $\chi^2(1)$. Significance here is about THIS dataset's evidence, not the physics — a true effect can fail on a small sample.

2 Term	3 Estimate	4 SE	5 LR / p	6 Verdict
7 b0 (intercept)	24.6506	2.5089	–	–
8 b1 (X1, ln x)	-3.0614	0.4424	22.545 / 0.0000	significant

Coefficients (this worksheet — 21 failures / 0 censored, 1 covariate(s))

- ① LR = 2·Δloglik dropping the term, ~ $\chi^2(1)$. Significance here is about THIS dataset's evidence, not the physics — a true effect can fail on a small sample.
- ② to ⑥ The columns Term, Estimate, SE, LR / p, Verdict.
- ⑦ b0 (intercept) 24.6506, SE 2.5089.
- ⑧ b1 (X1, ln x) -3.0614, SE 0.4424, LR / p 22.545 / 0.0000, significant: the voltage exponent.

REGRESSION WITH LIFE DATA — CAUTION

1 X1 = 100 lies OUTSIDE the observed range [200, 400] — this prediction is an extrapolation riding on the model form.

Regression with Life Data — caution

- ① X1 = 100 lies OUTSIDE the observed range [200, 400] — this prediction is an extrapolation riding on the model form.

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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

Does voltage change life? Yes, strongly. The coefficient on ln V is b1 = −3.0614 (SE 0.4424), and dropping it loses so much fit that LR = 22.545 (p below 0.0001): significant. With ln x the coefficient is the voltage exponent of the inverse power model - life falls as voltage to the power 3.0614, so halving the voltage multiplies life by 2^3.0614, about 8.3.

The scatter. The common Weibull shape is β = 1.5111 (SE 0.2538): above 1, the capacitors wear out at any voltage.

Life at 100 V. One capacitor in ten fails by 8,631.1 hours (B10), half by 30,025.1 (B50); the mean life is 34,514.6 hours. At the 20,000-hour mission R = 0.6872: about one capacitor in three fails first. If the design must reach 20,000 hours, derate the voltage or plan a replacement.

How far to trust it. 100 V lies below every tested voltage, so the prediction is an extrapolation and the report says so in a caution card. The B10 interval, 2,844.6 to 26,187.9 hours, shows how loosely the data pin it down; a test level nearer 100 V would narrow it.