Accelerated life testing — failures at high stress carried down to the use condition

Menu: Life Data ▸ Accelerated Life Testing...

Part 1 — What the function does

What it calculates. Some parts last too long at their normal conditions to test them there. An accelerated life test runs units at a higher stress - a higher temperature, voltage or load - so that they fail within weeks. ReliaEn fits a life–stress model (Arrhenius (temperature), Inverse power (load, V, speed), Eyring or Linear (no transform)) and one life distribution whose shape is shared by every level, in one maximum likelihood fit over all levels, and carries the life down to the use condition.

What ReliaEn prints	What it tells you
Use-level η, **B10** with bounds, **B50 / MTTF**, **R(t) at use**	The life at the use condition, and the reliability over the mission
Acceleration factors	How much faster each tested level ages the units
Shape test and **linearity test**	Whether one failure mode is accelerated, and whether the life–stress line is the right form
Activation energy Ea and the extrapolation card	How far the answer is extrapolated, and whether the physics is plausible (0.3–1.2 eV)
Trust check	Whether 50 simulated re-tests of the same design agree with the analytic answer
Percentile table at use with bounds	By what age a share of units has failed at the use condition

From which data. The failure time of every failed unit with the stress it ran at, in two worksheet columns; the running time and stress of every unit that survived, in two more, if any. At least two distinct stress levels.

When an engineer uses it. When a component must be qualified for years of field life in weeks of testing, and the questions are its life at the field condition and how much that answer rests on the model.

When not to use it.

Situation	Use instead
Every unit ran at one stress level	Life Data ▸ Time Dependence ▸ Weibull (2P) distribution... (this form refuses a single level)
A demonstration test is to be sized before any data exists	Life Data ▸ Test Plans...
The stress is one of several covariates, not a test level	Life Data ▸ Regression with Life Data...

Part 2 — The example's input data

Setting. A power module is qualified at 85, 105 and 125 °C; in the field it runs at 40 °C, and the mission is 10,000 hours. Twenty-three modules fail on test; one runs 6,000 hours at 85 °C without failing. The reliability engineer wants the module's life at 40 °C and its reliability over the mission.

Input	Value
Failure times at 85 °C, hours (7)	1582.9, 3248.4, 1277.8, 4719.0, 5811.1, 3102.1, 1510.7
Failure times at 105 °C, hours (8)	1681.0, 1049.1, 530.5, 1023.5, 816.0, 564.6, 1332.0, 614.0
Failure times at 125 °C, hours (8)	189.9, 366.2, 249.4, 347.4, 326.5, 431.6, 6.7, 245.3
Survivor	6000 hours at 85 °C
Life-stress model / Life distribution	Arrhenius (temperature) / Weibull
Temperatures are °C (convert to K)	ticked
Use stress / Mission time t / Confidence %	40 / 10000 / 95
File in the worked-example zip	2-Accelerated-Life-Testing/Example-1.csv — columns Failure time, Failure stress (23), Censored time, Censored stress (1)

	① A	② B	③ C	④ D	E
1	1582.9	85	6000	85	
2	3248.4	85			
3	1277.8	85			
4	4719.0	85			
5	5811.1	85			
6	3102.1	85			
7	1510.7	85			
8	1681.0	105			
9	1049.1	105			
10	530.5	105			
11	1023.5	105			
12	816.0	105			
13	564.6	105			
14	1332.0	105			
15	614.0	105			
16	189.9	125			
17	366.2	125			
18	249.4	125			
19	347.4	125			
20	326.5	125			
21	431.6	125			
22	6.7	125			
23	245.3	125			
24					

The example data in the worksheet

- ① Column A: the 23 failure times, in hours.
- ② Column B: the temperature each failed module ran at, in °C.
- ③ Column C: the survivor's running time.
- ④ Column D: the survivor's temperature.

Part 3 — How to use it, step by step

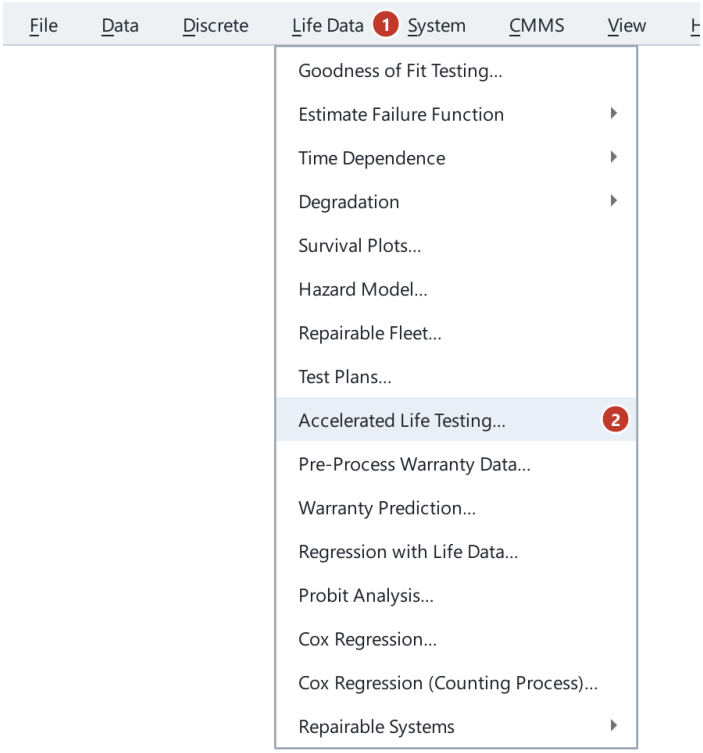
1. **Put the test results in columns A to D.** Copy the values of Example-1.csv into the worksheet, starting at row 1: its Failure time and Failure stress columns (23 rows) into columns A and B, its Censored time and Censored stress (1 row) into columns C and D.

	① A	② B	③ C	④ D	E
1	1582.9	85	6000	85	
2	3248.4	85			
3	1277.8	85			
4	4719.0	85			
5	5811.1	85			
6	3102.1	85			
7	1510.7	85			
8	1681.0	105			
9	1049.1	105			
10	530.5	105			
11	1023.5	105			
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19	347.4	125			
20	326.5	125			
21	431.6	125			
22	6.7	125			
23	245.3	125			
24					

Step 1 — the test results in columns A to D

- ① Column A: the 23 failure times, 6.7 to 5811.1 hours.
- ② Column B: the temperature each failed module ran at - 85, 105 or 125 °C.
- ③ Column C: the survivor's 6000 hours.
- ④ Column D: the survivor's 85 °C.

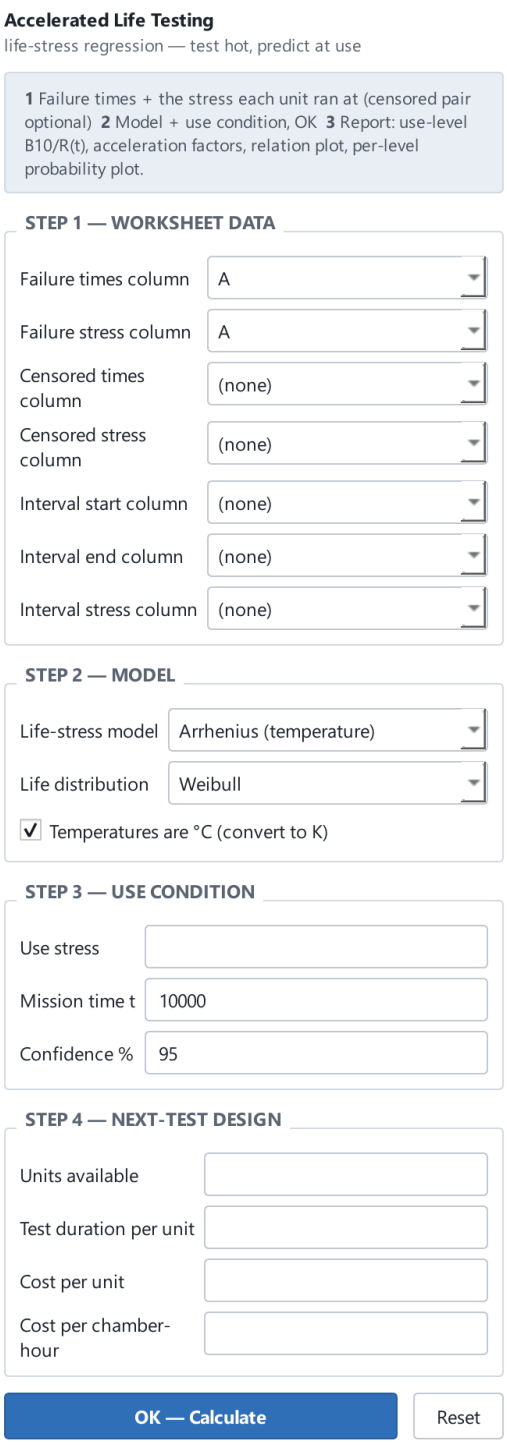
2. **Choose Life Data ▸ Accelerated Life Testing...** in the menu bar. The form Accelerated Life Testing opens in the left panel.



Step 2 — the menu path

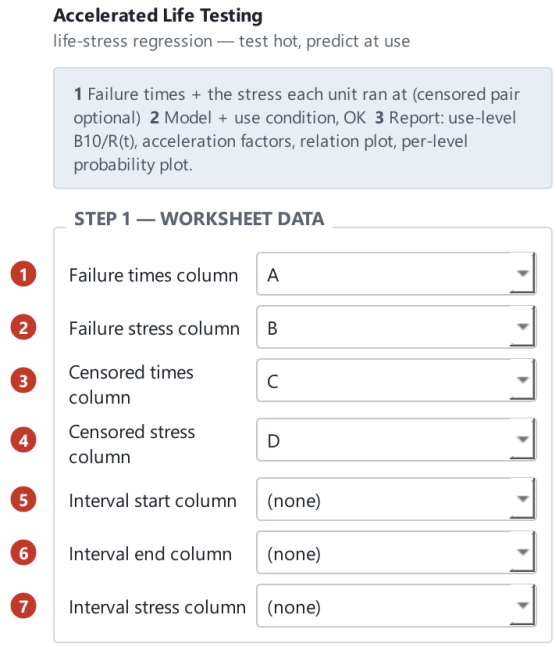
- ① Life Data: the menu.
- ② Accelerated Life Testing...: the entry to click.

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

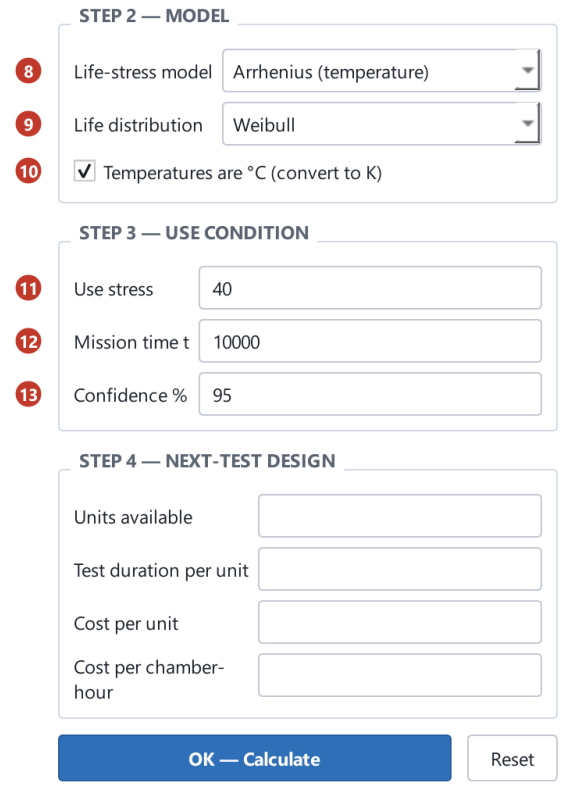


Step 2 — the form as it opens

Steps 3 to 15 set or check the form's thirteen boxes, shown in two pictures - STEP 1 — WORKSHEET DATA with ① to ⑦, then STEP 2 — MODEL and STEP 3 — USE CONDITION with ⑧ to ⑬:



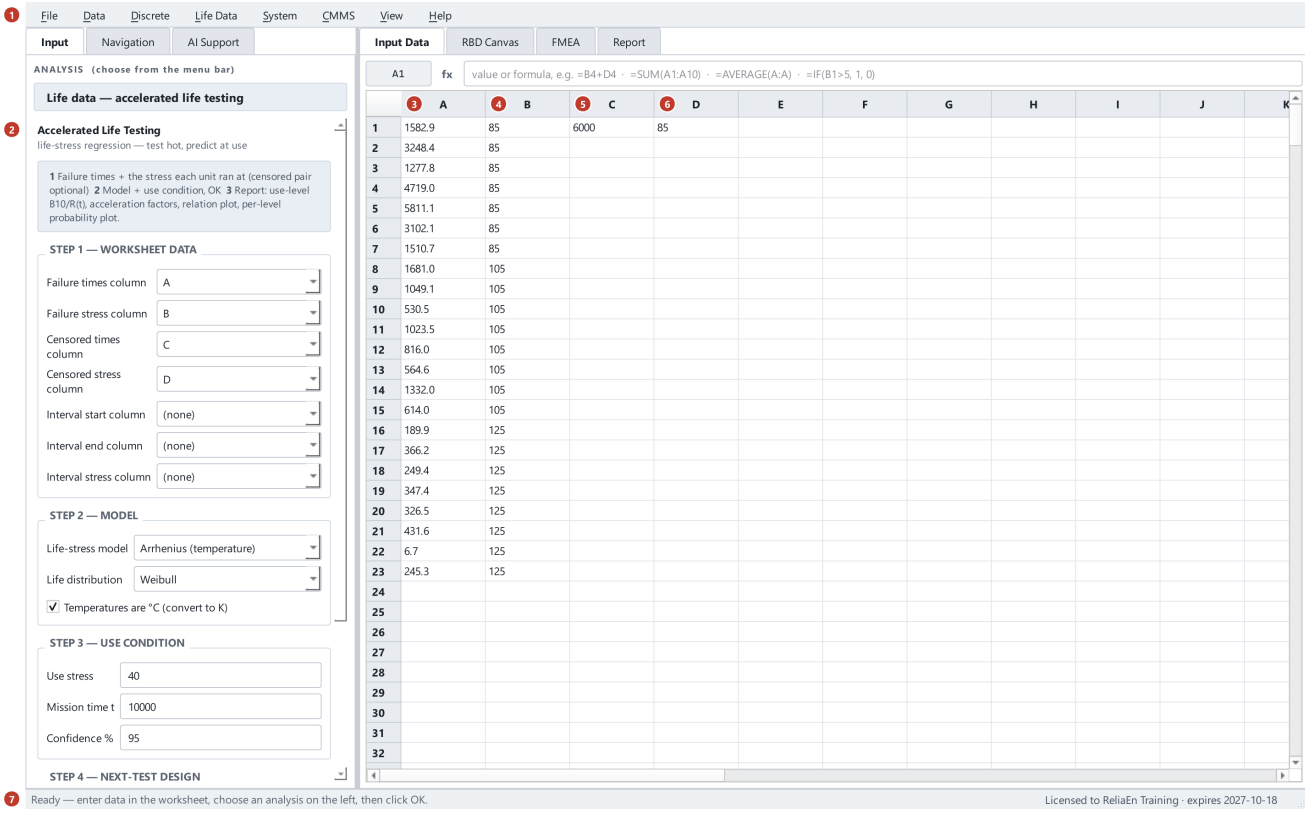
Steps 3 to 9 — the worksheet boxes set for this example



Steps 10 to 15 — the model and use-condition boxes set for this example

3. ① **Check that Failure times column reads A.**
4. ② **In Failure stress column, choose B.**
5. ③ **In Censored times column, choose C.**
6. ④ **In Censored stress column, choose D.**
7. ⑤ **Check that Interval start column reads (none).** The three interval boxes are for units found failed at an inspection.
8. ⑥ **Check that Interval end column reads (none).**
9. ⑦ **Check that Interval stress column reads (none).**
10. ⑧ **Check that Life-stress model reads Arrhenius (temperature).**
11. ⑨ **Check that Life distribution reads Weibull.**
12. ⑩ **Check that Temperatures are °C (convert to K) is ticked.** ReliaEn adds 273.15 to every temperature: the Arrhenius model works in kelvin.
13. ⑪ **In Use stress, type 40.**
14. ⑫ **Check that Mission time t reads 10000.**
15. ⑬ **Check that Confidence % reads 95.** The boxes of STEP 4 — NEXT-TEST DESIGN stay empty in this example.

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



Step 16 — 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 15; OK — Calculate at its foot.
- ③ Column A: the failure times.
- ④ Column B: the failure temperatures.
- ⑤ Column C: the survivor's time.
- ⑥ Column D: the survivor's temperature.
- 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

Life Data — Accelerated Life Testing

2026-11-04 07:18:55

Arrhenius: ln η = a + b/T ; combined censored MLE, common β

The report's head

- The title Life Data — Accelerated Life Testing, the date and time of the run, and the model in one line: Arrhenius: ln η = a + b/T; combined censored MLE, common β.

INPUT DATA

1	Data	this worksheet — 23 failures / 1 censored, 3 stress levels
2	Life-stress model	Arrhenius: ln η = a + b/T
3	Life distribution	weibull
4	Stress handling	°C converted to K (+273.15)
5	Use condition	stress 40, mission 10000

Input data

- ① Data this worksheet — 23 failures / 1 censored, 3 stress levels.
- ② Life-stress model Arrhenius: ln η = a + b/T.
- ③ Life distribution weibull.
- ④ Stress handling °C converted to K (+273.15).
- ⑤ Use condition stress 40, mission 10000.

RESULTS

1	Fitted a	-17.8451 (SE 2.3940)
2	Fitted b	9371.9891 (SE 904.9640)
3	Common shape β	2.0337 (SE 0.3575)
4	Activation energy Ea	0.808 eV
5	Use-level η	176,835.9
6	Use-level B10	58,479.9 [19,687.9, 173,706.1]
7	Use-level B50 / MTTF	147,673.3 / 156,674.4
8	R(10000) at use	0.9971

Results

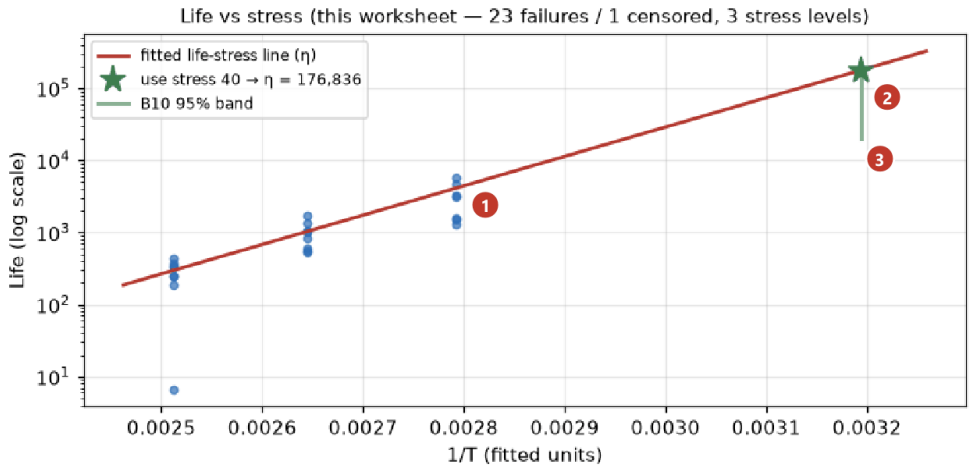
- ① Fitted a -17.8451 (SE 2.3940).
- ② Fitted b 9371.9891 (SE 904.9640): the slope of ln η against 1/T.
- ③ Common shape β 2.0337 (SE 0.3575): one shape for all three levels.
- ④ Activation energy Ea 0.808 eV: b times Boltzmann's constant.
- ⑤ Use-level η 176,835.9.
- ⑥ Use-level B10 58,479.9 [19,687.9, 173,706.1].
- ⑦ Use-level B50 / MTTF 147,673.3 / 156,674.4.
- ⑧ R(10000) at use 0.9971: the reliability over the mission at 40 °C.

INTERPRETATION

1 Units tested at high stress fail sooner; the life-stress line carries those failures down to the use condition. Everything below the lowest tested stress rides on the model assumption (stated above) — the acceleration table shows how far each level is being stretched.

Interpretation

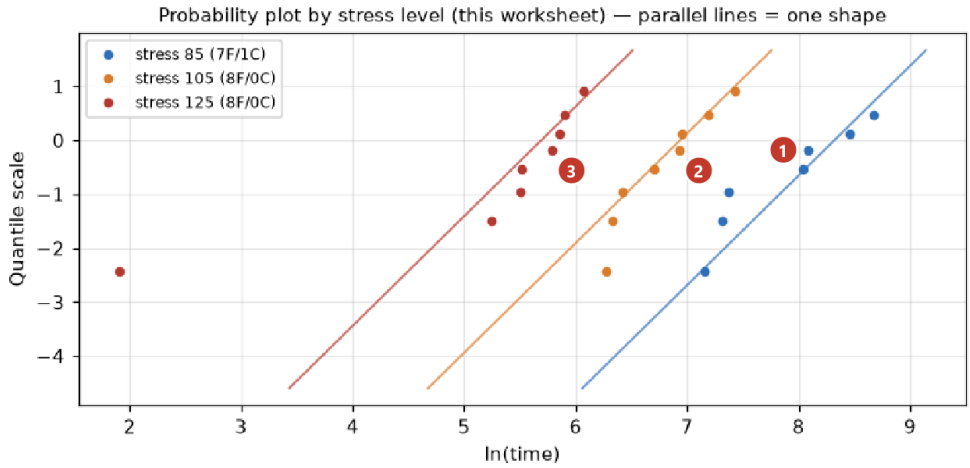
- ① ReliaEn's reading: Units tested at high stress fail sooner; the life-stress line carries those failures down to the use condition. Everything below the lowest tested stress rides on the model assumption (stated above) — the acceleration table shows how far each level is being stretched.



Interactive Plot

Life vs stress (this worksheet — 23 failures / 1 censored, 3 stress levels)

- ① fitted life-stress line (η): straight on these axes, life on a log scale against 1/T.
- ② use stress 40 → η = 176,836: the star, far to the right of the tested levels.
- ③ B10 95% band: the bar under the star.



Interactive Plot

Probability plot by stress level (this worksheet) — parallel lines = one shape

- ① stress 85 (7F/1C): 7 failures and 1 survivor.
- ② stress 105 (8F/0C).
- ③ stress 125 (8F/0C): its 6.7-hour failure stands apart at the far left.

The three lines are parallel: one shape fits every level.

ACCELERATION FACTORS — EACH TESTED LEVEL → USE (THIS WORKSHEET — 23 FAILURES / 1 CENSORED, 3 STRESS LEVELS)

1 AF = life at use / life at that level, from the fitted model. Large factors mean heavy extrapolation — the model choice carries the answer.

Tested stress	AF to use
85	42.96
105	171.46
125	595.42

Acceleration factors — each tested level → use (this worksheet — 23 failures / 1 censored, 3 stress levels)

- ① AF = life at use / life at that level, from the fitted model. Large factors mean heavy extrapolation — the model choice carries the answer.
- ② 85: 42.96.
- ③ 105: 171.46.
- ④ 125: 595.42.

STRESS LEVELS (THIS WORKSHEET — 23 FAILURES / 1 CENSORED, 3 STRESS LEVELS)

1 Model η at each level — compare against the probability plot's per-level points to judge the fit by eye.

2 Stress	3 Failures	4 Censored	5 Model η
85	7	1	4,116.0
105	8	0	1,031.4
125	8	0	297.0

Stress levels (this worksheet — 23 failures / 1 censored, 3 stress levels)

- ① Model η at each level — compare against the probability plot's per-level points to judge the fit by eye.
- ② to ⑤ The columns Stress, Failures, Censored, Model η.
- ⑥ 85: 7 failures, 1 censored, η 4,116.0.
- ⑦ 105: 8, 0, η 1,031.4.
- ⑧ 125: 8, 0, η 297.0.

CAN ONE SHAPE DESCRIBE EVERY LEVEL? (THIS WORKSHEET — 23 FAILURES / 1 CENSORED, 3 STRESS LEVELS)

1. Shape test: LR = 1.452, p = 0.484 — one β describes every level; the acceleration is transporting ONE failure mode. Linearity: LR = 0.001, p = 0.974 — the life-stress line fits the level lives.

2 Stress	3 β (own fit)	4 log-likelihood
5 85	1.7840	-63.504
6 105	2.7102	-58.570
7 125	1.7217	-51.669
8 COMMON	2.0337	-174.469

Can one shape describe every level? (this worksheet — 23 failures / 1 censored, 3 stress levels)

- ① Shape test: LR = 1.452, p = 0.484 — one β describes every level; the acceleration is transporting ONE failure mode. Linearity: LR = 0.001, p = 0.974 — the life-stress line fits the level lives.
- ② to ④ The columns Stress, β (own fit), log-likelihood.
- ⑤ 85: β 1.7840, -63.504.
- ⑥ 105: β 2.7102, -58.570.
- ⑦ 125: β 1.7217, -51.669.
- ⑧ COMMON: β 2.0337, -174.469.

HOW FAR IS THIS EXTRAPOLATION? (FLEET FIT)

1. The use condition sits 42.96× beyond the mildest tested level (1.63 decades of extrapolation) — everything past the data rides on the model assumption. Fitted Ea = 0.81 eV sits inside the usual 0.3–1.2 eV window for thermal mechanisms — the physics is plausible.

How far is this extrapolation? (fleet fit)

- ① The use condition sits 42.96× beyond the mildest tested level (1.63 decades of extrapolation) — everything past the data rides on the model assumption. Fitted Ea = 0.81 eV sits inside the usual 0.3–1.2 eV window for thermal mechanisms — the physics is plausible.

TRUST CHECK — SEEDED SIMULATION (ALT FIT)

1. 50 simulated re-tests of this exact design put the use-level B10 between 23,106 and 147,382 (5–95%). The analytic answer 58,480 sits inside that range — the two routes agree.

Trust check — seeded simulation (ALT fit)

- ① 50 simulated re-tests of this exact design put the use-level B10 between 23,106 and 147,382 (5–95%). The analytic answer 58,480 sits inside that range — the two routes agree.

PERCENTILE TABLE AT USE STRESS 40 — B-LIVES WITH BOUNDS

1 Delta-method bounds on ln B_p at the use level — the same machinery as the use-level B10 band; that row appears here as the 10% line.

2 Percentile	3 B-life	4 95% bounds
1%	18,416.8	[5,013.0, 67,659.4]
5%	41,047.6	[13,084.4, 128,772.5]
5 10%	58,479.9	[19,687.9, 173,706.1]
25%	95,831.9	[34,148.5, 268,935.6]
50%	147,673.3	[54,140.5, 402,792.9]
75%	207,645.7	[76,677.0, 562,316.7]
90%	266,487.8	[98,063.0, 724,185.0]
95%	303,301.2	[111,085.9, 828,112.4]
99%	374,712.6	[135,623.2, 1,035,291.0]

Percentile table at use stress 40 — B-lives with bounds

- ① Delta-method bounds on ln B_p at the use level — the same machinery as the use-level B10 band; that row appears here as the 10% line.
- ② to ④ The columns Percentile, B-life, 95% bounds.
- ⑤ The 10% row: 58,479.9 [19,687.9, 173,706.1] - the B10 of the results card.

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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 life at 40 °C. The characteristic life at use is 176,835.9 hours; one module in ten fails by 58,479.9 hours (B10), half by 147,673.3 hours, and the mean life is 156,674.4 hours. Over the 10,000-hour mission the reliability is 0.9971. Where an early failure is costly, plan with B10's lower bound, 19,687.9 hours, not the estimate.

One failure mode, a straight line. The levels' own shapes are 1.7840, 2.7102 and 1.7217 against the common 2.0337; the shape test gives p = 0.484 and the linearity test p = 0.974. Neither rejects: the stress speeds up one failure mode without changing it, and the Arrhenius line fits the level lives. The common shape above 1 says the modules wear out.

How far the answer is stretched. The acceleration factors are 42.96 at 85 °C, 171.46 at 105 °C and 595.42 at 125 °C: the use point lies 1.63 decades beyond the mildest tested level, and everything past the data rides on the model. The activation energy, 0.808 eV, sits inside the usual 0.3–1.2 eV window for thermal failure, so the physics is plausible. A lower test level would shorten the stretch if the answer must be firmer.

Would a repeat agree? Fifty simulated re-tests of this design put the B10 at use between 23,106 and 147,382 hours; the analytic 58,480 lies inside, so the bounds on the Results card can be used.