Probit analysis — a stress-response curve from pass/fail counts

Menu: Life Data ▸ Probit Analysis...

Part 1 — What the function does

What it calculates. Sometimes the moment each unit fails cannot be measured: a stress is applied - a voltage, a shock load, a drop height - and afterwards the failed units are counted. From one row per stress level - the stress, the units tested and the units that failed - ReliaEn fits a response curve, the probability of failure as a function of the stress: P(fail at s) = F(b0 + b1·g(s)), where F is the link you choose (normal for probit, logistic for logit, extreme value for complementary log-log) and g is the stress as it is or its logarithm. From the curve it reads the stress at which a given share of units fails.

What ReliaEn prints	What it tells you
b0 and **b1** with their SE, and the **slope Z** test	Where the curve sits and how steeply failure rises with stress - and whether it rises at all
Deviance GOF	Whether the curve fits the levels
Stress percentiles SP1 to SP99 with bounds	The stress at which 1 % to 99 % of units fail: screening and proof levels
P(survive design stress) (with a design stress), and survival at a list of stresses	The share of units that survive the stress they will really see
Levels as read	Each level's observed fraction against the fitted one

Optionally a natural response (units failing whatever the stress) and a factor (several groups with one common slope, and their relative potency).

From which data. One worksheet row per stress level: the stress, the number tested and the number failed.

When an engineer uses it. When each unit is tested once at one stress and the result is pass or fail: proof tests, drop and shock tests, screening at a fixed stress.

When not to use it.

Situation	Use instead
Each unit's time to failure is known, under different conditions	Life Data ▸ Regression with Life Data... (chapter 2.21)
An accelerated test with times to failure at each level	Life Data ▸ Accelerated Life Testing... (chapter 2.18)

Part 2 — The example's input data

Setting. A qualification laboratory applies eight levels of a stress, recorded on a logarithmic scale, to batches of about sixty units, and counts the failures in each batch: 481 units in all. It wants the stress for a proof test that fails at most one unit in ten, and the survival at its design stress of 1.70.

Stress	1.6907	1.7242	1.7552	1.7842	1.8113	1.8369	1.8610	1.8839
Tested	59	60	62	56	63	59	62	60
Failed	6	13	18	28	52	53	61	60

Input	Value
Link / Stress transform	Probit (normal) / Stress as-is
Design stress (optional) / Confidence %	1.70 / 95
File in the worked-example zip	2-Probit-Analysis/Example-1.csv — columns Stress, Trials and Events, 8 rows

	A	B	C	D
1	1.6907	59	6	
2	1.7242	60	13	
3	1.7552	62	18	
4	1.7842	56	28	
5	1.8113	63	52	
6	1.8369	59	53	
7	1.861	62	61	
8	1.8839	60	60	
9				

The example data in the worksheet

- ① Column A: the eight stress levels.
- ② Column B: the units tested at each.
- ③ Column C: the units failed at each.

Part 3 — How to use it, step by step

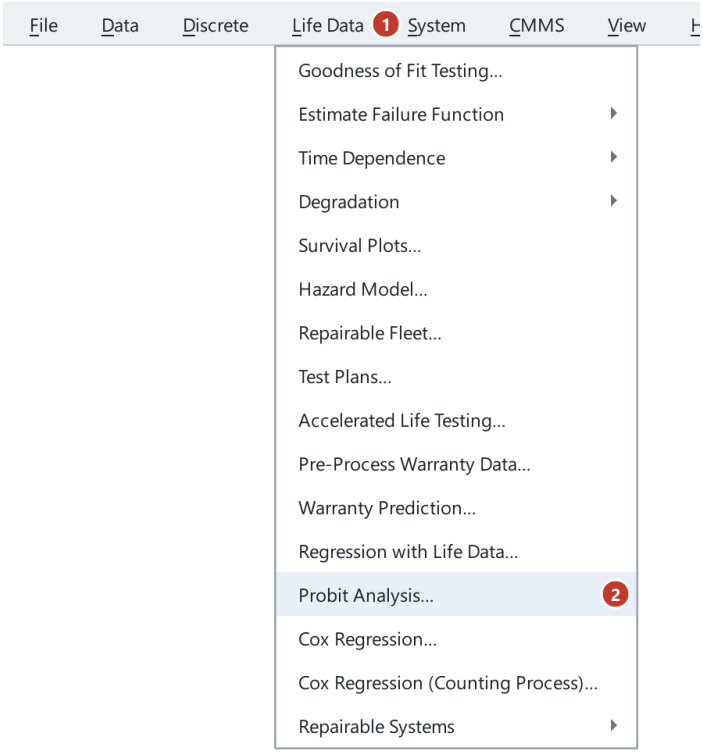
1. **Put the stress levels in columns A to C.** Copy the 8 rows of Example-1.csv - its columns Stress, Trials and Events - into columns A, B and C of the worksheet, starting at row 1.

	A	B	C	D
1	1.6907	59	6	
2	1.7242	60	13	
3	1.7552	62	18	
4	1.7842	56	28	
5	1.8113	63	52	
6	1.8369	59	53	
7	1.861	62	61	
8	1.8839	60	60	
9				

Step 1 — the stress levels in columns A to C

- ① Column A: the eight stress levels, 1.6907 to 1.8839.
- ② Column B: the units tested at each.
- ③ Column C: the units failed at each.

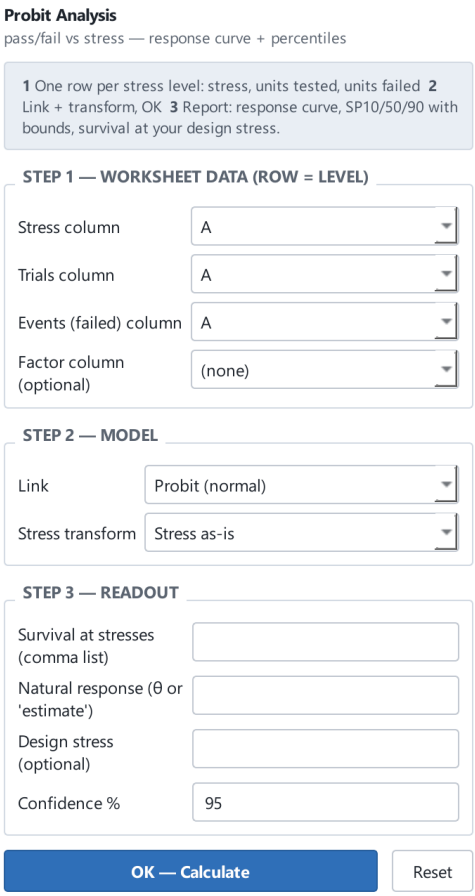
2. **Choose Life Data ▸ Probit Analysis...** in the menu bar. The form Probit Analysis opens in the left panel.



Step 2 — the menu path

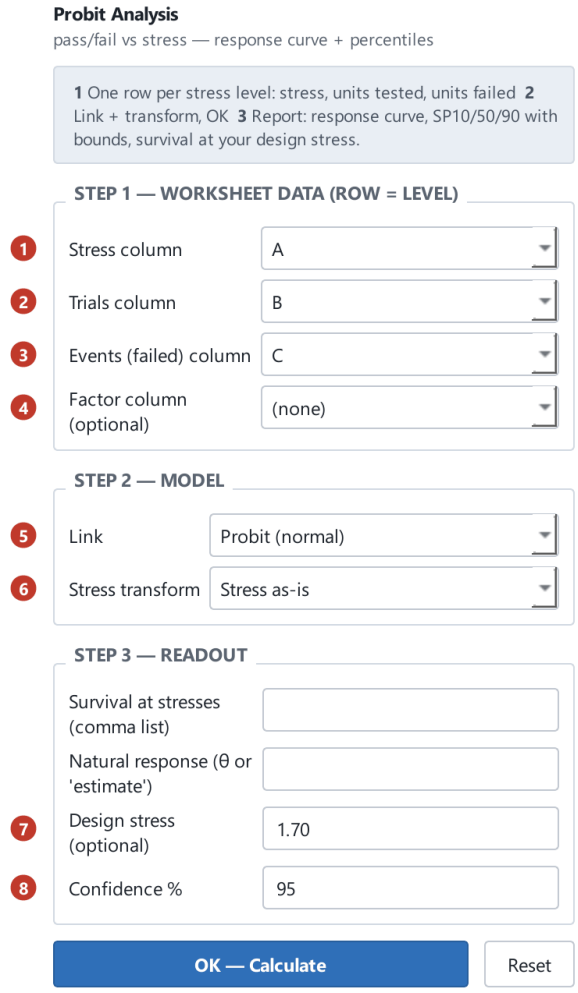
- ① Life Data: the menu.
- ② Probit Analysis...: the entry to click.

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



Step 2 — the form as it opens

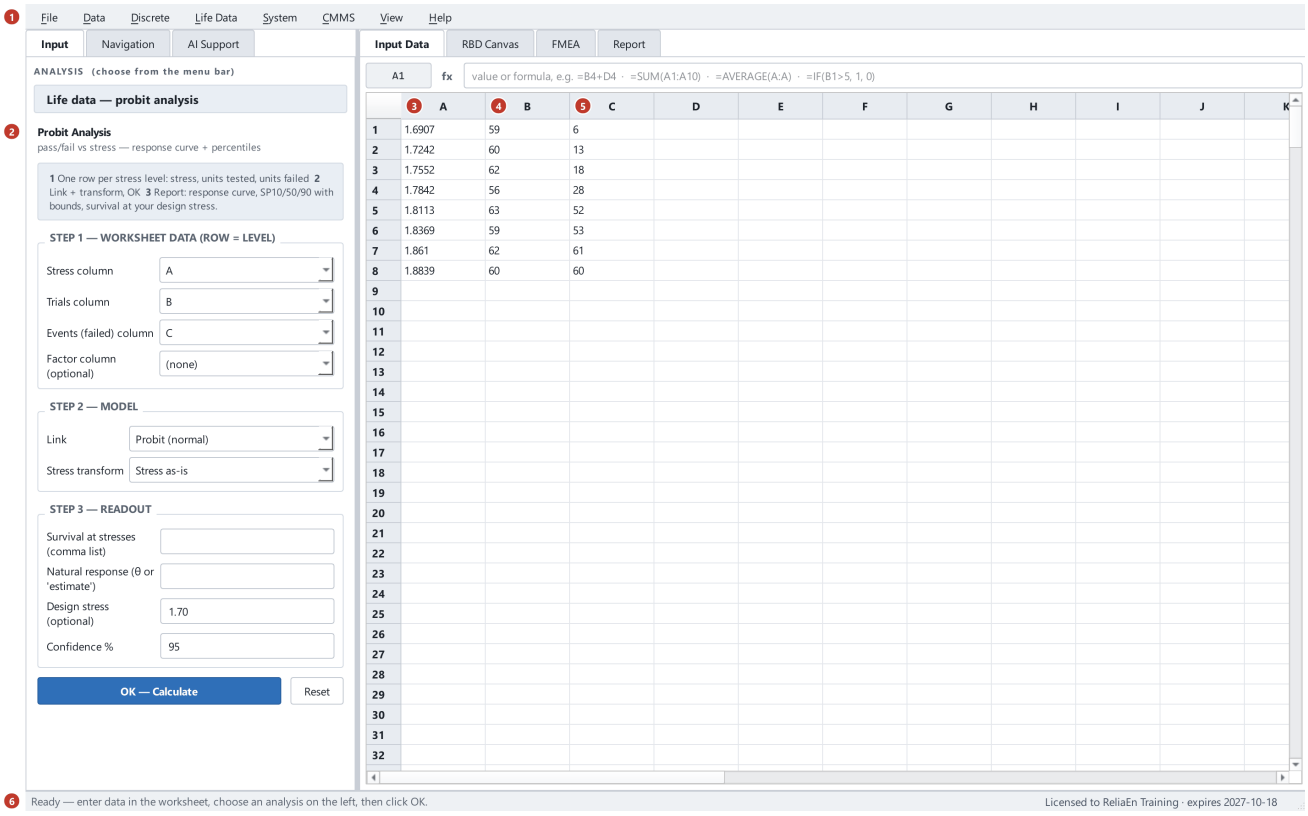
Steps 3 to 10 set or check the form's eight boxes, marked ① to ⑧ in the picture:



Steps 3 to 10 — the form set for this example

3. ① **Check that Stress column reads A.**
4. ② **In Trials column, choose B.**
5. ③ **In Events (failed) column, choose C.**
6. ④ **Check that Factor column (optional) reads (none).** One population, no groups.
7. ⑤ **Check that Link reads Probit (normal).**
8. ⑥ **Check that Stress transform reads Stress as-is.** The stress is already on a logarithmic scale.
9. ⑦ **In Design stress (optional), type 1.70.** The stress the units will see in service.
10. ⑧ **Check that Confidence % reads 95.**

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



Step 11 — 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 10; OK — Calculate at its foot.
- ③ Column A: the stress levels.
- ④ Column B: the units tested.
- ⑤ Column C: the units failed.
- ⑥ 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 — Probit Analysis

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P(fail | s) = F(b0 + b1·g(s)) ; SP_p: g(SP) = (z_p − b0)/b1

The report's head

- The title Life Data — Probit Analysis, the date and time of the run, and the model in one line: P(fail | s) = F(b0 + b1·g(s)); SP_p: g(SP) = (z_p − b0)/b1.

	INPUT DATA	
1	Data	this worksheet — 8 stress levels, 481 units
2	Link / transform	probit / stress as-is
3	Confidence	95%

Input data

- ① Data this worksheet — 8 stress levels, 481 units.
- ② Link / transform probit / stress as-is.
- ③ Confidence 95%.

	RESULTS	
1	b0 (intercept)	-34.9353 (SE 2.6479)
2	b1 (slope)	19.7279 (SE 1.4872)
3	Slope Z (b1/SE)	13.2648 → p = 0.0000 — the dose-response exists
4	Log-likelihood	-185.6792 (binomial kernel)
5	Deviance GOF	10.1198 on 6 dof → p = 0.1197
6	P(survive design stress 1.7)	0.9189 [0.8695, 0.9527]

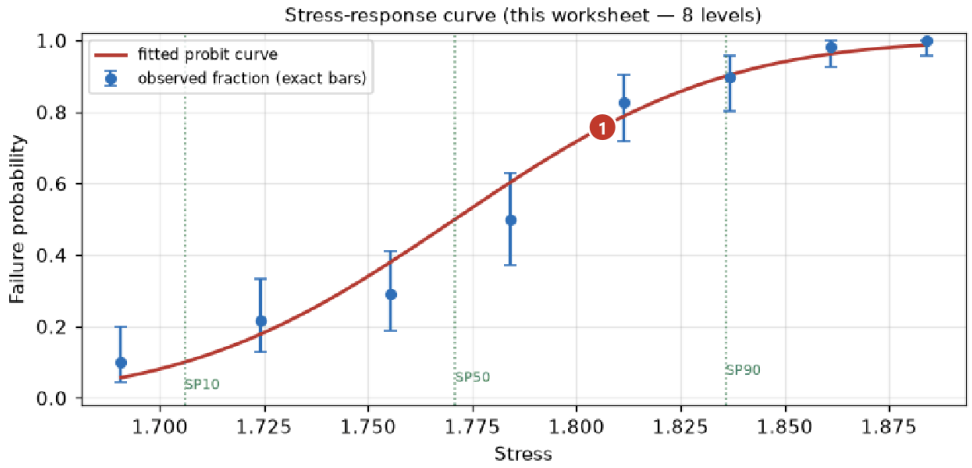
Results

- ① b0 (intercept) -34.9353 (SE 2.6479).
- ② b1 (slope) 19.7279 (SE 1.4872).
- ③ Slope Z (b1/SE) 13.2648 → p = 0.0000 — the dose-response exists.
- ④ Log-likelihood -185.6792 (binomial kernel): for comparing fits of these same data only.
- ⑤ Deviance GOF 10.1198 on 6 dof → p = 0.1197: the curve fits the levels.
- ⑥ P(survive design stress 1.7) 0.9189 [0.8695, 0.9527].

	INTERPRETATION
1	The curve turns pass/fail counts into a stress scale: SP10 is the stress that breaks the weakest 10% — the screening/proof level; SP50 locates the middle of the population. The deviance says the curve fits the levels.

Interpretation

- ① ReliaEn's reading: The curve turns pass/fail counts into a stress scale: SP10 is the stress that breaks the weakest 10% — the screening/proof level; SP50 locates the middle of the population. The deviance says the curve fits the levels.



Interactive Plot

Stress-response curve (this worksheet — 8 levels)

- ① fitted probit curve: the probability of failure rising with the stress, through the eight observed fractions and their error bars; drop-lines mark SP10, SP50 and SP90.

STRESS PERCENTILES (THIS WORKSHEET — 8 STRESS LEVELS, 481 UNITS)

1 SP_p solves F(b0 + b1·g(SP)) = p; bounds by the delta method on (b0, b1). Tail percentiles lean on the LINK choice — links agree in the middle and diverge in the tails.

2 Percentile	3 Stress	4 95% bounds
SP1	1.6529	[1.6328, 1.6731]
SP5	1.6875	[1.672, 1.703]
SP10	1.7059	[1.6927, 1.719]
SP25	1.7367	[1.7269, 1.7464]
SP50	1.7709	[1.7634, 1.7783]
SP75	1.805	[1.7968, 1.8133]
SP90	1.8358	[1.8247, 1.8469]
SP95	1.8542	[1.841, 1.8675]
SP99	1.8888	[1.8711, 1.9065]

Stress percentiles (this worksheet — 8 stress levels, 481 units)

- ① SP_p solves F(b0 + b1·g(SP)) = p; bounds by the delta method on (b0, b1). Tail percentiles lean on the LINK choice — links agree in the middle and diverge in the tails.
- ② to ④ The columns Percentile, Stress, 95% bounds: nine rows, SP1 1.6529 to SP99 1.8888. SP10 is 1.7059 [1.6927, 1.719], SP50 1.7709 [1.7634, 1.7783].

LEVELS AS READ (THIS WORKSHEET — 8 STRESS LEVELS, 481 UNITS)

1 Observed vs fitted per level — the GOF in table form.

2 Stress	3 Trials	4 Events	5 Observed	6 Fitted p
1.6907	59	6	0.102	0.057
1.7242	60	13	0.217	0.179
1.7552	62	18	0.290	0.379
1.7842	56	28	0.500	0.604
1.8113	63	52	0.825	0.788
1.8369	59	53	0.898	0.904
1.861	62	61	0.984	0.962
1.8839	60	60	1.000	0.987

Levels as read (this worksheet — 8 stress levels, 481 units)

- ① Observed vs fitted per level — the GOF in table form.
- ② to ⑥ The columns Stress, Trials, Events, Observed, Fitted p: the eight levels, from 6 of 59 failed (0.102 against a fitted 0.057) to 60 of 60 (1.000 against 0.987).

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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

Is there a stress response? Yes. The slope is b1 = 19.7279 (SE 1.4872), so Z = 13.2648 and p is far below 0.0001: failures really rise with the stress. The intercept is b0 = −34.9353 (SE 2.6479).

Does the curve fit? The deviance is 10.1198 on 8 − 2 = 6 degrees of freedom, p = 0.1197: above 5 %, so the probit curve describes the eight levels. The Pearson chi-square, 9.5134, agrees.

The proof level. Half of the units fail at SP50 = 1.7709 = −b0 / b1, one in ten at SP10 = 1.7059, and 99 % at SP99 = 1.8888. For a proof test that fails at most one unit in ten, set the stress at or below 1.7059 - with a cautious margin, at its lower bound in the percentile table.

Survival at the design stress. At 1.70 the survival is 0.9189, with bounds 0.8695 to 0.9527: about one unit in twelve fails there - 1.70 lies just below SP10, 1.7059. Plan with the lower bound if a failure in service is costly.

Where the curve is weakest. The tail percentiles, SP1 and SP99, lean on the link: probit, logit and cloglog agree in the middle of the data and part in the tails. If a decision rests on a tail, compare the links.