Test plans — how much testing proves the target, before any unit goes on the rig

Menu: Life Data ▸ Test Plans...

# Part 1 — What the function does

**What it calculates.** Before a test, someone must decide how much testing is enough: too little proves nothing, too much wastes units, rig hours and time. Test Plans answers that before any unit goes on the rig, from the target, the confidence and the assumptions alone - no failure data. A demonstration plan gives the units (or the total test hours) that prove a reliability or an MTBF floor, a trade of units against test length with its cost, and the chance that a good product fails the test. An estimation plan sizes a sample to estimate a B-life with a chosen precision; a sequential plan draws accept and reject lines; a prior-credit plan counts earlier evidence; an ALT plan designs an accelerated test.

| What ReliaEn prints (demonstration of a reliability) | What it tells you |
|---|---|
| **Units required**, with the range across the β uncertainty | How many units, tested one test length each, prove the target |
| **Each unit must survive at** R_test | The reliability each unit must show over its own test length |
| **Units vs test-length trade** and the **priced trade** | The same proof bought with fewer units tested longer, and the cheapest choice |
| **What this test does to good and bad products** | The chance a product at or above the target passes - the producer's risk |
| **Early-warning timeline** (no failure allowed) | When a first failure would mean the design is below target |

**From which data.** No worksheet: the form only - the plan type and quantity, the target and mission time, the confidence, the failures allowed, the test-time multiple, the assumed Weibull shape β with its uncertainty, and optionally the costs.

**When an engineer uses it.** Before a reliability demonstration, a qualification test or a supplier acceptance test, and whenever someone asks how many units are needed.

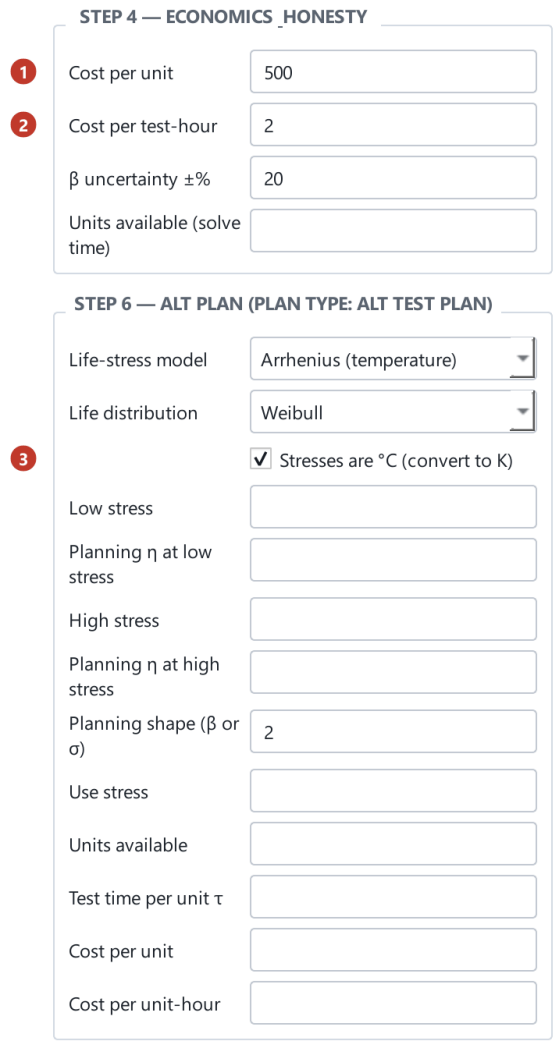
**When not to use it.**

| Situation | Use instead |
|---|---|
| The test is finished and the failure times are at hand | Life Data ▸ Time Dependence and the distribution, for example Weibull (2P) distribution... (chapter 2.6) |
| The test was run at raised stress and the life at use stress is wanted | Life Data ▸ Accelerated Life Testing... (chapter 2.18) |

# Part 2 — The example's input data

*Setting.* A valve actuator must show 90 % reliability over a 1,000-hour mission, at 90 % confidence, with no failure allowed. Its wear-out shape is taken as β = 2. The test rig costs 2 baht per test-hour and each test unit 500 baht. The engineer wants the number of units, and whether testing longer is cheaper.

| Input | Value |
|---|---|
| Plan type / Quantity | Demonstration (prove a floor) / Reliability at a time |
| Target value / Mission time / Confidence % | 0.90 / 1000 / 90 |
| Failures allowed c / Test-time multiple | 0 / 1 |
| Distribution / β — shape / β uncertainty ±% | Weibull (known β) / 2 / 20 |
| Cost per unit / Cost per test-hour | 500 / 2 |
| File in the worked-example zip | None - this function reads no worksheet; every value is typed into the form |



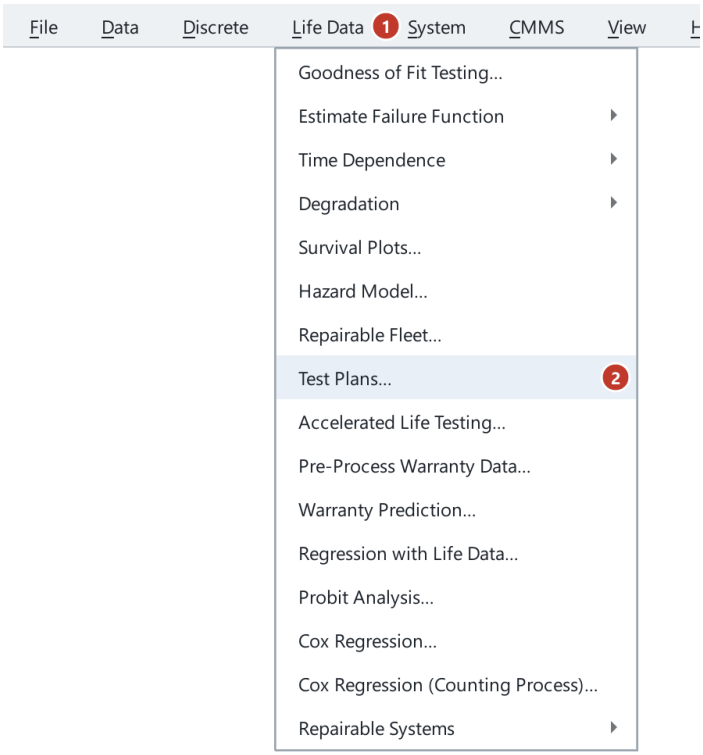

The two values typed into the form, in its Step 4

- ① Cost per unit: 500.
- ② Cost per test-hour: 2.
- ③ Stresses are °C (convert to K): ticked as the form opens; this example does not use it.

# Part 3 — How to use it, step by step

This function reads no worksheet: everything goes into the form.

1. **Choose Life Data ▸ Test Plans...** in the menu bar. The form Test Plans opens in the left panel.




Step 1 — the menu path

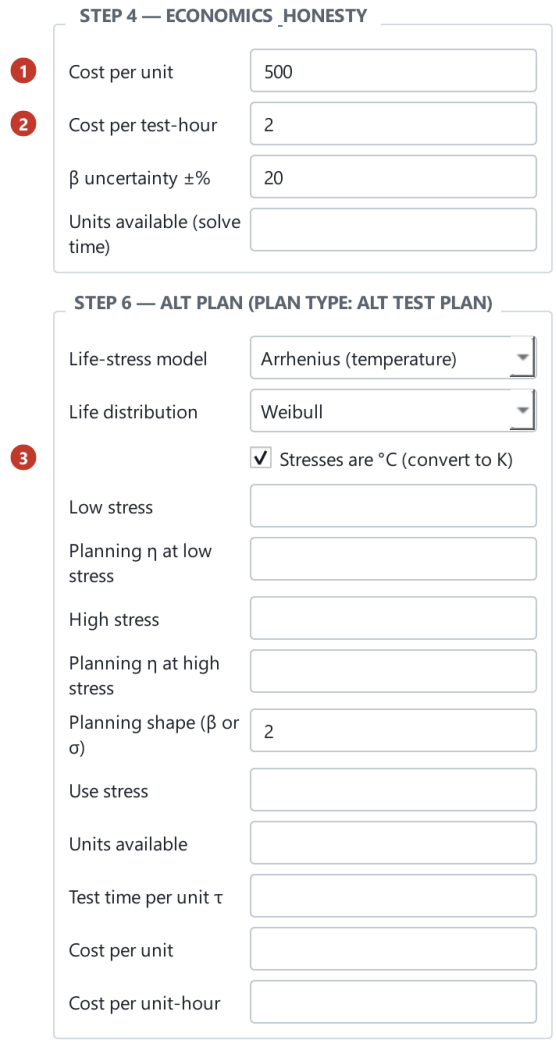
- ① Life Data: the menu.
- ② Test Plans...: the entry to click.

The form opens on this example's plan: Plan type Demonstration (prove a floor), Quantity Reliability at a time, Target value 0.90, Mission time 1000, Confidence % 90, Failures allowed c 0, Test-time multiple 1, Distribution Weibull (known β), β source Manual (field below), β — shape 2 and β uncertainty ±% 20. Check these boxes against the table in Part 2; none needs a change.

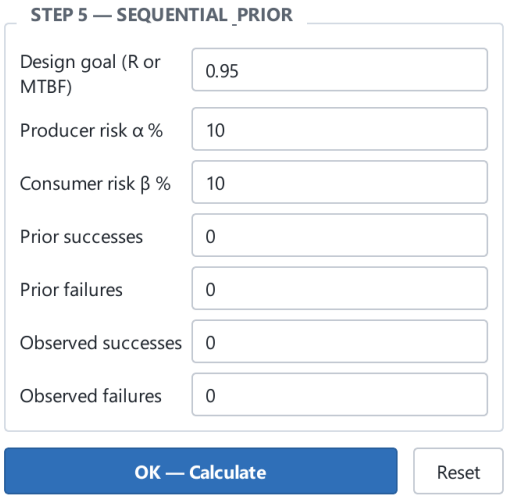
Steps 2 to 4 are the boxes marked ① to ③, in the second of the three pictures of the form:




The form's Steps 1 to 3, as they open



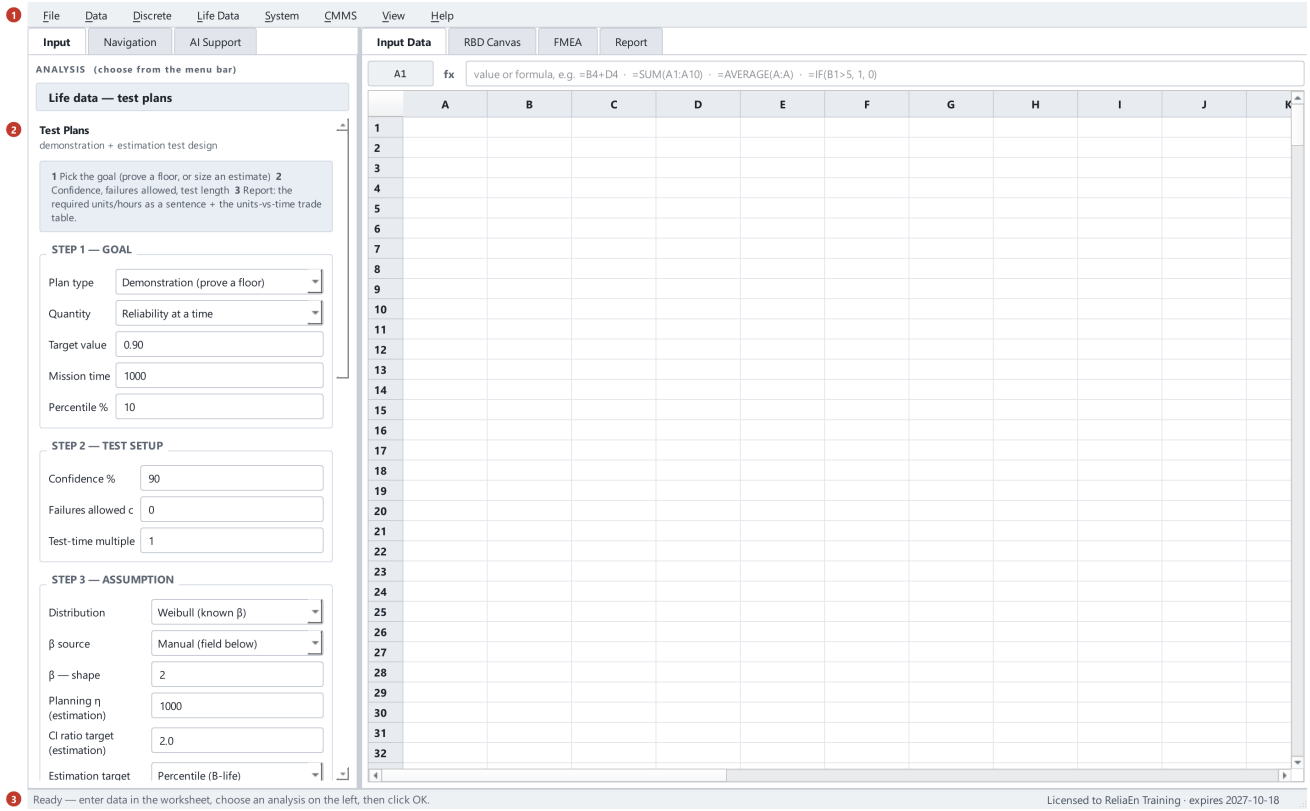

Steps 2 to 4 — the form's Step 4 and its ALT group, set for this example




The form's Step 5 and OK — Calculate

2. ① **In Cost per unit, type 500.** The box opens empty.
3. ② **In Cost per test-hour, type 2.** The box opens empty. With both costs the report adds the priced trade.
4. ③ **Check that Stresses are °C (convert to K) is ticked.** A demonstration plan does not use it.

5. **Scroll to the foot of the form and click OK — Calculate.** 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 2 to 4; it is taller than the panel, so OK — Calculate is below the part in view.
- ③ 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.

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# Part 4 — The report, card by card

### Life Data — Test Plans

2026-11-04 10:55:41

n: smallest with BinomCDF(c; n, 1−R_test) ≤ 1−C ; R_test = $R_0$^(m^β)

The report's head

- The title Life Data — Test Plans, the date and time of the run, and the rule in one line: n: smallest with BinomCDF(c; n, 1−R_test) ≤ 1−C; R_test = $R_0$^(m^β).

**INPUT DATA**

| | | |
|---|---|---|
| 1 | Plan type | `Demonstration — prove a floor` |
| 2 | Quantity | `R(t) — reliability at the mission time` |
| 3 | Target | `0.9` |
| 4 | Mission time | `1000` |
| 5 | Test-length multiple | `1×` |
| 6 | Confidence | `90%` |
| 7 | Failures allowed | `0` |
| 8 | Assumption | `manual β = 2` |

Input data

- ① Plan type Demonstration — prove a floor.
- ② Quantity R(t) — reliability at the mission time.
- ③ Target 0.9.
- ④ Mission time 1000.
- ⑤ Test-length multiple 1×.
- ⑥ Confidence 90%.
- ⑦ Failures allowed 0.
- ⑧ Assumption manual β = 2.

**RESULTS**

| | | |
|---|---|---|
| 1 | Units required | `22 — [22, 22] across β ± 20% (the plan leans on the β assumption)` |
| 2 | Test length per unit | `1000 (1× mission)` |
| 3 | Each unit must survive at | `R_test = 0.900000` |

Results

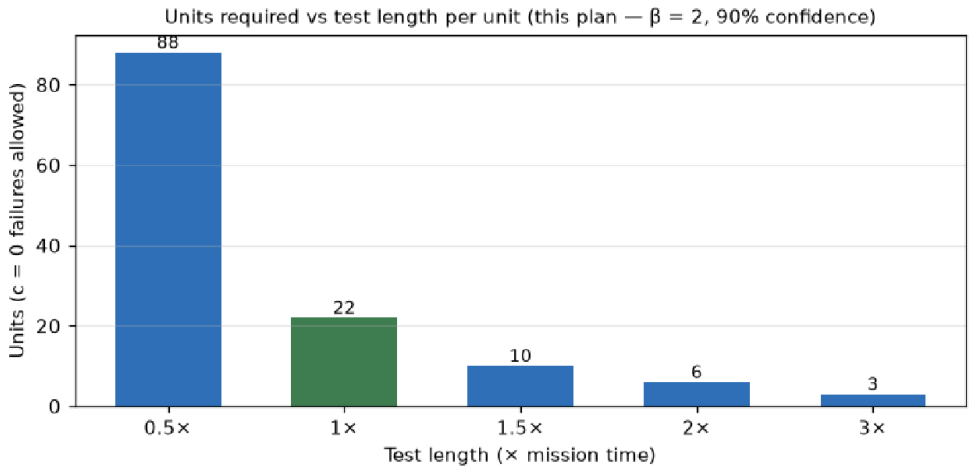
- ① Units required 22 — [22, 22] across β ± 20% (the plan leans on the β assumption).
- ② Test length per unit 1000 (1× mission).
- ③ Each unit must survive at R_test = 0.900000.

**INTERPRETATION**

1 Test 22 units for 1000 each with at most 0 failure(s): passing demonstrates R(t) — reliability at the mission time ≥ 0.9 at 90% confidence. The trade table shows the same demonstration bought with time instead of units — the β assumption (stated above) is what prices that trade.

Interpretation

- ① ReliaEn's reading: Test 22 units for 1000 each with at most 0 failure(s): passing demonstrates R(t) — reliability at the mission time ≥ 0.9 at 90% confidence. The trade table shows the same demonstration bought with time instead of units — the β assumption (stated above) is what prices that trade.




Interactive Plot

Units required vs test length per unit (this plan — β = 2, 90% confidence)

- The bars: 88, 22, 10, 6 and 3 units at 0.5×, 1×, 1.5×, 2× and 3×; the green bar is this plan.

**UNITS VS TEST-LENGTH TRADE (THIS PLAN)**

1 R_test = $R_0$^(multiple^β): testing longer than the mission makes each unit prove more, so fewer are needed. If β is only assumed, treat the 0.5× row with suspicion — short tests lean hardest on the assumption.

| | 2 Test length | 3 R_test per unit | 4 Units required |
|---|---|---|---|
| 5 | 0.5× | 0.974004 | 88 |
| 6 | 1× ★ | 0.900000 | 22 |
| 7 | 1.5× | 0.788943 | 10 |
| 8 | 2× | 0.656100 | 6 |
| 9 | 3× | 0.387420 | 3 |

Units vs test-length trade (this plan)

- ① R_test = $R_0$^(multiple^β): testing longer than the mission makes each unit prove more, so fewer are needed. If β is only assumed, treat the 0.5× row with suspicion — short tests lean hardest on the assumption.
- ② to ④ The columns Test length, R_test per unit, Units required.
- ⑤ 0.5×: 0.974004, 88 units.
- ⑥ 1× ★, this plan: 0.900000, 22 units.
- ⑦ 1.5×: 0.788943, 10 units.
- ⑧ 2×: 0.656100, 6 units.
- ⑨ 3×: 0.387420, 3 units.

**PRICED TRADE — CHEAPEST PLAN MEETING THE TARGET (THIS PLAN)**

1 ★ 3× at 19,500 total — longer testing wins here (wear-out β: units drop faster than hours grow). The β assumption is what prices this trade.

| 2 Test length | 3 Units | 4 Units cost | 5 Hours cost | 6 TOTAL |
|---|---|---|---|---|
| 7 0.5× | 88 | 44,000 | 88,000 | 132,000 |
| 8 1× | 22 | 11,000 | 44,000 | 55,000 |
| 9 1.5× | 10 | 5,000 | 30,000 | 35,000 |
| 10 2× | 6 | 3,000 | 24,000 | 27,000 |
| 11 3× ★ | 3 | 1,500 | 18,000 | 19,500 |

Priced trade — cheapest plan meeting the target (this plan)

- ① ★ 3× at 19,500 total — longer testing wins here (wear-out β: units drop faster than hours grow). The β assumption is what prices this trade.
- ② to ⑥ The columns Test length, Units, Units cost, Hours cost, TOTAL.
- ⑦ 0.5×: 88 units, 44,000 + 88,000 = 132,000.
- ⑧ 1×: 22 units, 11,000 + 44,000 = 55,000.
- ⑨ 1.5×: 10 units, 5,000 + 30,000 = 35,000.
- ⑩ 2×: 6 units, 3,000 + 24,000 = 27,000.
- ⑪ 3× ★: 3 units, 1,500 + 18,000 = 19,500, the cheapest.

**WHAT THIS TEST DOES TO GOOD AND BAD PRODUCTS (THIS PLAN)**

1 Closed-form binomial operating characteristics. A demonstration proves a floor; it is HARD on products only slightly above the floor — that is the producer's risk, priced here before you commit units.

| 2 True R | 3 P(test passes) | 4 Reading |
|---|---|---|
| 5 0.9 | 0.0985 | at target — the pass chance IS the designed risk |
| 6 0.95 | 0.3235 | 67.6% chance a product this good still FAILS the test |
| 7 0.98 | 0.6412 | 35.9% chance a product this good still FAILS the test |
| 8 0.995 | 0.8956 | 10.4% chance a product this good still FAILS the test |

What this test does to good and bad products (this plan)

- ① Closed-form binomial operating characteristics. A demonstration proves a floor; it is HARD on products only slightly above the floor — that is the producer's risk, priced here before you commit units.
- ② to ④ The columns True R, P(test passes), Reading.
- ⑤ 0.9: 0.0985, at target — the pass chance IS the designed risk.
- ⑥ 0.95: 0.3235, 67.6% chance a product this good still FAILS the test.
- ⑦ 0.98: 0.6412, 35.9% chance a product this good still FAILS the test.
- ⑧ 0.995: 0.8956, 10.4% chance a product this good still FAILS the test.

**EARLY-WARNING TIMELINE — IF THE DESIGN IS ONLY JUST AT TARGET (THIS PLAN)**

1 Order-statistic medians under the target-barely-true Weibull. With 0 failures allowed, the FIRST failure ends the test — if it arrives near or before the first median time, stop early and save the remaining test budget.

| 2 Failure # | 3 Median rank | 4 Median time |
|---|---|---|
| 5 1 | 0.0312 | 549 h |
| 6 2 | 0.0759 | 866 h |
| 7 3 | 0.1205 | 1,104 h |

Early-warning timeline — if the design is only JUST at target (this plan)

- ① Order-statistic medians under the target-barely-true Weibull. With 0 failures allowed, the FIRST failure ends the test — if it arrives near or before the first median time, stop early and save the remaining test budget.
- ② to ④ The columns Failure #, Median rank, Median time.
- ⑤ Failure 1: 0.0312, 549 h.
- ⑥ Failure 2: 0.0759, 866 h.
- ⑦ Failure 3: 0.1205, 1,104 h.

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The report's foot

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# Part 5 — How to interpret the results

**How many units.** With no failure allowed, n units tested one mission each prove the target when $0.9^n \le 1 - 0.90$: n = ln 0.1 / ln 0.9 = 21.85, so 22 units. With β 20 % lower or higher the answer stays 22: at a 1× test the shape does not matter.

**Testing longer.** A unit tested for m missions must survive R_test = 0.9^(m^β): at 3× that is $0.9^9$ = 0.387420, and 3 units prove the same as 22. The trade runs 88 units at 0.5×, 22 at 1×, 10 at 1.5×, 6 at 2× and 3 at 3×. Priced at 500 a unit and 2 an hour, 3 units for 3,000 hours cost 19,500 against 55,000 for the 1× plan: for a wear-out item longer testing wins. That saving rests entirely on β = 2 - if the shape is only assumed, the short and long rows lean hardest on it.

**What the test does to a good product.** A product exactly at 0.9 passes with chance $0.9^{22}$ = 0.0985 - the designed 10 % risk. But a product at 0.95 passes only with 0.3235: two times in three a good design still fails this test. If a good design must pass, it has to be well above 0.9, or the plan needs a failure allowed.

**Stop early.** If the design is only just at target, the first failure is expected around 549 hours (the median rank (1 − 0.3) / 22.4 on that Weibull). A first failure before then means the design is likely below target: stop and save the remaining budget.