Degradation: Wiener process — a life distribution from a fluctuating condition signal

Menu: Life Data ▸ Degradation ▸ Wiener process…

Part 1 — What the function does

What it calculates. A fleet of like units is inspected at set ages, and one condition signal is read on each: a vibration level, a wall loss, a resistance. The signal rises on average but moves up and down between inspections, and a unit fails the first time its signal touches a limit you set, the failure threshold D. ReliaEn fits a Wiener process to the readings - a mean drift ν per time unit with a fluctuation of strength σ - and from it the life of a unit, which follows an inverse Gaussian (IG) distribution in closed form.

What ReliaEn prints	What it tells you
ν̂ — drift and **σ̂ — fluctuation**, each with its interval	How fast the signal grows, and how much it moves around that growth
Mean life D/ν̂, **B10 life** and **Median life**	When units reach the threshold: on average, one in ten, and half
Model routing	Whether readings really fall between inspections, so the Wiener model fits (no falls: use the gamma process)
Drift trend test	Whether the drift is linear in time or bends (t^β)
Reliability ladder with a lower planning column	The share of units not yet at D at each age
Unit projections	Each unit at its own average drift: which reaches D first
With a unit or a second fleet chosen: remaining life, schedule, alarm, comparison	The remaining useful life of one unit, an inspection schedule, an alarm level, and a two-fleet test

From which data. One worksheet column of inspection ages and one column per unit with its readings at those ages, all units read at the same ages; the threshold D in the same unit as the readings.

When an engineer uses it. When failure is defined by a signal limit rather than a recorded failure time, and the readings can fall as well as rise.

When not to use it.

Situation	Use instead
The readings never fall: monotone wear (wall loss, tread depth, crack length)	Life Data ▸ Degradation ▸ Gamma process… (chapter 2.13)
Failure times are recorded, not signal readings	Life Data ▸ Time Dependence ▸ Weibull (2P) distribution… (chapter 2.6)

Part 2 — The example's input data

Setting. Six bearings are read for vibration at eight ages, in hundreds of operating hours; a bearing fails when its vibration reaches 30. The reliability engineer wants the bearings' life distribution and which bearing to attend to first.

Age	8	16	24	32	40	50	60	72
U1	2.78	7.95	12.43	16.87	23.33	23.78	25.69	26.23
U2	2.56	7.62	10.37	14.29	12.76	16.64	17.84	26.96
U3	4.81	9.75	12.42	16.61	20.90	23.53	25.77	29.65
U4	1.43	2.89	5.04	6.20	10.73	10.19	15.78	18.24
U5	1.56	1.31	3.78	6.02	9.25	11.40	15.14	24.38
U6	3.73	5.23	10.18	12.69	16.84	21.89	24.40	23.25

Input	Value
Failure threshold D / Confidence %	30 / 95
File in the worked-example zip	2-Wiener-Process/Example-1.csv — the ages in column A (Time), the units U1 to U6 in columns B to G

	① A	② B	③ C	④ D	⑤ E	⑥ F	⑦ G	H
1	8	2.78	2.56	4.81	1.43	1.56	3.73	
2	16	7.95	7.62	9.75	2.89	1.31	5.23	
3	24	12.43	10.37	12.42	5.04	3.78	10.18	
4	32	16.87	14.29	16.61	6.2	6.02	12.69	
5	40	23.33	12.76	20.9	10.73	9.25	16.84	
6	50	23.78	16.64	23.53	10.19	11.4	21.89	
7	60	25.69	17.84	25.77	15.78	15.14	24.4	
8	72	26.23	26.96	29.65	18.24	24.38	23.25	
9								

The example data in the worksheet

- ① Column A: the eight inspection ages.
- ② to ⑦ Columns B to G: the readings of U1 to U6.

Part 3 — How to use it, step by step

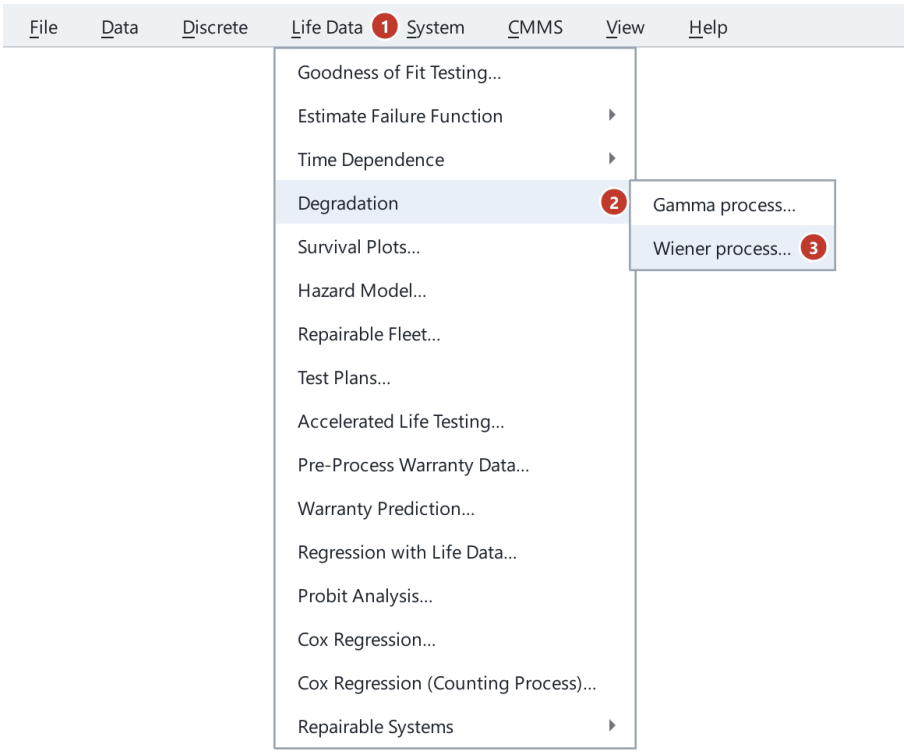
1. **Put the readings in columns A to G.** Copy the 8 rows of values of Example-1.csv - the ages under Time and the readings under U1 to U6 - into columns A to G of the worksheet, starting at row 1. The report then names each bearing by its column: U1 is B, U3 is D.

	① A	② B	③ C	④ D	⑤ E	⑥ F	⑦ G	H
1	8	2.78	2.56	4.81	1.43	1.56	3.73	
2	16	7.95	7.62	9.75	2.89	1.31	5.23	
3	24	12.43	10.37	12.42	5.04	3.78	10.18	
4	32	16.87	14.29	16.61	6.2	6.02	12.69	
5	40	23.33	12.76	20.9	10.73	9.25	16.84	
6	50	23.78	16.64	23.53	10.19	11.4	21.89	
7	60	25.69	17.84	25.77	15.78	15.14	24.4	
8	72	26.23	26.96	29.65	18.24	24.38	23.25	
9								

Step 1 — the readings in columns A to G

- ① Column A: the eight inspection ages, 8 to 72.
- ② to ⑦ Columns B to G: the readings of U1 to U6.

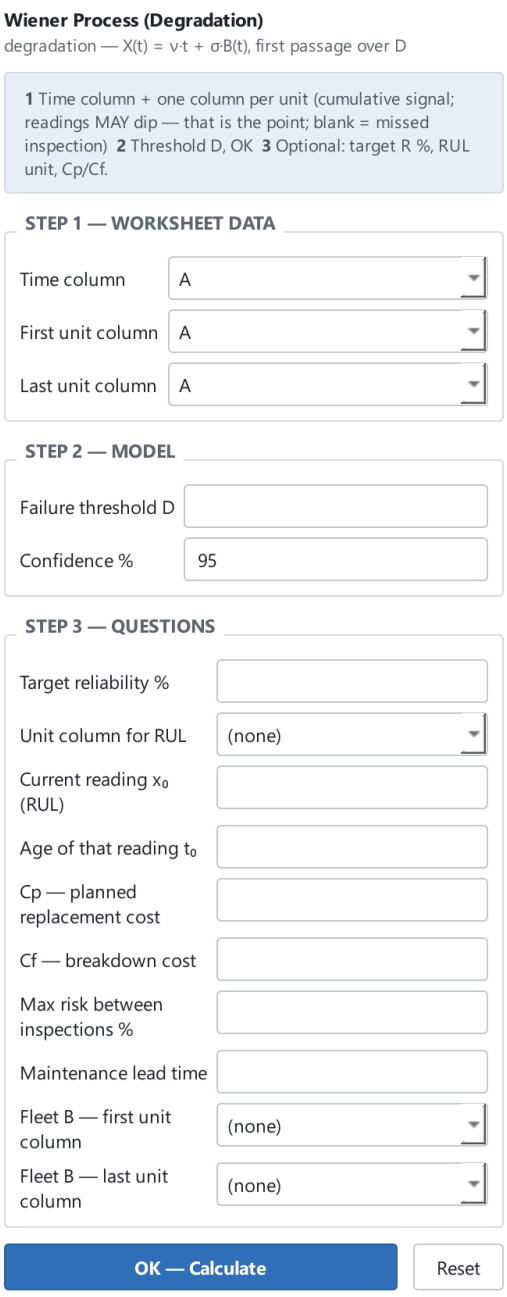
2. **Choose Life Data ▸ Degradation ▸ Wiener process...** in the menu bar. The form Wiener Process (Degradation) opens in the left panel.



Step 2 — the menu path

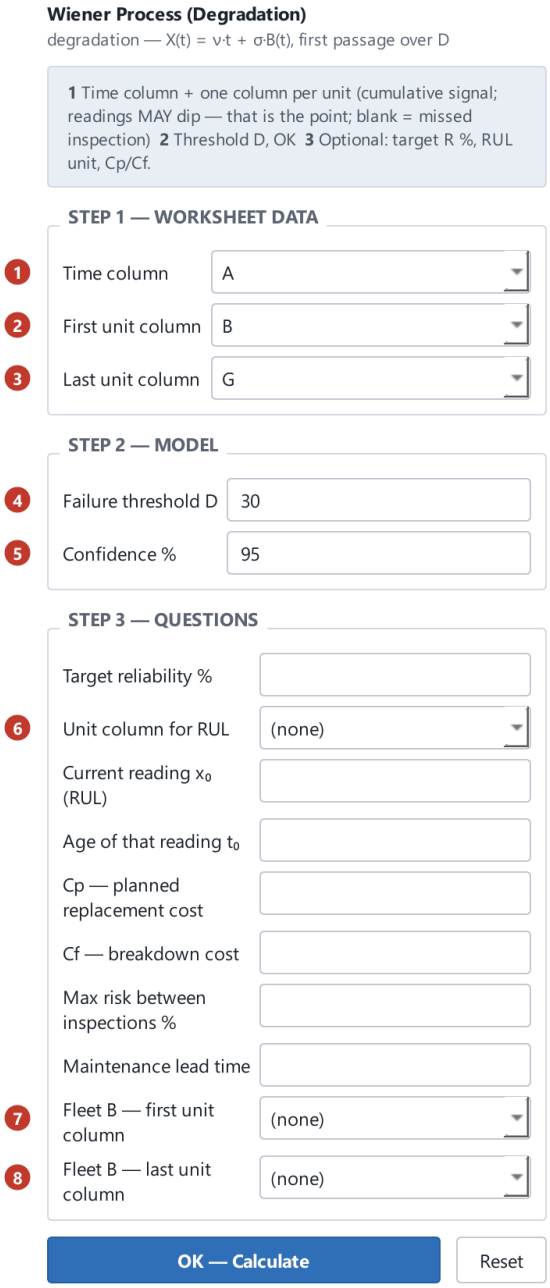
- ① Life Data: the menu.
- ② Degradation: the submenu.
- ③ Wiener process...: the entry to click.

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



Step 2 — the form as it opens

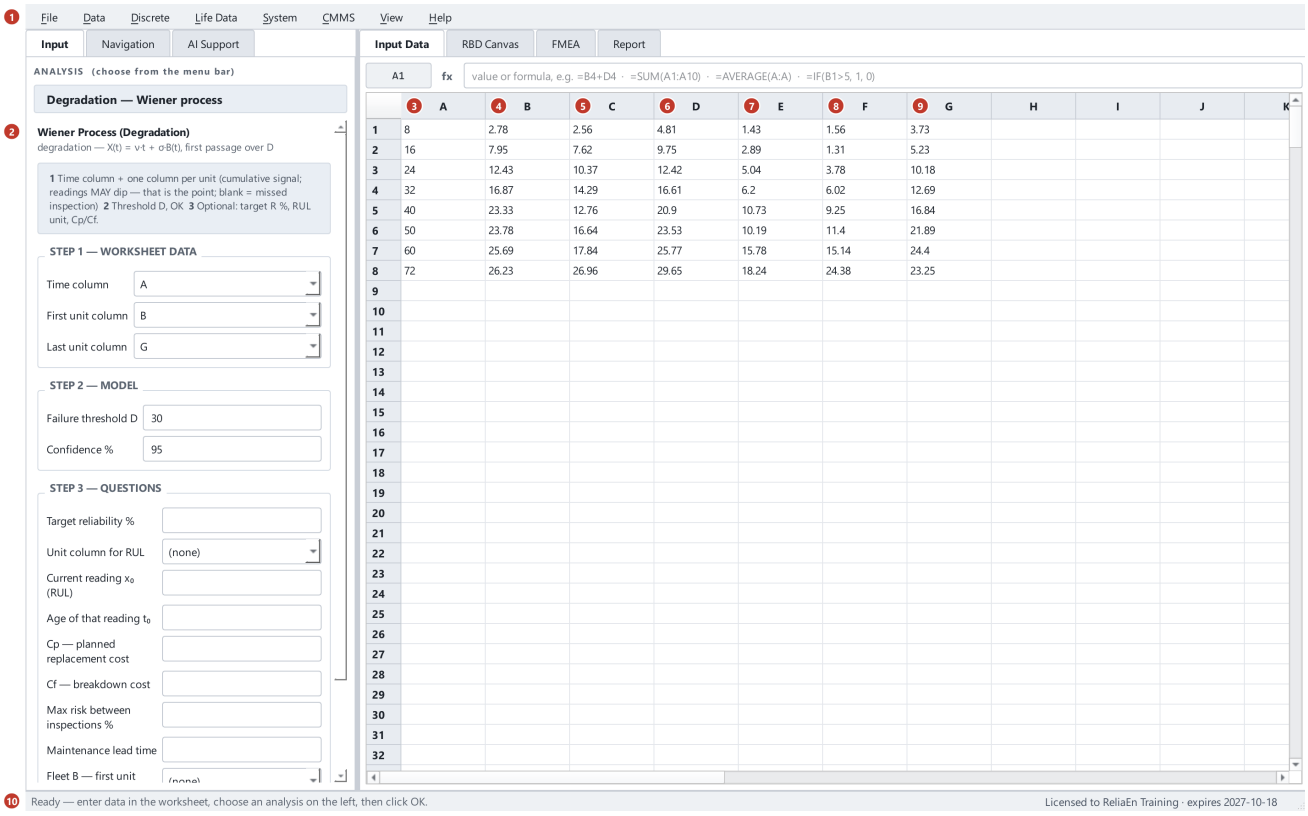
Steps 3 to 10 set or check the form's eight boxes, marked ① to ⑧ in the picture:



Steps 3 to 10 — the form set for this example

3. ① **Check that Time column reads A.**
4. ② **In First unit column, choose B.**
5. ③ **In Last unit column, choose G.** The fleet is the columns from B to G.
6. ④ **In Failure threshold D, type 30.**
7. ⑤ **Check that Confidence % reads 95.**
8. ⑥ **Check that Unit column for RUL reads (none).** One column here adds the remaining life of that bearing.
9. ⑦ **Check that Fleet B — first unit column reads (none).**
10. ⑧ **Check that Fleet B — last unit column reads (none).** The two Fleet B boxes compare a second fleet on the same ages.

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 ages.
- ④ to ⑨ Columns B to G: the six bearings.
- ⑩ 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 — Degradation — Wiener Process

2026-11-04 08:12:00

X(t) = ν·t + σ·B(t) ; F_T(t) = Φ((νt − D)/(σ√t)) + e^(2νD/σ²)·Φ(−(νt + D)/(σ√t))

The report's head

- The title Life Data — Degradation — Wiener Process, the date and time of the run, and the model in one line: X(t) = ν·t + σ·B(t); F_T(t) = Φ((νt − D)/(σ√t)) + e^(2νD/σ²)·Φ(−(νt + D)/(σ√t)).

INPUT DATA

1	Fleet A — units analyzed	`B, C, D, E, F, G`
2	Units / inspections	`6 / 8 times`
3	n — increments used	`48`
4	— of which negative	`4 (8%)`
5	D — failure threshold	`30`
6	Estimation	`closed-form MLE (drift + fluctuation)`

Input data

- ① Fleet A — units analyzed B, C, D, E, F, G: the six bearings, by column.
- ② Units / inspections 6 / 8 times.
- ③ n — increments used 48: the changes between successive readings, from age 0.
- ④ — of which negative 4 (8%): readings that fell.
- ⑤ D — failure threshold 30.
- ⑥ Estimation closed-form MLE (drift + fluctuation).

RESULTS

1	ν̂ — drift (per time unit)	`0.344236 [0.277505, 0.410967]`
2	σ̂ — fluctuation	`0.707657 [0.595337, 0.895778]`
3	Mean life D/ν̂	`87.15`
4	B10 life (IG quantile)	`64.3574`
5	Median life (IG quantile)	`85.0942`

Results

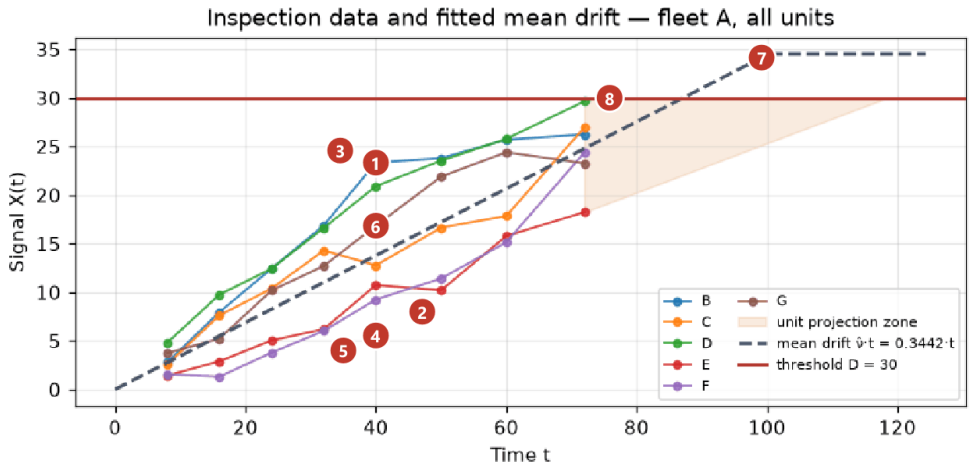
- ① ν̂ — drift (per time unit) 0.344236 [0.277505, 0.410967].
- ② σ̂ — fluctuation 0.707657 [0.595337, 0.895778].
- ③ Mean life D/ν̂ 87.15.
- ④ B10 life (IG quantile) 64.3574: one bearing in ten at the limit.
- ⑤ Median life (IG quantile) 85.0942.

INTERPRETATION

1. The signal is modeled as X(t) = ν·t + σ·B(t): a mean drift of 0.344236 per time unit with random fluctuation — readings may dip without anything having healed. Failure is the FIRST TOUCH of D (even if the signal would recover), and the life distribution is closed form (Inverse Gaussian). Mean life = D/ν̂ = 87.15; policy answers come from R(t), not the mean. Unlike monotone wear, a good reading at an inspection does NOT prove the limit was never touched in between.

Interpretation

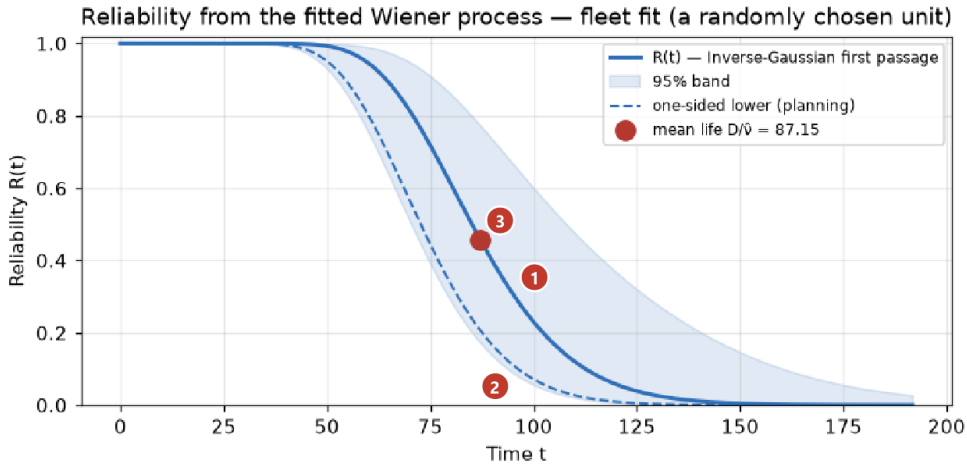
- ① ReliaEn's reading: The signal is modeled as X(t) = ν·t + σ·B(t): a mean drift of 0.344236 per time unit with random fluctuation — readings may dip without anything having healed. Failure is the FIRST TOUCH of D (even if the signal would recover), and the life distribution is closed form (Inverse Gaussian). Mean life = D/ν̂ = 87.15; policy answers come from R(t), not the mean. Unlike monotone wear, a good reading at an inspection does NOT prove the limit was never touched in between.



Interactive Plot

Inspection data and fitted mean drift — fleet A, all units

- ① to ⑥ B to G: each bearing's readings, rising with dips.
- ⑦ mean drift v̂·t = 0.3442·t: the fitted average path.
- ⑧ threshold D = 30: the limit. The shaded unit projection zone spans the bearings' own-drift paths onward from age 72.



Interactive Plot

Reliability from the fitted Wiener process — fleet fit (a randomly chosen unit)

- ① R(t) — Inverse-Gaussian first passage: the share of bearings not yet at the limit, inside its shaded 95% band.
- ② one-sided lower (planning): the cautious curve at 95 %.
- ③ mean life D/v̂ = 87.15: by then R has fallen below one half.

MODEL ROUTING — IS THE WIENER MODEL RIGHT FOR THIS DATA? (FLEET A INCREMENTS)

1 4 of 48 increments (8%) are negative — the signal genuinely fluctuates, which monotone models cannot represent. The Wiener model is appropriate.

Model routing — is the Wiener model right for this data? (fleet A increments)

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DRIFT TREND — LINEAR VS T^B (FLEET FIT, LIKELIHOOD-RATIO TEST)

1 p = 0.7949 ≥ 0.05 — acceleration NOT detected: the simpler linear drift is reported (β̂ = 1.025, its interval includes 1). Not proof of linearity — a statement about this data's evidence.

Quantity	Value
2 β̂ — free trend exponent	1.0253 [0.834, 1.217]
3 LR = 2(lnL_β − lnL_linear)	0.0675
4 p-value (χ², 1 dof)	0.7949
5 Model reported	linear drift (β = 1)

6 Nested models: β = 1 inside free β; LR ~ $\chi^2(1)$.

Drift trend — linear vs t^β (fleet fit, likelihood-ratio test)

- ① p = 0.7949 ≥ 0.05 — acceleration NOT detected: the simpler linear drift is reported (β̂ = 1.025, its interval includes 1). Not proof of linearity — a statement about this data's evidence.
- ② β̂ — free trend exponent 1.0253 [0.834, 1.217].
- ③ LR = 2(lnL_β − lnL_linear) 0.0675.
- ④ p-value (χ², 1 dof) 0.7949.
- ⑤ Model reported linear drift (β = 1).
- ⑥ Nested models: β = 1 inside free β; LR ~ $\chi^2(1)$.

RELIABILITY LADDER — FLEET FIT

1 R(t) = probability a unit has NOT yet touched D by age t; the lower column is the planning value at the chosen confidence.

2 Time t	3 R(t)	4 R lower (one-sided)	5 F(t)
21.79	1.0000	1.0000	0.0000
34.86	1.0000	0.9994	0.0000
43.57	0.9991	0.9882	0.0009
52.29	0.9878	0.9276	0.0122
65.36	0.8869	0.6815	0.1131
78.43	0.6453	0.3668	0.3547
87.15	0.4566	0.2061	0.5434
108.94	0.1292	0.0301	0.8708
130.72	0.0242	0.0025	0.9758

Reliability ladder — fleet fit

- ① R(t) = probability a unit has NOT yet touched D by age t; the lower column is the planning value at the chosen confidence.
- ② to ⑤ The columns Time t, R(t), R lower (one-sided), F(t): nine ages from 21.79 to 130.72. At 65.36, R is 0.8869 but the planning value only 0.6815; at the mean life, 87.15, R is 0.4566.

UNIT PROJECTIONS — EACH UNIT AT ITS OWN AVERAGE DRIFT

1 Fastest first. Deterministic mean-trend projections for triage — the probabilistic per-unit answer is the RUL card.

2 Unit	3 Last reading	4 Own drift	5 Projected crossing	6 Remaining
7 D	29.65	0.4118	72.85	0.85
8 C	26.96	0.3744	80.12	8.12
9 B	26.23	0.3643	82.35	10.35
10 F	24.38	0.3386	88.60	16.60
11 G	23.25	0.3229	92.90	20.90
12 E	18.24	0.2533	118.42	46.42

13 A unit listed as already at/over D touched the threshold at the time shown — with a fluctuating signal, verify with a confirmatory reading before acting.

Unit projections — each unit at its own average drift

- ① Fastest first. Deterministic mean-trend projections for triage — the probabilistic per-unit answer is the RUL card.
- ② to ⑥ The columns Unit, Last reading, Own drift, Projected crossing, Remaining.
- ⑦ D (U3): 29.65, 0.4118, crossing 72.85, 0.85 remaining - first.
- ⑧ C (U2): 26.96, 0.3744, 80.12, 8.12.
- ⑨ B (U1): 26.23, 0.3643, 82.35, 10.35.
- ⑩ F (U5): 24.38, 0.3386, 88.60, 16.60.
- ⑪ G (U6): 23.25, 0.3229, 92.90, 20.90.
- ⑫ E (U4): 18.24, 0.2533, 118.42, 46.42 - last.
- ⑬ A unit listed as already at/over D touched the threshold at the time shown — with a fluctuating signal, verify with a confirmatory reading before acting.

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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 signal really fluctuates. Of the 48 increments between readings, 4 are negative - U2 falls from 14.29 to 12.76 at age 40, for one - so the Wiener model is the right one; with no falls the gamma process would be.

How fast it grows. The drift is $\hat{\nu}$ = 0.344236 per hundred hours, [0.277505, 0.410967] at 95 %: 148.71 of total growth over 6 × 72 = 432 unit-hundred-hours. The fluctuation is $\hat{\sigma}$ = 0.707657, [0.595337, 0.895778].

When the bearings fail. The mean life is D/$\hat{\nu}$ = 30 / 0.344236 = 87.15 hundred hours, but by then about half have failed: the median life is 85.0942. One bearing in ten reaches the limit by 64.3574 hundred hours, the B10 life - plan from that, not from the mean. The drift-trend test finds no bend (p = 0.7949), so the linear drift stands.

Which bearing first. The report names each bearing by its worksheet column. At its own average pace U3, in column D - last read 29.65, drift 29.65 / 72 = 0.4118 - reaches 30 at age 72.85, only 0.85 after the last inspection; U4, in column E, is last, at 118.42. With a fluctuating signal, confirm D's reading before acting, and for a probability ask the remaining-life question for that unit (Unit column for RUL).