MY8DATA — STATISTICAL ANALYSIS METHODS

Validation Report — Method Validation

Report ID	**20260625-140308**	Created on	2026-06-25 14:03:08
Created by	roland.schnurr@sixsigmablackbelt.de	Datasets total	9
Method	On-demand validation through the application's real computation path (incl. R backend). Calculated metrics are compared against stored target values within defined tolerances.		

Overall verdict: PASSED — 9/9 datasets passed

of which literature-validated: 7 · with literature reference (not digit-exact): 1

LITERATURE-VALIDATED standard/publication reproduced · REFERENCE SOFTWARE reference software (e.g. Minitab) reproduced · REFERENCE (dev.) source cited, engine deviates methodically · GOLDEN MASTER no external evidence

1. MFU Machine Capability (normal distribution) — Bosch Booklet 9 (Cm/Cmk)

LITERATURE-VALIDATED PASSED Dataset ID: `mfu-bosch-h9`

Source: **Robert Bosch GmbH**, Booklet 9 – Machine and Process Capability, Edition 11.2019 (2019), Sec. 4.4 / 8.3.
Reference/method: Normal distribution: Cm=T/(6s), Cmk=min(USL-x,x-LSL)/(3s)
Validation type: literature-validated — target values from publication/standard, engine reproduces them within tolerance.

Metric	Target	Actual	Deviation	Tolerance	Status
basic_statistics.n	50	50	0	exact	✓
basic_statistics.mean	19.002	19.002	0	± 0.0001	✓
basic_statistics.std	1.169421626	1.1694216257516	2.484e-10	± 0.0001	✓
capability_indices.cm	0.99764417	0.997644169541366	4.58634e-10	± 0.0001	✓
capability_indices.cmk	0.855693656	0.855693656275194	2.75194e-10	± 0.0001	✓
defects.ppm_total	5443	5443	0	± 2	✓
distribution_test.statistic	0.178301539	0.178301539364213	3.64213e-10	± 0.0001	✓
distribution_test.result	normalverteilt	normalverteilt	—	exact	✓

Dataset note: Machine capability (MFU), normal distribution. Target values derived independently from the Bosch Booklet 9 formula (T=7; Cm=7/(6*1.169422)=0.997644; Cmk=3.002/(3*1.169422)=0.855694); the engine reproduces them. Standard-conformance validation (Booklet 9 provides formulas/limits, no printed worked example).

2. MSA1 MSA1 Type 1 study (Cg/Cgk) — Bosch Booklet 10 evaluation-form example

LITERATURE-VALIDATED PASSED Dataset ID: `msa1-bosch-h10`

> Source: **Robert Bosch GmbH**, Booklet 10 – Capability of Measurement and Test Processes, Edition 11.2019 (2019), Sec. 4.1, p. 11 (form).
> Reference/method: Type 1 study, evaluation form (Bosch 2018) — example body diameter, reference value 6.002, 50 measurements; printed results Cg/Cgk (point estimate, k=6)
> Validation type: literature-validated — target values from publication/standard, engine reproduces them within tolerance.

Metric	Target	Actual	Deviation	Tolerance	Status
basic_statistics.mean	6.0009	6.000899999999998	1.77636e-15	± 0.0001	✓
basic_statistics.std	0.00099488	0.0009948848769417344	4.87694e-09	± 1e-06	✓
bias	0.0011	0.0011000000000018773	1.87719e-15	± 0.0001	✓
capability_indices.cg	2.01	2.01028284412966	0.000282844	± 0.01	✓
capability_indices.cgk	1.64	1.6417309893719298	0.00173099	± 0.01	✓
capability_indices.prozentRE	0.016667	0.016666666666666528	3.33333e-07	± 0.0001	✓
evaluation.overall_status	pass	pass	—	exact	✓
derived_values.t_tmin_cg	0.039701	0.039695906589975204	5.09341e-06	± 0.0001	✓
derived_values.t_tmin_cgk	0.050696	0.050695906589993976	9.341e-08	± 0.0001	✓
derived_values.t_tmax_aufloesung	0.02	0.02	0	± 1e-06	✓

Dataset note: Bosch Booklet 10 Type 1 original example (evaluation form p. 11). Target values = results printed in the form: x-bar 6.00090, s 0.00099488, bias 0.0011, Cg 2.01, Cgk 1.64 (k=6 point estimate; 1.61/2.41 and 1.30/1.98 are the confidence limits), %RE 1.67%, verdict 'measuring system capable'. The engine reproduces them digit-exact. Per the form, bias is significant (informational only, no effect on the overall verdict). Derived minimum tolerances ('minimum reference quantity for a capable measuring system'): Tmin(Cg) 0.039701, Tmin(Cgk) 0.050696, Tmin(RE) 0.020000 = resolution/%RE requirement.

3. MSA2 MSA2 Gage R&R (ANOVA) — Bosch Booklet 10 Appendix D.2

LITERATURE-VALIDATED PASSED Dataset ID: `msa2-bosch-d2`

> Source: **Robert Bosch GmbH**, Booklet 10 – Capability of Measurement and Test Processes, Edition 11.2019 (2019), Appendix D.2.
> Reference/method: Appendix D.2 (Type 2, evaluation via analysis of variance/ANOVA) — example 10 parts x 3 appraisers x 3 measurements; ANOVA results table (%StudyVar)
> Validation type: literature-validated — target values from publication/standard, engine reproduces them within tolerance.

Metric	Target	Actual	Deviation	Tolerance	Status
sixsigma_result.studyVar.Total Gage R&R.%StudyVar	27.86	27.86	0	± 0.02	✓
sixsigma_result.studyVar. Repeatability.%StudyVar	18.42	18.42	0	± 0.02	✓
sixsigma_result.studyVar. Reproducibility.%StudyVar	20.9	20.9	0	± 0.02	✓
sixsigma_result.studyVar.Part-To-Part.%StudyVar	96.04	96.04	0	± 0.05	✓
sixsigma_result.ncat	4	4	0	exact	✓

Dataset note: Bosch Booklet 10 Appendix D.2 (Gage R&R, ANOVA method), original example 10 parts x 3 appraisers x 3 measurements (dataset identical to AIAG MSA 4th). Target %StudyVar from the printed ANOVA results table: GRR 27.86 / EV (repeatability) 18.42 / AV (reproducibility) 20.90 / PV (parts) ~96; the engine reproduces GRR/EV/AV digit-exact. Verdict per the booklet: 10% < %GRR <= 30% -> conditionally capable. R expects comma decimals in the header; the %StudyVar values are tolerance-independent. ndc: Bosch criterion >= 5, the engine reports ncat=4 (truncation) -> ncat serves as an engine consistency check. MSA3 (Type 3) uses the same ANOVA core and is covered through this.

4. MSA4 MSA4 Linearity — AIAG MSA 4th Edition example (linearity problem)

LITERATURE-VALIDATED PASSED Dataset ID: `msa4-aiag-linearity`

> Source: **AIAG (Automotive Industry Action Group)**, Measurement Systems Analysis (MSA) Reference Manual, 4th Edition (2010), p. 99.
> Reference/method: Table III-B 4 (linearity example)
> Validation type: literature-validated — target values from publication/standard, engine reproduces them within tolerance.

Metric	Target	Actual	Deviation	Tolerance	Status
regression.a	-0.131667	-0.13166666666666668	3.33333e-07	± 0.0001	✓
regression.b	0.736667	0.7366666666666667	3.33333e-07	± 0.0001	✓
regression.r2_prozent	71.4	71.43184159322422	0.0318416	± 0.1	✓
regression.t_a	12.043	12.04255941149917	0.000440589	± 0.01	✓
regression.t_b	10.158	10.157518860132106	0.00048114	± 0.01	✓
regression.t_krit	2.00172	2.0017174841452356	2.51585e-06	± 0.0001	✓
linearitaet_bestanden	False	False	—	exact	✓

> Dataset note: AIAG original dataset; the manual concludes a linearity problem. Target values from the literature (validated:true). The engine reproduces a/b/R2/t_a/t_b/t_crit digit-exact.

5. MSA7 MSA7 Attribute MSA (Fleiss' Kappa) — Bosch Booklet 10 Type 7 example

LITERATURE-VALIDATED PASSED Dataset ID: `msa7-bosch-h10`

> Source: **Robert Bosch GmbH**, Booklet 10 – Capability of Measurement and Test Processes, Edition 11.2019 (2019), Sec. 5.2.
> Reference/method: Type 7 (attribute test processes, Fleiss' Kappa); example 3 appraisers x 50 parts, Kappa results table
> Validation type: literature-validated — target values from publication/standard, engine reproduces them within tolerance.

Metric	Target	Actual	Deviation	Tolerance	Status
daten.AA.K	0.76	0.759999999999999	9.99201e-16	± 0.001	✓
daten.BB.K	0.8451	0.845073331956207	2.6668e-05	± 0.001	✓
daten.CC.K	0.7029	0.702911467617351	1.14676e-05	± 0.001	✓
daten.PP.K	0.7936	0.7936056917845	5.69178e-06	± 0.001	✓
daten.AR.K	0.8802	0.8802362	3.62e-05	± 0.001	✓
daten.BR.K	0.9226	0.9226119	1.19e-05	± 0.001	✓
daten.CR.K	0.7747	0.7747032	3.2e-06	± 0.001	✓
daten.PR.K	0.8592	0.859183785457124	1.62145e-05	± 0.001	✓
evaluation	marginal	marginal	—	exact	✓

> Dataset note: Bosch Booklet 10 Type 7 (Fleiss' Kappa), original example 3 appraisers x 50 parts. Target values = Kappa results table printed in the booklet (Mueller A, Huber B, C; AA/BB/CC = appraiser-appraiser, AR/BR/CR = appraiser-reference, PP/PR = all). Minimum 0.7029 -> conditionally capable (marginal). The engine reproduces the booklet values digit-exact.

6. PPK PPK Process Performance (normal distribution) — Bosch Booklet 9 (Pp/Ppk)

LITERATURE-VALIDATED PASSED Dataset ID: `ppk-bosch-h9`

> Source: **Robert Bosch GmbH**, Booklet 9 – Machine and Process Capability, Edition 11.2019 (2019), Sec. 6.6 / 8.3.
> Reference/method: Pp=T/(6*sigma_overall), Cp=T/(6*sigma_within), sigma_within=R-bar/d2 (n=5: d2=2.326)
> Validation type: literature-validated — target values from publication/standard, engine reproduces them within tolerance.

Metric	Target	Actual	Deviation	Tolerance	Status
basic_statistics.N	50	50	0	exact	✓
basic_statistics.k	10	10	0	exact	✓
basic_statistics.grand_mean	29.9996	29.9996	0	± 0.0001	✓
sigma.sigma_overall	0.026104969	0.0261049686411441	3.58856e-10	± 0.0001	✓
sigma.sigma_within	0.030524506	0.0305245055889942	4.11006e-10	± 0.0001	✓
sigma.d2	2.326	2.326	0	± 0.0001	✓
overall.pp	6.384480631	6.38448063116931	1.6931e-10	± 0.001	✓
overall.ppk	6.379373047	6.37937304666438	3.3562e-10	± 0.001	✓
within.cp	5.460093897	5.46009389671358	2.8642e-10	± 0.001	✓
within.cpk	5.455725822	5.45572582159622	4.0378e-10	± 0.001	✓
distribution_test.statistic	0.521565801	0.521565800695065	3.04935e-10	± 0.001	✓

> Dataset note: PPK (process performance), normal distribution. Target values derived independently from the Bosch Booklet 9 formulas (T=1; sigma_within=0.071/2.326=0.030524506; Pp=1/(6*0.026105)=6.384481; Cp=1/(6*0.030525)=5.460094); the engine reproduces them. Standard-conformance validation (Booklet 9 provides formulas/factors, no printed worked example).

7. SPC SPC X-bar/R chart (normal distribution) — Bosch Booklet 7, control-limit factors

LITERATURE-VALIDATED PASSED Dataset ID: `spc-bosch-h7`

> Source: **Robert Bosch GmbH**, Booklet 7 – Statistical Process Control (SPC), Edition 11.2020 (2020), Sec. 4 / appendix factor table.
> Reference/method: Control-limit formulas x-bar +/- A2*R-bar and R chart D4*R-bar; factor table appendix (n=5: A2=0.577, D3=0, D4=2.114)
> Validation type: literature-validated — target values from publication/standard, engine reproduces them within tolerance.

Metric	Target	Actual	Deviation	Tolerance	Status
chart_type	xbar_r	xbar_r	—	exact	✓
statistics.grand_mean	25.0005	25.0005	0	± 1e-05	✓
statistics.mean_range	0.038	0.038	0	± 1e-05	✓
statistics.sigma_estimate	0.016337	0.016337	0	± 1e-05	✓
limits_primary.cl	25.0005	25.0005	0	± 1e-05	✓
limits_primary.ucl	25.022426	25.022426	0	± 1e-05	✓
limits_primary.lcl	24.978574	24.978574	0	± 1e-05	✓
capability.cp	2.04	2.04	0	± 0.005	✓
capability.cpk	2.03	2.03	0	± 0.005	✓
in_control	False	False	—	exact	✓

> Dataset note: SPC X-bar/R chart. Target limits derived independently from the published Bosch Booklet 7 formulas + factor table (UCL=25.0005+0.577*0.038=25.022426; UCL_R=2.114*0.038=0.080332); the engine reproduces them exactly. Standard-conformance validation (no printed worked example - Booklet 7 provides formulas/factors).

8. MSA3 MSA3 Gage R&R without appraiser influence — Bosch Booklet 10 Type 3 example

LITERATURE REFERENCE PASSED Dataset ID: `msa3-bosch-h10`

> Source: **Robert Bosch GmbH**, Booklet 10 – Capability of Measurement and Test Processes, Edition 11.2019 (2019), Sec. 4.3, p. 23 (form).
> Reference/method: Type 3 (Gage R&R without appraiser influence), evaluation form — part 'nozzle', 25 parts x 2 measurements, T=0.060
> Validation type: publication/standard available as reference — engine deviates methodically (not digit-exact), see dataset notes.

Metric	Target	Actual	Deviation	Tolerance	Status
sixsigma_result.ncat	17	17	0	exact	✓
sixsigma_result.studyVar.Total Gage R&R.%StudyVar	8.25	8.25	0	± 0.05	✓
sixsigma_result.studyVar. Repeatability.%StudyVar	8.25	8.25	0	± 0.05	✓
sixsigma_result.studyVar.Part-To-Part.%StudyVar	99.66	99.66	0	± 0.05	✓
sixsigma_result.studyVar.Total Gage R&R.StdDev	0.0014629	0.00146287388383266	2.61162e-08	± 1e-06	✓

> Dataset note: Authentic Bosch Booklet 10 Type 3 data (25 parts x 2 measurements; columns 3-6 empty = as in the UI). GOLDEN MASTER (validated:false), NO digit-exact literature evidence: Bosch prints %GRR(Tol)=14.70%, EV-StdDev 0.001470, ndc criterion >=5; the engine yields EV-StdDev 0.0014629 (%GRR(Tol)=14.63%) and ndc=17. The ~0.5% EV difference is a method difference (Bosch qs-STAT/solara vs. standard ANOVA method), not an error: 0.0014629 is the correct ANOVA within-part value (confirmed by hand). Verdict on both sides 'conditionally capable'. The ANOVA mathematics behind MSA3 is identical to MSA2 and is validated digit-exact there via the Gage R&R example (Bosch Booklet 10 Appendix D.2).

9. MSA7A MSA7A Attribute MSA automated gauge (Fleiss' Kappa) — demo dataset

GOLDEN MASTER PASSED Dataset ID: `msa7a-golden-demo`

> Source: Internal golden master (no external literature evidence).
> Origin: Internal MSA7A demo dataset
> Validation type: Regression guard — frozen engine output.

Metric	Target	Actual	Deviation	Tolerance	Status
daten.AA.K	0.765079365	0.765079365079365	7.93651e-11	± 0.0001	✓
daten.AR.K	0.85803766	0.858037659508248	4.91752e-10	± 0.0001	✓
daten.AA.prozentrichtig	0.8	0.8	0	± 0.0001	✓
daten.AR.prozentrichtig	0.8	0.8	0	± 0.0001	✓
evaluation	marginal	marginal	—	exact	✓

> Dataset note: MSA7A (automated gauge), computed in the R backend. 8 columns [part, A1-A6, reference], 1 automated gauge. Only AA + AR. Golden master.

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