



QUALITY INSPECTION TECHNICAL MANUAL UNIFIED INCH SCREW THREAD (UN SERIES)

UNC / UNF / UNEF — Production Standards, Inspection & Acceptance

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Classification:	Internal Technical Document
Scope:	Unified Inch screw threads per ASME B1.1-2024 (UN, UNR, UNJ forms). Classes 1A/2A/3A (ext), 1B/2B/3B (int). Sizes #0 (0.060") through 6". Does NOT cover metric ISO threads, pipe threads, or Acme/Buttress threads.

IATF 16949 | ISO 9001 | ISO 14001 Certified Facility

Revision History

Rev.	Date	Description & Triggering Standards	Author	Approved
A	2005-06	Initial release based on ASME B1.1-2003, ASME B1.2-1983 (R2001), ASME B1.3M-1992. Established GO/NO-GO gauging per ASME B1.2.	Quality Eng.	Quality Dir.
B	2009-03	Added UNJ thread form provisions (formerly ASME B1.15-1995). Added three-wire method for inch threads. Extended gauge calibration to include Class 3A/3B precision gauges.	Quality Eng.	Quality Dir.
C	2013-09	Updated mechanical property references to SAE J429 (current) and ASTM A574. Added torque-tension testing per ASME PCC-1.	Quality Eng.	Quality Dir.
D	2016-11	Added optical sorting for 100% final inspection. Updated SPC targets to $Cpk \geq 1.67$. Added coated thread provisions for zinc and zinc-nickel plated inch threads.	Quality Eng.	Quality Dir.
E	2019-08	Updated to ASME B1.1-2019 which incorporated UNJ thread forms (formerly B1.15). Consolidated UN, UNR, and UNJ into single reference. Added CMM scanning parameters for inch threads.	Quality Eng.	Quality Dir.
F	2026-03	Updated to ASME B1.1-2024 (latest edition with metric translation appendix). Verified ASME B1.2-1983 (R2001) remains current for gauging. Added: short-batch protocols, post-HT verification, packaging audit, torque-angle verification, micro-thread provisions for #0-#4 sizes, rework restriction matrix.	Quality Eng.	Quality Dir.

1. Scope and Purpose

1.1 Purpose

This manual establishes inspection procedures and acceptance criteria for Unified Inch screw threads (UN series) produced at KeyFixPro, primarily for North American automotive and industrial export projects.

1.2 Scope

- (a) Thread forms: UN (flat/rounded root), UNR (controlled rounded root, external only), UNJ (defined root radius for fatigue, per ASME B1.1-2024).
- (b) Series: UNC (coarse), UNF (fine), UNEF (extra-fine), UNS (special).
- (c) Classes: 1A/1B (loose fit), 2A/2B (standard, most common), 3A/3B (precision/close fit).
- (d) Sizes: #0 (0.060") through 6" diameter; TPI from 80 (finest) to 4 (coarsest).

1.3 Exclusions

ISO metric threads (KFP-QIM-THD-001), pipe threads (THD-003/004), Acme/Buttress (THD-007), and non-standard special thread forms.

1.4 Normative References

Standard	Title / Scope
ASME B1.1-2024	Unified Inch Screw Threads (UN, UNR, UNJ forms). Thread form, series, class, allowance, tolerance, designation. Latest edition.
ASME B1.2-1983 (R2001)	Gauges and Gauging for Unified Inch Screw Threads. GO/NO-GO system.
ASME B1.3M-1992 (R2001)	Screw Thread Gauging Systems for Dimensional Acceptability. Gauge classification (W, X, Y, Z tolerances).
ASME B1.16M-1984 (R2001)	Gauges and Gauging for MJ Series Metric Screw Threads (reference for UNJ equivalence).
SAE J429	Mechanical and Material Requirements for Externally Threaded Fasteners (inch series Grade 2/5/8).
SAE J995	Mechanical and Material Requirements for Steel Nuts (inch series).
ASTM A193/A193M	Alloy-Steel and Stainless Steel Bolting for High-Temperature Service (Grade B7, B8, etc.).
ASTM A194/A194M	Carbon, Alloy, and Stainless Steel Nuts for Bolts for High-Pressure or High-Temperature Service.
ASTM F606/F606M	Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners.
ISO 16047:2005	Torque/clamp force testing.
DIN 76-1:2025	Thread run-outs and undercuts (reference for inch-to-metric conversion projects).

IMPORTANT: ASME B1.1-2024 now incorporates UNJ thread forms (previously in B1.15-1995). All UNJ references should cite B1.1-2024 directly.

2. Thread Geometry Fundamentals (per ASME B1.1-2024)

2.1 Basic Profile

Unified threads use the same 60° included angle as ISO metric. The fundamental difference is dimensional units (inches) and the allowance system (Class-based rather than grade-position). Key parameters:

Parameter	Formula (inches)	Description
Basic height (H)	$H = 0.86603 / \text{TPI}$	Fundamental triangle height
Pitch diameter (d_2)	$d_2 = d - 0.6495 / \text{TPI}$	Where ridge = groove width
Minor diameter, ext. (d_3)	$d_3 = d - 1.2269 / \text{TPI}$	Root of external thread
Minor diameter, int. (D_1)	$D_1 = d - 1.0825 / \text{TPI}$	Root of internal thread
UNR root radius (R)	$R \geq 0.108 / \text{TPI}$	Mandatory for UNR; improves fatigue
UNJ root radius (R)	$R = 0.15011 / \text{TPI}$ to $0.18042 / \text{TPI}$	Controlled radius for aerospace fatigue life

2.2 Common UNC/UNF Sizes

Size	TPI	Series	Pitch Dia.	Size	TPI	Series	Pitch Dia.	d_2 Tol (2A)
#6	32	UNC	0.1177	3/8"	16	UNC	0.3344	0.0050
#8	32	UNC	0.1437	7/16"	14	UNC	0.3911	0.0052
#10	24	UNC	0.1629	1/2"	13	UNC	0.4500	0.0055
1/4"	20	UNC	0.2175	5/8"	11	UNC	0.5660	0.0059
5/16"	18	UNC	0.2764	3/4"	10	UNC	0.6850	0.0063
1/4"	28	UNF	0.2268	1/2"	20	UNF	0.4675	0.0050
5/16"	24	UNF	0.2854	5/8"	18	UNF	0.5889	0.0053
3/8"	24	UNF	0.3479	3/4"	16	UNF	0.7094	0.0056

Note: All pitch diameter values in inches per ASME B1.1-2024 Table 2A. Tolerance column shows total pitch diameter tolerance for Class 2A external thread.

3. Tolerance and Class System (per ASME B1.1-2024)

3.1 Class Comparison

Class	External Thread	Internal Thread	KFP Application
1A / 1B	Loosest fit; allowance on ext. thread	Widest tolerance	Rarely used; low-precision assemblies
2A / 2B	Standard fit; most common industrial class. Allowance provides clearance for plating.	Standard tolerance	Default for all production unless drawing specifies otherwise
3A / 3B	No allowance (zero fundamental deviation); tightest tolerance	Tightest tolerance	Precision applications; aerospace; where Class 2 clearance is excessive

3.2 Class 2A Allowance and Coated Threads

Class 2A external threads have a built-in allowance (fundamental deviation) that provides clearance between mating parts. This allowance accommodates thin coatings (electroplate $\leq 12 \mu\text{m}$) without exceeding the maximum material limit. For thicker coatings:

- (a) Zinc-nickel (8–15 μm): Class 2A allowance is typically sufficient. Gauge AFTER plating.
- (b) Hot-dip galvanize (40–80 μm): Class 2A allowance is NOT sufficient. Use overtapped (oversize) nuts or specify thread dimensions before galvanizing per project engineering.
- (c) Class 3A has ZERO allowance: any coating will cause the thread to exceed maximum material limit. Class 3A threads must be gauged before coating, or coating must be applied only to non-functional surfaces.

IMPORTANT: Class 3A threads cannot accommodate ANY coating on thread flanks without violating the max material limit. Specify coating exclusion zones on drawings for Class 3A parts.

4. Gauge System (per ASME B1.2 / B1.3M)

4.1 GO / NO-GO Matrix

Test	PASS	FAIL	Action	Tag
GO (ext.)	Ring screws on fully	Ring does NOT fully pass	Segregate; check tooling	✓ GREEN
NO-GO (ext.)	Ring ≤2 turns	Ring >2 turns	Segregate; d ₂ undersize	✗ RED
GO (int.)	Plug screws in fully	Plug does NOT fully pass	Segregate; check tap	✓ GREEN
NO-GO (int.)	Plug ≤2 turns	Plug >2 turns	Segregate; D ₂ oversize	✗ RED

4.2 ASME Gauge Classification (per B1.3M)

ASME B1.3M defines four gauge tolerance grades for thread gauges: W (working), X (inspection), Y (reference), and Z (master). KeyFixPro uses:

- (a) W-tolerance gauges: production floor (operator use). Most common.
- (b) X-tolerance gauges: QC inspection department. Higher accuracy.
- (c) Y-tolerance gauges: gauge room referee measurements. Used to arbitrate disputes.
- (d) Calibration: all gauges calibrated against Y-class or Z-class masters traceable to NIST.

4.3 Three-Wire Method for Unified Threads

Same principle as ISO metric. For 60° Unified threads:

$$d_2 = M - 3 \times dw + 0.86603 / TPI$$

Best-size wire: $dw = 0.57735 / TPI$

| **Note:** Wire sets must be calibrated to $\pm 0.00002''$ (± 0.0005 mm). Measurement environment: $68^\circ F \pm 2^\circ F$ ($20^\circ C \pm 1^\circ C$).

5. Inspection Equipment

Equipment	Specification	Parameters Measured	Application
CMM	Acc. ± 0.001 mm; inch/metric dual output; 120 pts/rev scan	d, d ₂ , d ₃ , TPI, flank angle, lead, helix	FAI, PPAP, audit
GO/NO-GO gauges	Per ASME B1.2; W-class (floor), X-class (QC)	Functional fit per class	100% in-process + final
Optical sorter	0.01 mm/pixel; programmed for inch sizes	Thread presence, major dia., damage	100% final sort (>#6)
Profile projector	10×–50×; with inch overlay charts	Flank angle, root form (UN vs UNR vs UNJ)	Root radius verification
Three-wire sets	Per ASME B1.2 Appendix; certified ± 0.00002 "	Pitch diameter	Borderline verification
Micrometer (inch)	0.0001" resolution	Major diameter, thread length	SPC dimensional checks
AMETEK OES	Multi-element	Alloy composition	Incoming: every heat/lot
Torque tester	0.5–500 N·m; $\pm 1\%$	Install/prevail/strip torque	PPAP; per SAE J429

6. Inspection Procedures

6.1 Incoming Material

Same protocol as KFP-QIM-THD-001 Section 6.1. Material grades per SAE J429 (Grade 2/5/8), ASTM A193 (Grade B7/B8), or customer specification.

6.2 First Article Inspection (FAI)

11-point FAI protocol identical in structure to THD-001 Section 6.2, with the following Unified-specific modifications:

- (a) Tolerance lookup: use ASME B1.1-2024 Tables 2A/2B (ext.) and 3A/3B (int.), NOT ISO 965.
- (b) Class verification: confirm drawing callout (Class 1A/2A/3A). Default: 2A/2B.
- (c) UNJ root radius: if UNJ specified, verify root radius $R = 0.15011/\text{TPI}$ to $0.18042/\text{TPI}$ using optical projector at 50 \times .
- (d) TPI (threads per inch): verify via CMM lead measurement or optical comparator. Tolerance: $\pm 0.0003''$ cumulative per inch.

6.3 In-Process SPC

SPC frequency and methods follow THD-001 Section 6.3. Key differences:

- (a) Pitch diameter tolerance zones are wider for Class 2A than ISO 6g; Cpk target remains ≥ 1.67 .
- (b) Short batch <500 pcs: same enhanced frequency as THD-001.
- (c) Class 3A production: increase d_2 measurement frequency to every 25 pcs or 4 \times /hour due to zero allowance.

6.4 Post-Heat-Treatment

Same protocol as THD-001 Section 6.4. Critical for SAE Grade 8 and ASTM A193 Grade B7 (quench & temper).

6.5 Final Inspection

Same 8-point final inspection protocol as THD-001 Section 6.5, substituting ASME B1.1-2024/B1.2 gauge references.

6.6 Pre-Shipment Packaging Audit

Same protocol as THD-001 Section 6.6.

7. Thread Production Process Control

Manufacturing methods are identical to those in THD-001 Section 8 (rolling, CNC single-point, CNC milling, tapping). Unified-specific considerations:

- (a) Thread rolling dies: must be specified in TPI (not mm pitch). Die sets maintained separately from metric dies.
- (b) CNC programming: ensure CNC thread cycle uses TPI input, not pitch. Verify G76/G92 parameters.
- (c) Thread run-out: ASME B1.1-2024 Appendix contains run-out guidance; also reference DIN 76-1:2025 for cross-system projects.
- (d) UNR threads: rolling die must produce controlled rounded root. Flat root (UN form) is NOT acceptable for UNR callout.
- (e) UNJ threads: requires precision ground rolling dies or single-point CNC with radius insert to achieve the controlled root radius.

Non-Conformance Handling and Disposition

Standard NC Procedure

Step	Action
1. Containment	STOP production. Segregate with RED tag. Quarantine. NCR Form KFP-NCR-001.
2. Scope	Trace to last good inspection. Re-inspect 100% of suspect window.
3. Root cause	8D/5-Why analysis. Common: tool wear, wrong setup, gauge error, material variation.
4. Disposition (MRB)	REWORK / USE-AS-IS (customer concession) / SCRAP.
5. Corrective action	Permanent fix; verify effectiveness over ≥ 3 production lots.
6. Customer notification	If NC product shipped: 24-hr notice + 8D per IATF 16949 §8.7.1.6.

Records, Traceability & Documentation

Record	Doc ID	Retention	Storage
Material cert (EN 10204 3.1)	Per lot	15 yr (auto) / 10 yr	QMS + archive
OES report	KFP-MAT-OES-[lot]	= material cert	QMS
FAI report	KFP-FAI-[part]-[date]	Part life + 1 yr	QMS
SPC charts	Auto-generated	Current + 2 yr	SPC database
Gauge log	KFP-GAG-LOG-[line]	Current + 1 yr	QMS
CMM thread report	KFP-CMM-THD-[part]	Part life + 1 yr	QMS + PDF
Final inspection	KFP-FIN-[lot]-[date]	15 yr (auto)	QMS
NCR / 8D	KFP-NCR-[seq]	Part life + 3 yr	QMS
Gauge cal cert	KFP-CAL-[gauge ID]	+ 2 cal cycles	QMS
PPAP package	Per customer	Part life + 1 yr EOL	QMS + portal

Document Approval

Reviewed and approved by:

Role	Name	Signature	Date
Prepared by:	Quality Engineer		
Reviewed by:	Production Manager		
Approved by:	Quality Director		
Authorized by:	General Manager		

END OF DOCUMENT

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