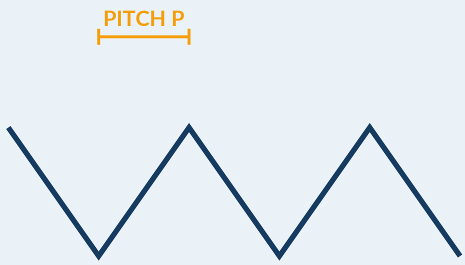
KINGSFORM METALWORKS

ENGINEERING TOOLKIT

THREAD REFERENCE

Metric and Unified thread selection, drill sizing, engagement, tolerances, manufacturing and inspection



60 DEG BASIC PROFILE

MAJOR DIAMETER

PITCH DIAMETER

MINOR DIAMETER

SYSTEM + SIZE

M10 x 1.5

TOLERANCE / CLASS

6H internal | 6g external

DEPTH + CONDITION

THRU or 15 DEEP

PROCESS / ACCEPTANCE

tap, form, mill, gauge

FUNCTION FIRST

Choose the system, fit, depth and inspection method before selecting tooling.

DOCUMENT	VERSION	RELEASE DATE	LANGUAGE
KFR-013	1.0	2026-07-17	English
FORMAT	OWNER	CONTACT	WEBSITE
A4 PDF	KingsForm Engineering	info@kingsformmetalworks.com	www.kingsformmetalworks.com

01 SELECTION AND DESIGNATION

Choose the thread system before choosing the tool

A complete callout identifies the geometry, fit, hand, depth and acceptance requirement.

Decision	ISO metric M	Unified inch UN / UNR / UNJ	Engineering implication
Customer / mating part	Use when drawing, fastener or market is metric	Use for inch-based equipment or existing inch hardware	Do not convert a mating interface by rounding
Pitch notation	Pitch in millimetres: M10 x 1.5	Threads per inch: 1/4-20 UNC	Metric pitch decreases as threads become finer; inch TPI increases
Common general fit	6H internal / 6g external	2B internal / 2A external	Confirm if coating, temperature or precision needs a different fit
Preferred series	ISO 262 selected commercial fastener sizes	UNC / UNF / UNEF series	Prefer stocked fasteners and gauges
High fatigue / aerospace	Special requirements may use MJ or customer profile	UNJ is included in ASME B1.1-2024	Root form and inspection are not interchangeable with standard M / UN

Callout anatomy

Example	What it defines	What is still project-specific
M10 x 1.5 - 6H THRU	ISO metric internal thread, 10 mm nominal diameter, 1.5 mm pitch, class 6H, through	Quantity, location tolerance, entry chamfer, coating state and gauging plan
M8 x 1 - 6H, 12 DEEP	Fine-pitch metric internal thread with 12 mm full thread depth	Required drill depth and bottom clearance
1/4-20 UNC-2B THRU	Unified coarse internal thread, class 2B, through	Countersink / spotface, coating and functional gauge requirement
3/8-24 UNF-2A LH	Unified fine external left-hand thread, class 2A	Thread length, runout, end relief and surface finish

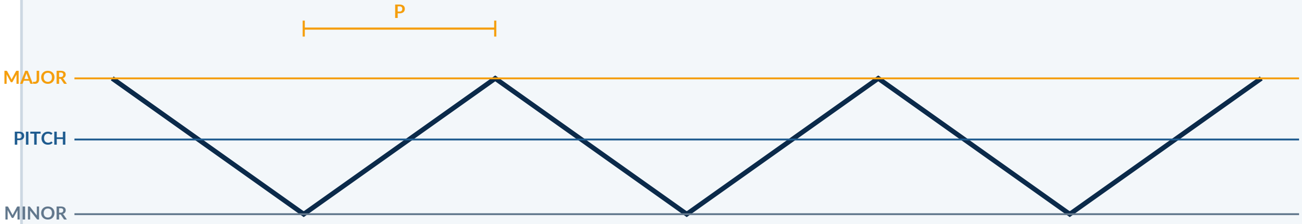
Never write only 'M10 tapped' or '1/4 thread'. State system, nominal size, pitch / series, tolerance class, hand if left-hand, usable length or depth, and THRU / blind condition.

02 GEOMETRY AND TERMINOLOGY

Thread anatomy and the dimensions that control fit

The pitch diameter carries most of the fit information; major and minor diameters alone cannot prove functional assembly.

Lead = pitch for a single-start thread; lead = starts x pitch for a multi-start thread.



Term	Definition	Design / inspection use
Major diameter	Largest diameter of an external thread; corresponding largest profile diameter for internal thread	External size control, crest condition and stock allowance
Minor diameter	Smallest profile diameter	Internal tap-drill effect, external root clearance and stripping area
Pitch diameter	Imaginary cylinder where thread and space widths are equal	Primary functional fit dimension
Pitch P	Axial distance between corresponding points on adjacent threads	Metric designation and lead calculation
TPI	Threads per inch	Pitch in inches = 1 / TPI
Lead	Axial travel in one revolution	Lead = pitch for single-start; starts x pitch for multi-start
Flank angle	Angle between each flank and a perpendicular to the axis	ISO M and Unified basic profiles use a symmetrical 60-degree included angle

Metric pitch	Unified pitch	Basic triangle height
P is stated directly in mm	P = 25.4 / TPI in mm	H = 0.866025 x P

Basic profile equations are useful for understanding geometry, but manufacturing limits and acceptance must come from the specified tolerance standard and thread class.

03 ISO METRIC QUICK REFERENCE

Preferred ISO metric sizes and approximate tapping drills

The drilling values below are practical starting points based on nominal diameter minus pitch. Verify against the tap supplier, material, thread percentage and tolerance class.

Thread	Coarse pitch mm	Approx. cut-tap drill mm	Common fine pitch options mm	Use note
M2	0.40	1.60	0.25	Micro hardware; tool rigidity is critical
M2.5	0.45	2.05	0.35	Often drilled 2.05 or 2.10 by process
M3	0.50	2.50	0.35	Common electronics and sheet-metal hardware
M4	0.70	3.30	0.50	3.3 mm is a common production drill
M5	0.80	4.20	0.50	General machinery and brackets
M6	1.00	5.00	0.75 / 0.50	Common frame and assembly size
M8	1.25	6.80	1.00 / 0.75	6.8 mm commonly used for cut tapping
M10	1.50	8.50	1.25 / 1.00	Fine pitch often used where wall or adjustment matters
M12	1.75	10.20	1.50 / 1.25 / 1.00	Check torque and engagement, not only drill size
M14	2.00	12.00	1.50	Less common than M12 and M16 in some markets
M16	2.00	14.00	1.50 / 1.00	Heavy assemblies
M18	2.50	15.50	2.00 / 1.50	Confirm fastener availability
M20	2.50	17.50	2.00 / 1.50 / 1.00	Structural / machinery applications
M22	2.50	19.50	2.00 / 1.50 / 1.00	Availability varies by region
M24	3.00	21.00	2.00 / 1.50 / 1.00	Large joint and anchor applications
M27	3.00	24.00	2.00 / 1.50 / 1.00	Prefer clear purchasing specification
M30	3.50	26.50	3.00 / 2.00 / 1.50	Large-machinery interface

M without an explicit pitch normally denotes the coarse-pitch series when the context and governing standard make that convention unambiguous. For manufacturing drawings, stating the pitch removes doubt and improves cross-market communication.

04 UNIFIED INCH QUICK REFERENCE

Common UNC and UNF sizes with practical cut-tap drill starting points

Use the exact ASME thread designation. Numbered and fractional drills are shop references; decimal diameter should remain available for verification.

Nominal size	UNC TPI	Typical UNC tap drill	UNF TPI	Typical UNF tap drill	Approx. major dia. in
#4	40	#43 (0.0890)	48	#42 (0.0935)	0.1120
#6	32	#36 (0.1065)	40	#33 (0.1130)	0.1380
#8	32	#29 (0.1360)	36	#29 (0.1360)	0.1640
#10	24	#25 (0.1495)	32	#21 (0.1590)	0.1900
1/4	20	#7 (0.2010)	28	#3 (0.2130)	0.2500
5/16	18	F (0.2570)	24	I (0.2720)	0.3125
3/8	16	5/16 (0.3125)	24	Q (0.3320)	0.3750
7/16	14	U (0.3680)	20	25/64 (0.3906)	0.4375
1/2	13	27/64 (0.4219)	20	29/64 (0.4531)	0.5000
5/8	11	17/32 (0.5313)	18	37/64 (0.5781)	0.6250
3/4	10	21/32 (0.6563)	16	11/16 (0.6875)	0.7500
7/8	9	49/64 (0.7656)	14	13/16 (0.8125)	0.8750
1	8	7/8 (0.8750)	12	59/64 (0.9219)	1.0000

Series	Typical reason to use	Trade-off
UNC	General assembly, softer materials, dirty environments, rapid assembly	Lower thread count per length; larger pitch
UNF	Thin walls, adjustment, higher clamp resolution, existing equipment	More sensitive to damage and contamination
UNEF	Special thin-wall or fine adjustment applications	Availability, tooling and gauging must be confirmed
UNJ	Controlled external root radius for fatigue-sensitive applications	Requires correct mating profile, tooling and inspection

The drill sizes shown are common cut-tap starting points, not acceptance limits. Form taps require a larger pre-hole and tighter process control; always use the tool manufacturer's chart.

05 PRE-HOLE AND THREAD PERCENTAGE

Size the pre-hole for the process, material and required engagement

A smaller hole increases thread percentage and torque; it does not automatically produce a stronger or more reliable thread.

Method	Approximation	Example	Use / limitation
Metric cut tap	Tap drill approx. D - P	M10 x 1.5 -> 10 - 1.5 = 8.5 mm	Good starting point for many cut-tap applications
Unified cut tap	Tap drill approx. major diameter - 1/TPI	1/4-20 -> 0.250 - 0.050 = 0.200 in	Choose the nearest practical drill after checking desired thread percentage
Metric thread percentage	% approx. = 76.98 x (D - drill) / P	M6 x 1 with 5.0 mm drill -> about 77% theoretical	Approximation for 60-degree threads; actual crest truncation and tolerance matter
Unified thread percentage	% approx. = 76.98 x TPI x (D - drill)	1/4-20 with #7 drill gives about 75%	Use decimal drill diameter

Target range	Typical observation	Engineering action
50-60%	Lower torque, useful in hard / tough materials or deep holes	Validate stripping strength and customer requirement
60-75%	Common production region for many cut taps	Balance strength, torque, tool life and burrs
75-85%	Higher tapping torque and breakage risk; limited strength gain	Use only with controlled material, tooling and lubrication
>85%	Often unnecessary and process-sensitive	Recheck pre-hole, drill wear and specification

CUT TAP	FORM TAP	THREAD MILL
Creates chips. Choose flute style, coolant and hole depth for chip evacuation.	Displaces material. Requires ductile material, larger pre-hole and supplier-specific limits.	Programmable diameter and depth. Useful for large, blind, expensive or difficult threads.

Pre-hole diameter is a process characteristic. Put the finished thread requirement on the product drawing; place the drill size in the manufacturing plan unless the pre-hole itself is functional.

06 BLIND HOLES AND ENGAGEMENT

Separate usable thread depth from drill depth and tool runout

Many assembly failures come from a screw bottoming in an under-defined blind hole rather than from inadequate thread strength.

Drill depth must exceed usable thread depth. Do not dimension only the drill-point apex unless that is the functional requirement.

Material receiving internal thread	Starting engagement range	What must be checked
Steel / stainless steel	About 1.0 x nominal diameter is a common starting point	Bolt strength, thread class, galling, corrosion and cyclic loading
Cast iron	About 1.0-1.5 x diameter	Grade, graphite structure, edge breakout and casting porosity
Aluminum / magnesium	About 1.5 x diameter is a common starting point	Alloy / temper, insert need, repeated service and local wall thickness
Engineering plastics	Often 2 x diameter or an insert / molded boss	Creep, temperature, moisture, torque and service cycles
Thread insert	Follow insert system and parent-material requirements	Boss diameter, installation depth, pull-out and removal

Design rule	Reason
Specify full usable thread depth, not only tap travel	Lead chamfers and runout do not create complete threads
Allow bottom clearance beyond the screw penetration	Prevents bottoming and false torque
Add drill-point depth below cylindrical depth	A 118-degree drill point adds depth; flat-bottom tools require separate planning
Provide entry chamfer / countersink appropriate to assembly	Improves lead-in and protects the first thread
Avoid blind threads too close to the opposite wall	Protects wall thickness and prevents breakthrough

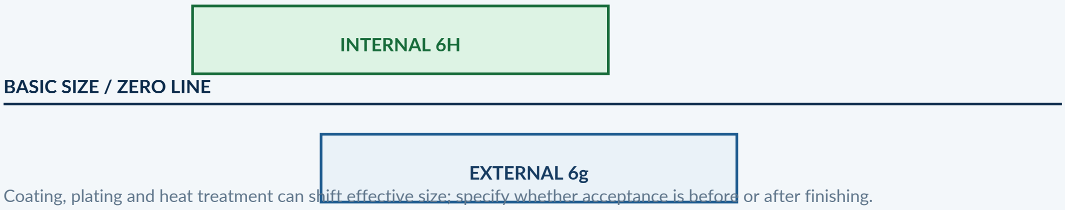
Engagement ratios are starting heuristics, not universal design values. Joint strength depends on material shear strength, bolt strength, pitch, thread geometry, load distribution, preload and service conditions.

07 TOLERANCE CLASSES AND FITS

Specify the fit system and the acceptance condition

Tolerance class controls the permitted size zone; coating and finishing can consume clearance and shift the functional fit.

Tolerance class = tolerance grade (width) + fundamental deviation (position).



Coating, plating and heat treatment can shift effective size; specify whether acceptance is before or after finishing.

System	Internal examples	External examples	Practical meaning
ISO metric	6H is a common general-purpose internal class	6g is a common general-purpose external class	Medium commercial fit; class numbers and letters define tolerance width and position
ISO metric tighter / special	5H, 4H5H and other combinations may be specified	6h, 4g6g, 4h6h and others	Use only when function, gauging and process capability justify the tighter fit
Unified inch	2B internal	2A external	General commercial fit with allowance on external thread
Unified inch tighter	3B internal	3A external	Closer fit, more sensitive to processing, coating and contamination

Drawing callout	Interpretation / addition
4X M6 x 1 - 6H THRU	Four internal metric threads, through; add location tolerance and entry requirement
2X M10 x 1.25 - 6H, 18 FULL THREAD DEPTH	Fine-pitch blind metric threads; drill depth must be separately adequate
1/4-20 UNC-2B THRU	Unified coarse internal thread, class 2B, through
3/8-24 UNF-2A x 22 LONG	External fine thread with controlled threaded length
M12 x 1.5 - 6g LH	External metric left-hand thread

Finish condition	Drawing / control implication
Plating on external thread	Allowance and final pitch diameter must permit coating buildup
Coating inside internal thread	Mask, chase after coating, use dedicated class / allowance, or specify final gauge acceptance
Hot-dip galvanized threads	Use the applicable ISO 965 galvanized-thread provisions or governing product standard
Paint / powder coat	Normally mask functional threads or define post-coat cleaning and final acceptance

08 MANUFACTURING PROCESS SELECTION

Choose the thread process around quantity, material, access and risk

The same finished callout can be produced by different processes, but chip control, tool access, surface integrity and economics differ.

Process	Best suited to	Advantages	Key controls
Cut tapping	General internal threads, small to medium sizes	Low tooling cost, broad availability	Tap geometry, chip evacuation, lubrication, pre-hole and reversal
Form tapping	Ductile materials, clean chip-free holes	Strong burnished thread, no chips, good productivity	Material ductility, larger pre-hole, high torque, lubricant and tool chart
Thread milling	CNC blind holes, large threads, expensive parts, one-tool flexibility	Diameter compensation, full-depth control, low breakage consequence	Machine interpolation, tool runout, programming and gauge correlation
Single-point turning	External / internal threads on rotational parts	Flexible profiles, lead and relief control	Tool geometry, pitch synchronization, runout and support
Thread rolling	High-volume external threads in suitable ductile materials	Good surface finish, favorable grain flow, no chips	Blank diameter, material condition, die match and end relief
Die cutting / chasing	External threads, repair or lower-volume work	Simple equipment	Straight start, stock diameter, lubrication and burr control

Material / condition	Common concern	Useful planning response
Austenitic stainless steel	Work hardening, galling, built-up edge	Rigid setup, sharp tools, suitable lubricant, controlled speed and uninterrupted cut
High-strength steel	Tap breakage and poor tool life	Reduce thread percentage where allowed, use premium tooling, thread mill large / critical holes
Aluminum	Chip packing, oversize / torn threads in some alloys	Correct flute style, coolant, sharp tool and burr control
Cast iron	Abrasive dust, brittle breakout	Dry / controlled extraction as appropriate, edge distance, suitable tool grade
Thin sheet / tube wall	Insufficient engagement and distortion	Use extruded holes, weld nuts, rivet nuts, PEM-type fasteners or threaded bosses

Do not change between cut tapping and form tapping without revising the pre-hole size and confirming material suitability. The finished thread callout may be unchanged, but the process plan is not.

09 DESIGN DETAILS AROUND THREADS

Protect wall thickness, access, lead-in and service life

A correct nominal thread can still be unmanufacturable or unreliable when the surrounding geometry is weak or inaccessible.

Feature	DFM question	Recommended design action
Edge distance	Can the thread or pre-hole break out under tapping or load?	Provide enough surrounding material for the hole, chamfer and expected load path
Boss diameter	Is the parent material thick enough for stripping and installation loads?	Size from strength calculation or insert-system data; avoid thin unsupported rings
Tool access	Can drill, tap, gauge and driver enter on-axis?	Provide straight-line access and space for spindle, holder, chip evacuation and gauge handle
Entry chamfer	Will the fastener start without cross-threading?	Use a controlled lead-in; do not create an oversized countersink that removes useful threads
Thread runout	Does the mating component require full thread to a shoulder?	Add relief / undercut or leave a defined runout zone
Weld nut / boss	Will welding distort the thread or coat the interface?	Locate before welding, use fixtures, protect thread and gauge after welding / finishing
Rivet nut / clinch fastener	Is the sheet thickness and access compatible with the hardware?	Specify exact supplier family, grip range, installation hole and proof requirements
Insert	Is repeated service, repair or soft parent material expected?	Define insert type, length, installation depth, tang policy and pull-out / torque validation

GALLING CONTROL
Material pair, surface finish, lubricant and assembly speed matter. Stainless-on-stainless joints may need anti-galling measures.

CROSS-THREAD CONTROL
Use lead-in geometry, alignment, controlled driver speed and accessible starts. Do not rely on torque shutoff alone.

PRELOAD CONTROL
Torque is an indirect preload method and is highly influenced by friction. Specify joint procedure when preload is critical.

REPEATED SERVICE
Soft parent materials, coatings and small threads may need inserts, replaceable nuts or lower service torque.

For weld nuts, clinch fasteners, rivet nuts and inserts, the hardware manufacturer's installation specification is part of the design requirement - not merely a purchasing note.

10 INSPECTION AND FAILURE DIAGNOSIS

Use functional gauging and measured data for the characteristic that matters

A GO / NO-GO result verifies a defined acceptance boundary; it does not describe every element of the thread or guarantee joint performance.

Method	Best use	What it does not prove by itself
GO plug / ring gauge	Functional acceptance of maximum-material boundary and mating capability	Exact pitch diameter, lead error distribution or root condition
NO-GO plug / ring gauge	Checks that selected size elements do not exceed the nonfunctional limit	Complete form or every local defect
Thread micrometer	External pitch diameter measurement	Internal thread condition or full functional assembly
Three-wire method	Accurate external pitch diameter when correctly applied	Major diameter, lead and flank form unless separately checked
Optical / vision system	Profile, angle, pitch, burrs and external geometry	Deep internal threads without suitable access
CMM / scanning	Location, axis, related geometry and accessible profile data	May not substitute for functional gauging; probe access and strategy matter
Mating fastener test	Assembly demonstration under defined hardware and torque	Conformance to the governing thread standard

Symptom	Likely contributors	Immediate investigation
GO gauge will not enter	Undersize internal pitch diameter, coating buildup, burr, taper, damaged first thread	Clean, inspect entry, verify pre-hole / tap wear, check final finish state
NO-GO enters too far	Oversize pitch diameter, wrong tap, tool wear / compensation, bell-mouth	Confirm gauge condition and rule, measure pitch diameter, inspect process history
Fastener bottoms before clamp	Insufficient usable thread or drill depth, screw too long, debris	Compare screw penetration to full thread depth and bottom clearance
Thread strips	Low parent strength, short engagement, oversize pre-hole, excessive torque	Verify material, thread percentage, engagement and assembly torque
Galling / seizure	Incompatible material pair, dry assembly, rough finish, high speed	Review lubricant, surface, assembly speed and fastener grade
Tap breaks	High percentage, hard spot, chip packing, misalignment, poor lubrication	Check drill size, hardness, tap geometry, depth and coolant

Control gauge calibration, gauge wear, temperature, cleanliness and the exact acceptance rule. A good part can appear bad with a dirty or damaged gauge, and a bad part can pass an incorrect gauging method.

11 RELEASE CHECKLIST AND STANDARDS

Thread design release checklist

Use this page before issuing an RFQ, drawing or inspection plan.

01 Thread system and profile are named (ISO M, UN, UNR, UNJ, pipe thread or other).	13 Engagement length is based on joint strength and service, not a fixed rule only.
02 Nominal diameter and pitch / TPI are explicit.	14 Fastener length cannot bottom before clamp load is developed.
03 Internal or external thread and right- / left-hand condition are clear.	15 Coating, plating, galvanizing or paint allowance is defined.
04 Tolerance class is specified and compatible with the mating part.	16 Masking, chasing or post-finish gauging is specified where needed.
05 THRU, usable thread depth or threaded length is defined.	17 Welded nuts / bosses are protected and inspected after welding.
06 Blind-hole drill depth, runout and bottom clearance have been checked.	18 Insert, rivet-nut or clinch-fastener supplier series and grip range are specified.
07 Entry chamfer / countersink is defined without removing excessive full thread.	19 Galling, corrosion and repeated-service risks are reviewed.
08 Edge distance, boss diameter and remaining wall thickness are adequate.	20 Inspection method and GO / NO-GO rule are defined.
09 Tool, gauge and assembly access are available on axis.	21 Gauge type, class, calibration and final acceptance condition are controlled.
10 Cut tap, form tap, thread mill, rolling or turning process is feasible for the material.	22 Thread location, axis and related GD&T; are specified separately from thread size.
11 Pre-hole size and thread percentage are controlled in the process plan.	23 Mating hardware standard, grade and finish are identified.
12 Chip evacuation and coolant / lubricant strategy are suitable for depth and material.	24 Drawing, 3D model, BOM and purchase specification use the same designation.

Standards and official sources checked for this release

Reference	Status / role	Official source
ISO 68-1:2023	Basic and design profiles for ISO metric fastening threads	https://www.iso.org/standard/85107.html
ISO 261:1998	General plan; confirmed current in 2024	https://www.iso.org/standard/4165.html
ISO 262:2023	Selected commercial metric fastener sizes	https://www.iso.org/standard/85105.html
ISO 724:2023	Basic dimensions for ISO metric threads	https://www.iso.org/standard/85104.html
ISO 965-1:2026 / ISO 965-2:2024	Tolerance principles and common 6H / 6g limits	https://www.iso.org/standard/87889.html
ISO 1502:1996	Metric gauges and gauging; current at release, under systematic review	https://www.iso.org/standard/6092.html
ASME B1.1-2024	Unified inch UN, UNR and UNJ thread forms	https://www.asme.org/codes-standards/find-codes-standards/b1-1-unified-inch-screw-threads-un-unr-thread-form
ASME B1.13M-2005 (S2025)	Metric M-profile thread system in ASME practice	https://www.asme.org/codes-standards/find-codes-standards/b1-13m-metric-screw-threads-m-profile
ASME B1.2-1983 (R2017)	Unified inch gauges and gauging; stabilized maintenance	https://www.asme.org/codes-standards/find-codes-standards/b1-2-gages-gaging-unified-inch-screw-threads

This guide summarizes engineering practice and does not reproduce proprietary tolerance or gauging tables. Use a controlled copy of the governing standard for final limits, gauges and acceptance.