

Operating Manual: Common Wire Nail

*Plain-shank common steel wire nail | 16d common, 3.5 in x 0.162 in |
ASTM F1667 NLCMS-11*

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Document control

Field	Entry
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Governing product standards	ASTM F1667/F1667M-21a (inch-pound and SI series); EN 10230-1:1999 (metric series)
Governing design standards	AWC NDS for Wood Construction (United States); EN 1995-1-1 Eurocode 5 (Europe)
Review cycle	On change of any cited standard, or 3 years, whichever is sooner

Revision history

Rev	Date	Description	Prepared	Approved
1.0	2026-09-13	First issue. Covers the plain-shank common wire nail across the inch-pound and metric series, with the US and European regulatory routes.	Technical Publications	<i>pending</i>

Foreword

A common wire nail is the least remarkable object on a construction site and one of the most consequential. A single dwelling contains tens of thousands of them. Almost every one is installed by hand, in seconds, without measurement, by an operator who will never read a specification for it. The nail is nevertheless a **structural component**: in the United States it is named explicitly in the prescriptive

fastening schedule of the residential building code, and in the European Union it is a construction product that may not lawfully be placed on the market without a declaration of performance.

That gap — between how casually the product is used and how formally it is regulated — is what this manual exists to close. It treats the common wire nail the way any other load-bearing component would be treated: it defines the product, states its rated performance and the limits of that rating, sets out the correct procedure for putting it into service, and says plainly what it must never be asked to do.

Three themes run through the document and are worth stating at the outset.

First, a plain-shank nail is a shear connector, not a tension connector. It is very good at resisting load applied across its shank and comparatively poor at resisting load applied along it. Many nailed-joint failures in service follow from that distinction being ignored.

Second, the product's holding power is not a fixed property. It is a function of the timber it sits in, the moisture history of that timber, and the workmanship of the installation. A nail correctly driven into seasoned timber and a nail identically driven into green timber that subsequently dries are not the same fastener — the second can retain as little as a quarter of the withdrawal resistance of the first.

Third, nomenclature in this trade is genuinely unreliable. The same penny designation is applied to nails of materially different diameters, and widely circulated size charts contradict the standards they claim to reproduce. Section 2.5 and Appendix A address this directly. Wherever a dimension matters, specify diameter and length, not a penny size.

1 About this manual

1.1 Purpose

This manual states how to select, receive, store, install, inspect, remove and dispose of plain-shank common steel wire nails, so that the joints made with them achieve and retain the capacity the designer assumed.

1.2 Scope

1.2.1 In scope

- Plain (smooth) round-shank steel wire nails with a full flat head and a diamond point, hand-driven or driven by a portable fastener-driving tool.
- The inch-pound “penny” series specified in ASTM F1667/F1667M and tabulated for design in the AWC NDS.
- The metric round wire nail series specified in EN 10230-1.
- Bright, hot-dip galvanized, electro-galvanized, mechanically deposited zinc, and cement or vinyl coated finishes.
- Installation into solid sawn softwood and hardwood, structural composite lumber, and wood structural panels.

1.2.2 Out of scope

The following are excluded. Where one of them is the right answer, this manual says so and stops.

Excluded	Why, and where to go instead
Deformed-shank nails — annular ring, helical, screw shank	Different withdrawal mechanism and different design values. See the manufacturer’s evaluation report.
Hardened masonry, concrete and steel-pin fasteners	Different material and a different hazard profile — brittle fracture on mis-strike. A common nail must never be substituted, and vice versa.
Cut nails (ASTM F1667 Type II), spikes (Type III), staples (Type IV)	Separate product families within the same specification.
Collated strip and coil nails <i>as a product</i>	The nails themselves are in scope; the collation material is expressly excluded from ASTM F1667 (clause 1.4), and collation governs tool compatibility.

Excluded	Why, and where to go instead
Powder-actuated and gas-actuated tools	Governed by a separate safety regime.
Structural design of the connection	This manual states rated capacities and their limits. It does not replace the governing design code or the engineer of record.
Nail plates, punched metal plate fasteners, joist hangers	A different product family under a different conformity route.

1.3 Intended audience and required competency

Audience	Sections of primary interest	Assumed competency
Carpenter, joiner, framer	5, 6, 7, 8, 10	Trained in the safe use of striking and fastener-driving tools.
Site supervisor, foreman	5, 6, 7.11, 9, 11, 12	As above, plus responsibility for the fastening schedule and site housekeeping.
Goods-in and stores	6.1, 6.2, 12	Able to read a product label and a declaration of performance.
Inspector, clerk of works	3, 7.11, 9, 10, Appendix G	Able to read the governing fastening schedule.
Design engineer, specifier	2.5, 3, 4, 6.4, 12, Appendices A–D	Competent in timber connection design to the applicable code.
Buyer, estimator	2.5, 2.9, 3.1, 3.2, 6.4, Appendix B	—

This manual does not qualify anyone to use a fastener-driving tool. Powered tools require the training described in Section 5.5 and in the tool manufacturer's own instructions.

1.4 Safety signal words

Signal	Meaning
DANGER	An imminently hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	A potentially hazardous situation which, if not avoided, could result in death or serious injury.

Signal	Meaning
CAUTION	A potentially hazardous situation which, if not avoided, may result in minor or moderate injury.
NOTICE	A practice not related to personal injury — property damage, loss of capacity, or non-compliance.
NOTE	Supplementary information. No hazard.

1.5 Units and conventions

- Both inch-pound and SI units are given. Where a value originates in one system, that value is authoritative and the conversion is a convenience. **Conversions are not re-specifications** and must not be quoted back to a supplier as a requirement.
- Nail diameter is denoted **d** (metric practice, mm) or **D** (US practice, inches). Both mean the nominal shank diameter, measured away from the gripper marks and clear of any coating.
- Length **L** is the overall length as defined by the governing product standard. Section 3.3 notes that the two systems do not measure it identically.
- Decimal separators follow the source: a point in inch-pound and ASTM material, a comma where a European standard is quoted.
- “Timber” and “lumber” are used interchangeably.

1.6 Identifier traceability

Every part number, model code, standard reference and numeric requirement in this manual either traces to a cited published source or is flagged **[VERIFY]**.

A **[VERIFY]** flag means the value is believed correct and is in general circulation, but the primary source could not be read directly — most often because the standard is behind a paywall. **A [VERIFY] value must be confirmed against the purchased standard before it is used contractually or in a design calculation.** All such items are collected in Appendix H.

1.7 Jurisdictional note

Two separate regulatory systems govern this product. They use different designations, different dimensions, different test methods and different design mathematics. They are **not** interchangeable, and a nail compliant with one is not thereby compliant with the other.

	United States	European Union / United Kingdom
Product standard	ASTM F1667/F1667M-21a	EN 10230-1:1999 (general); EN 14592 (structural)
Design code	AWC NDS for Wood Construction	EN 1995-1-1 (Eurocode 5)
Prescriptive schedule	IRC Table R602.3(1); IBC Table 2304.10.2	National Annex and project specification
Market access	Code compliance; no CE-equivalent marking	Mandatory CE marking (EU), CE or UKCA (GB), with a declaration of performance
Sizing convention	Penny (d) series, inches	Nominal diameter × length, millimetres

Jurisdiction-specific material is marked **[US]** or **[EU/UK]**.

2 Product description

2.1 Definition and function

A **common wire nail** is a one-piece fastener cold-formed from drawn carbon steel wire, comprising a flat bearing head, a plain cylindrical shank and a tapered point. It is installed by driving it along its axis into wood, displacing rather than removing material. It is held by the elastic recovery of the compressed wood fibres clamping radially onto the shank.

Its function in a joint is to **transfer load between two or more wood members**, principally as shear across the shank. It is the heaviest-gauge member of the common/box/sinker family for a given length, which makes it both the strongest and the most likely to split the timber.

2.2 Reference unit

Worked values and examples throughout this manual use the following reference unit unless stated otherwise.

Property	Value	Source
Trade designation	16d common	ASTM F1667 clause 4.2 — the penny weight is referenced in the dimensional tables
ASTM part identifying number	F1667 NLCMS-11	ASTM F1667 clause 4.1, Note 2
Length L	3½ in (88,9 mm)	AWC NDS Appendix L, Table L4
Shank diameter D	0.162 in (4,11 mm)	AWC NDS Table L4
Head diameter H	0.344 in (8,74 mm), nominally 11/32 in	AWC NDS Table L4
Steel Wire Gauge	8 — exactly 0.162 in	ASTM A510/A510M-20, Table 1
Head form	Flat, full, commonly checkered	ASTM F1667 Type I, Style 10
Point	Diamond	ASTM F1667 Type I, Style 10
Minimum bending yield strength Fyb	90 000 psi (620 MPa) — only if ordered to Supplementary Requirement S1	ASTM F1667 Table S1.1, band 0.142 in < D ≤ 0.177 in
Approximate count	44–49 per lb (97–108 per kg)	Published sources disagree — see Section 3.1.3

Why this unit. The 16d common is the fastener named in more connections than any other in the IRC prescriptive fastening schedule — among them stud to stud, built-up header, top plate to top plate, double top plate splice, bottom plate to joist or rim, and top or bottom plate to stud as an end nail. That is a checkable basis for calling it the usual nail.

NOTE. No production or market-share statistic supports the claim that the 16d common is the most-manufactured nail, and none is made here. The argument rests on code citation frequency, which is verifiable.

2.3 Anatomy and nomenclature

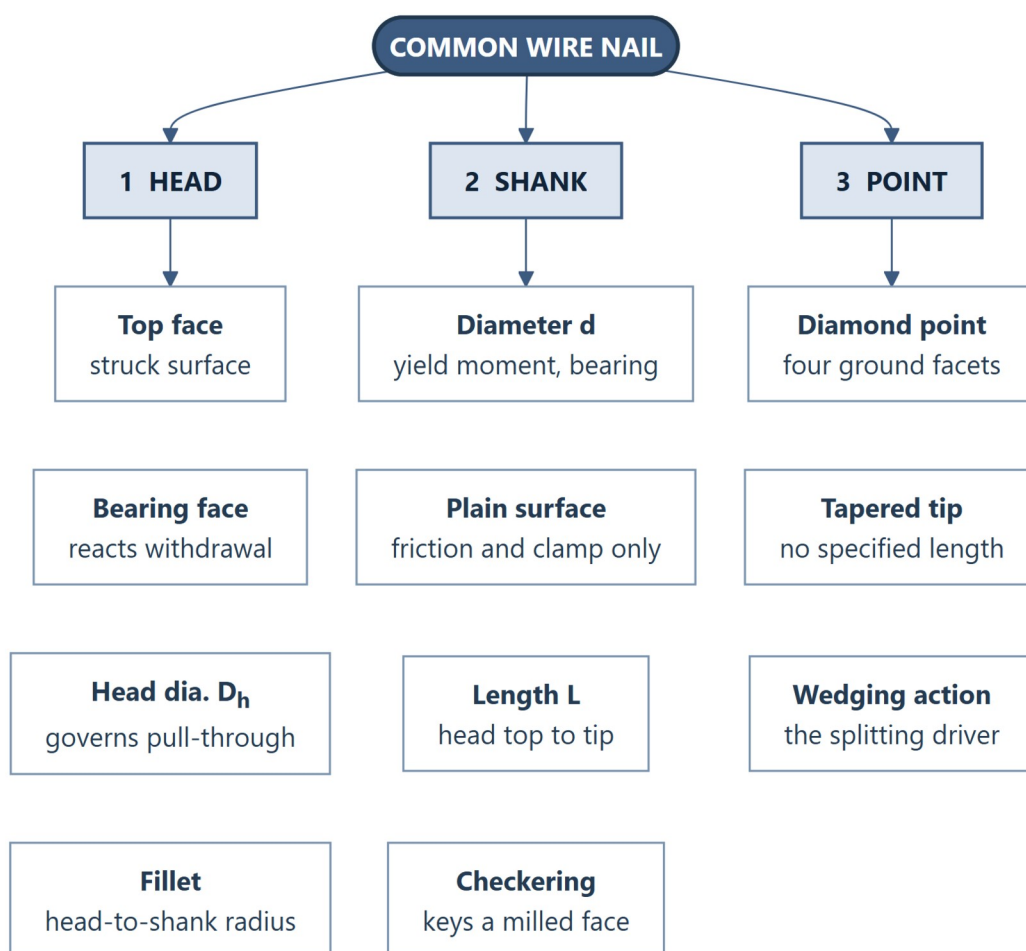


Figure 2-1 — Principal parts of a common wire nail, and what each one governs.

Three features are routinely misread.

The fillet under the head. ASTM F1667 clause 8.2.3.1 requires that *"a fillet shall be provided under the head if not otherwise specified."* This radius is the transition between head and shank, and it is where a nail fails at the head if it is going to. It is not decorative.

The checkering on the head. The grid pattern on the top face of many commons exists to key with a milled (“waffle”) hammer face and reduce glancing blows. It has no structural function.

The point. ASTM F1667 specifies a diamond point for common nails but **does not specify a point length**. For design, the AWC NDS permits the tapered tip to be taken as 2D (Table L4, footnote 2) — a modelling permission, not a dimensional requirement on the product.

2.4 Position within the fastener family

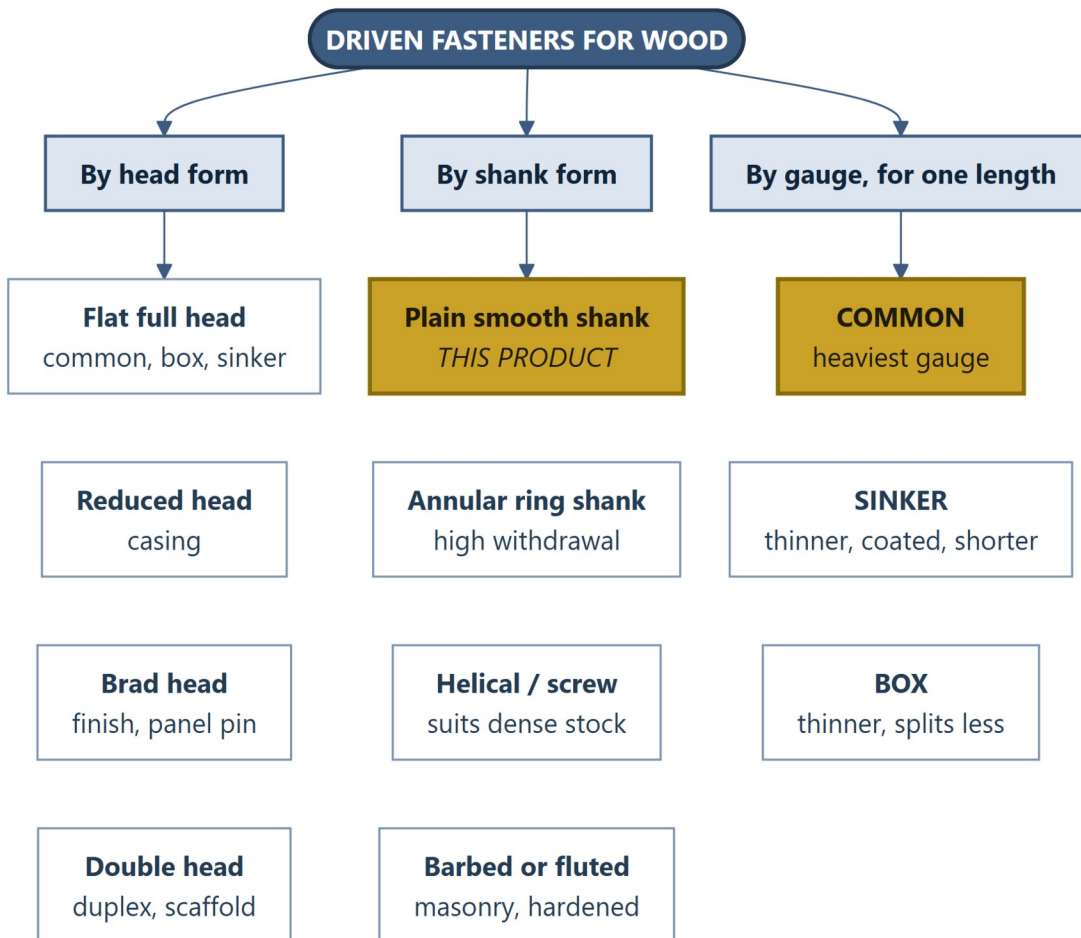


Figure 2-2 — Where the common wire nail sits among driven fasteners. The two highlighted boxes together define this product.

2.5 Designation systems

2.5.1 The penny (d) system [US]

The suffix **d** abbreviates *denarius*, the pre-decimal English penny. In fifteenth-century England the number denoted the price of a hundred nails; the names outlived the prices and became size labels.

The penny system fixes **length only**, and does so reliably: 2d = 1 in, rising in ¼-in steps to 12d = 3¼ in, then 16d = 3½ in, 20d = 4 in, and in ½-in steps to 60d = 6 in.

NOTICE — the penny system does not fix diameter. A 10d common is 0.148 in, a 10d box is 0.128 in, and a 10d sinker is 0.120 in. Three different fasteners, three different capacities, one label. APA – The Engineered Wood Association states the position plainly: there is no standard for nail nomenclature, and the remedy is to “specify diameter and length, with an optional description of nail by pennyweight and type (e.g., 0.148" × 3" [10d common]).” **Adopt that convention in every specification, order and drawing.**

2.5.2 The ASTM F1667 part identifying number [US]

ASTM F1667/F1667M-21a establishes a formal PIN. Clause 4.1, Note 2 states that classification by style and type (alpha indicators) followed by a dash number based on the dimensional tables “*identifies dimensions specifically and establishes a PIN (part identifying number) system when preceded by the F1667 ASTM designator of this specification.*”

The structure is:

```

F1667  NL  CM  S  -  11
|      |   |   |   |
|      |   |   |   |  +-- dash number: the dimensional row in the applicable table
|      |   |   |   |  +----- material / drive sub-code: S = steel wire, hand-driven
|      |   |   |   |  +----- style: CM = Common (Type I, Style 10)
|      |   |   |   |  +----- type: NL = Nail (Type I). Others: CN cut nail, SP spike, ST staple
|      |   |   |   |  +----- the specification designator

```

Style variants within Style 10 (Common): **CMS** steel wire, hand-driven; **CMM** for mechanical (power) drivers; **CMA** aluminium alloy wire; **CMC** copper.

Verified dash numbers for bright steel commons:

PIN	Trade size	Length × diameter
F1667 NLCMS-03	4d	1½ in × 0.099 in
F1667 NLCMS-05	6d	2 in × 0.113 in
F1667 NLCMS-07	8d	2½ in × 0.131 in
F1667 NLCMS-09	10d	3 in × 0.148 in
F1667 NLCMS-11	16d — the reference unit	3½ in × 0.162 in
F1667 NLCMS-16	60d	6 in × 0.262 in

NOTE — trailing letter suffixes. Defence and distributor records consistently show a trailing letter, for example NLCMS-11B, NLCMS-10Z, NLBXA-02C, which strongly implies **B = bright, Z = zinc coated, C = cement coated**. This key could not be confirmed from the text of the standard. **[VERIFY]** — do not use the suffix contractually until it is confirmed against ASTM F1667/F1667M-21a.

An alternative defence-style callout for the same product is ASTM F1667 TB15 TY1ST10NR05 — Table 15, Type 1, Style 10, dash 05.

2.5.3 The metric system [EU/UK]

EN 10230-1:1999, *Steel wire nails — Part 1: Loose nails for general applications*, is the governing product standard for the metric series. It was adopted in the UK as BS EN 10230-1:2000 (published 15 January 2000, current) and in Germany as DIN EN 10230-1:2000-01. Its scope is to establish “*the preferred form and dimensions, tolerances and surface coatings for nails for general applications.*”

Nails are designated by **nominal shank diameter × length in millimetres** — for example 3,1 × 80 or 4,0 × 100.

[VERIFY] — EN 10230-1 internal designation. The standard’s own nail **type numbers**, its formal **designation string format**, and its **tolerance classes** could not be read; the standard is paywalled and no national body publishes an extract. All three must be taken from a purchased copy before they are quoted in a specification.

Superseded national standards. DIN EN 10230-1 explicitly replaced DIN 1144:1973-04, **DIN 1151:1973-04**, DIN 1152:1973-04 and DIN 1160:1973-04. DIN 1151 covered *Drahtstifte* in two head forms — **Form A** flat head and **Form B** countersunk head, the latter usually checkered.

NOTICE — a withdrawn standard is still on the label. German and Austrian distributors universally trade on the pattern “*DIN 1151 – 3,1 × 80*” and dual-label products “*DIN EN 10230-1 (DIN 1151)*”. DIN 1151 has been withdrawn since 2000. Accept it as **shorthand for a shape**, never as evidence of conformity. Only the EN 10230-1 reference — and, for structural use, the EN 14592 declaration of performance — carries any weight.

A standard designated “DIN 1151-1” is frequently cited but **could not be shown to exist [VERIFY]**. Only DIN 1151:1973-04 is documented.

2.6 Telling common, box and sinker apart

These three share a penny designation and are not substitutable. The IRC fastening schedule distinguishes them explicitly and calls for different counts and spacings accordingly.

	Common	Box	Sinker
16d length	3½ in	3½ in	3¼ in — shorter
16d shank D	0.162 in	0.135 in	0.148 in
16d head H	0.344 in	0.344 in	0.344 in
Head form	Flat, full, often checkered	Flat, full	Flat countersunk , usually checkered
Finish	Bright, zinc or cement coated as specified	Bright or coated	Bright or cement coated

	Common	Box	Sinker
Relative capacity	Highest	Lowest	Intermediate
Splitting tendency	Highest	Lowest	Intermediate
Typical use	Structural framing	Thin stock and sheathing, where splitting governs	High-volume framing; the coating and countersunk head speed driving

Dimensions are from AWC NDS Appendix L, Table L4, whose footnote states that tolerances are specified in ASTM F1667. The F1667 style definition for sinkers (Type I, Style 8) reads: *“Steel wire, flat countersunk head, diamond point, round smooth shank, bright or cement coated. When specified, sinkers shall have an altered or T-head for use with mechanical drivers.”*

NOTICE — two contradictory 16d sinker dimensions are in circulation. AWC NDS Table L4 and Simpson Strong-Tie both give **0.148 in × 3¼ in**. Several major retail listings advertise a “16d sinker” at 0.162 in or 0.165 in. **Retail listings are not a dimensional source.** If a design calls for a sinker, specify the diameter.

A further claim in circulation — that a 16d box or sinker head is “roughly 0.191 to 0.230 inches” — contradicts NDS Table L4, which gives 0.344 in for both. The NDS value governs.

2.7 Materials

2.7.1 What the standard actually requires [US]

ASTM F1667 clause 6.1 is the entire material requirement for a steel common nail: *“Steel wire used in the manufacture of driven fasteners shall be of low-carbon, medium-low carbon, or medium-high carbon.”*

There is **no specified SAE or AISI grade, and no specified tensile strength for the finished nail**. Clause 7.2 is explicit: *“Finished driven fasteners are not normally subject to tension testing. However, the wire or sheet used to manufacture the fastener is tested as required for control in the production process during manufacture.”*

Where a gauge is used for a nominal diameter, clause 8.6 requires it to accord with the decimal equivalents in ASTM A510/A510M — the Washburn & Moen Steel Wire Gauge (Section 3.1.2).

2.7.2 What is actually used

Trade practice, not a standard requirement: low-carbon cold-heading wire rod in the SAE 1006 / 1008 / 1010 range is the standard feedstock. One wire-rod producer’s technical sheet maps SAE 1006 to *“black & galvanized wires, small nails”*, SAE 1008 to *“black & galvanized wires, nails”*, and SAE 1010 to *“nails, galvanized fencing mesh”*, all to ASTM A510M.

Nail-machine builders indicate a working window of roughly **350–450 MPa** wire tensile strength: above it the wire resists heading and cracks at the shoulder; below it the head deforms in service. **[VERIFY]** — trade guidance from equipment suppliers, not a specification.

NOTE — the wire is work-hardened, and this matters. Finished nail wire is cold-drawn, so it is stronger than the annealed rod it came from, and the effect increases as diameter falls. The NDS Commentary attributes the rise in bending yield strength at smaller diameters to *“the work hardening of the steel as it is formed into progressively smaller diameters”*, and gives the regression **Fyb = 130.4 – 2140·D** (Fyb in ksi, D in inches). This is why a thin nail is proportionally stronger in bending than a thick one — and why the ASTM S1 bands step downward as diameter rises.

2.7.3 Other materials permitted by ASTM F1667

Material	Clause	Requirement
Stainless steel wire	6.2	Types 302, 304, 305 or 316
Hardened steel nails	6.3	Wire “suitable for heat treatment to a minimum hardness of 37 HRC”
Copper	6.5	Minimum 98 % pure copper
Copper-clad wire	6.6	Not less than 20 % copper by weight; average clad thickness ≥ 10 % of the wire radius, minimum ≥ 8 %
Aluminium alloy wire	6.7	Alloy 2024, 5056, 6061 or 6110; minimum ultimate tensile 60 000 psi

DANGER — hardened nails are a different product with a different failure mode. A common nail is **unhardened**: ASTM F1667 Table 2 requires it to bend through **180°** without fracture, whereas hardened fasteners are required to reach only **20°**. Hardened masonry and concrete nails can fracture and throw fragments when struck. Never substitute one for the other, and never strike a hardened nail with a claw hammer — see Section 5.4.

2.7.4 Wire material [EU/UK]

The European wire-rod route is EN ISO 16120-2:2017, *Non-alloy steel wire rod for conversion to wire — Specific requirements for general purpose wire rod*, which superseded the withdrawn EN 10016-2. Relevant grades and cast analyses (mass %):

Grade	C	Si	Mn	P max	S max
C4D	≤ 0,06	≤ 0,30	0,30–0,60	0,035	0,035

Grade	C	Si	Mn	P max	S max
C7D	0,05–0,09	—	0,30–0,60	0,035	0,035
C9D	≤ 0,10	—	0,30–0,60	0,035	0,035

NOTICE — the rod standard does not deliver the Eurocode strength assumption. ISO 16120-2 clause 5.6 imposes **no absolute minimum tensile strength** on the rod; strength is an optional ordering basis. Eurocode 5's yield-moment expression is valid only *"for smooth nails produced from wire with a minimum tensile strength of 600 N/mm²"* — a property of the **cold-drawn finished wire**, not of the rod. It must therefore come from the nail manufacturer's declaration of performance under EN 14592, not from a rod certificate.

Which wire standard, if any, EN 10230-1 itself nominates could not be established [VERIFY].

2.8 Coatings and finishes

2.8.1 What "galvanized" does and does not mean [US]

This is the single most consequential specification trap in the product.

NOTICE — "galvanized" without a class is meaningless. ASTM F1667 clause 10.1.3 makes ASTM A153/A153M **Class D** apply only *"when a heavier coating for exterior use is specified. If not otherwise specified, the coating weight shall be per A641/A641M Supplementary Requirements Class 1."*

For a 16d nail (0.162 in), the default A641 Class 1 coating is **0.35 oz/ft²** against Class D's **1.00 oz/ft²** — **barely a third of the zinc**. A nail sold simply as "galvanized" is, by default, the light coating. **Class D must be called out by name.**

Route	Standard	Requirement for nails
Bright (uncoated)	—	The as-formed condition. ASTM F1667 Table 15 reads <i>"bright, zinc or cement coated as specified."</i>
Galvanized wire , formed after coating	ASTM A641/A641M, Supplementary Requirements Class 1	The F1667 default . Diameter-keyed values in Table 3-6.
Hot-dip galvanized after forming	ASTM A153/A153M Class D	1.00 oz/ft ² (305 g/m ²) average, 0.85 oz/ft ² (259 g/m ²) individual; 1.7 mils (43 μm) average, 1.4 mils (36 μm) individual. Class D is defined for <i>"fasteners ≤ 3/8 in. diameter, rivets, nails and similar articles."</i>

Route	Standard	Requirement for nails
Mechanically deposited zinc	ASTM B695 Class 40 unless otherwise specified	40 µm minimum — thinner than A153 Class D . Class 55 = 53 µm.
Electro-galvanized	—	ASTM B633 is the general fastener plating specification but explicitly excludes wire , and F1667 does not cite it . For electrogalvanized nail wire, F1667 cites A641 Class 1.
Cement coated	ASTM F1667 clause 10.2.1	Qualitative only: applied by tumbling, dispensing or immersion, and <i>"shall not be tacky or gummy."</i> Note 4 records that cement coatings increase withdrawal holding strength.
Vinyl coated	—	Not defined anywhere in ASTM F1667 . A trade term for a coating intended to melt on driving and reharden.
Blued	ASTM F1667 clause 10.2.3	<i>"heated to form a thin, colored oxide on the surface."</i> Very little corrosion resistance; interior use only.

ASTM F1667 clause 10.1.1 sets out the two permitted production routes: zinc-coated fasteners *"shall be cut and formed from hot-dip, hard-wiped, galvanized steel wire, electrogalvanized steel wire, or zinc flake/chromate dispersion-coated steel wire; or they shall be cut from uncoated (bright) steel wire and shall be hot-dip galvanized, electrodeposited zinc coated, mechanically deposited zinc coated, or zinc flake/chromate dispersion coated after forming."*

NOTICE — cement and vinyl coatings are lubricants, not corrosion protection. Neither carries any standardised thickness, mass or corrosion-resistance value. Never treat a cement- or vinyl-coated sinker as a protected fastener.

2.8.2 Coating specification [EU/UK]

Eurocode 5 Table 4.1 gives minimum material protection, related to ISO 2081 and keyed to service class:

Fastener	Service class 1	Service class 2	Service class 3
Nails and screws, d ≤ 4	None	Fe/Zn 12c	Fe/Zn 25c

Fastener	Service class 1	Service class 2	Service class 3
mm			
Bolts, dowels, nails and screws, d > 4 mm	None	None	Fe/Zn 25c
Staples	Fe/Zn 12c	Fe/Zn 12c	Stainless steel

Table 4.1 footnote: *"If hot dip zinc coating is used, Fe/Zn 12c should be replaced by Z275 and Fe/Zn 25c by Z350 in accordance with EN 10147."* A further footnote adds that *"for especially corrosive conditions consideration should be given to heavier hot dip coatings or stainless steel."*

"Fe/Zn 12" means electroplated zinc on steel, 12 µm; "Fe/Zn 25" means 25 µm. The meaning of the trailing "c" — a supplementary conversion treatment — could not be confirmed against ISO 2081 itself **[VERIFY]**.

NOTICE — two dated references inside Eurocode 5. EN 10147 is itself superseded, by EN 10346. And for fasteners specifically, EN ISO 4042 rather than the general ISO 2081 is the applicable electroplating standard. Resolve both against the project's National Annex before specifying.

Hot-dip galvanizing of finished nails is covered by **EN ISO 1461:2022** (4th edition, superseding EN ISO 1461:2009). Note its scope exclusion: the standard *"does not apply to sheet, wire and woven or welded mesh products that are continuously hot dip galvanized."* Batch and centrifuge galvanizing of finished nails **is** in scope; continuously galvanized wire is not.

[VERIFY] — ISO 1461 coating tables. The centrifuged-article coating minima commonly quoted — for "other articles" under 3 mm, 35 µm local and 45 µm mean — are from the **2009** edition. The 2022 edition is stated to include revised thickness and corrosion-resistance requirements, and the current values could not be read. Do not publish the 2009 numbers as 2022 values.

A real declaration of performance issued in March 2025 for timber-construction fasteners declares durability as *"Zinc plated, minimal thickness 3 µm (Service Class 1 or 2 acc. to EN 1995-1-1); hot dip galvanised, minimal thickness 40 µm (Service Class 3 acc. to EN 1995-1-1)."* Note that the 3 µm figure is **less onerous** than Eurocode 5 Table 4.1's 12 µm for a service class 2 nail of $d \leq 4$ mm. Check declared values against the design assumption; they are not automatically aligned.

2.9 Marking, packaging, and what a label must tell you

A common nail carries no marking on the product itself. **All identification is on the packaging**, which makes the label the only traceability the product has.

A label adequate for structural use states:

1. Nominal size — **diameter and length**, not only a penny designation
2. Type and head form — common / box / sinker; flat or countersunk
3. Finish and, if coated, **the coating standard and class**
4. The governing product standard

5. Batch or lot reference
6. Manufacturer or responsible supplier
7. **[EU/UK]** CE (and where applicable UK or UKCA) marking with the declaration of performance reference — see Section 12
8. **[US]** Where ordered to ASTM F1667 Supplementary Requirement S1, the marking “*Engineered Construction Nails, ASTM F1667*” (clause S1.5)

NOTICE — decanting destroys traceability. Once nails are tipped into a nail bag, apron or unlabelled bin, the batch reference is gone and they cannot afterwards be shown to comply with anything. Keep the carton, keep the label, and never mix batches or sizes in one container.

3 Technical specification

3.1 Dimensional data — inch-pound series [US]

3.1.1 Standard dimensions

Table 3-1 — Common wire nail dimensions, inch-pound series. Rows 6d to 60d are from AWC NDS Appendix L, Table L4, whose footnote records that tolerances are specified in ASTM F1667. Gauge is the ASTM A510/A510M Steel Wire Gauge whose decimal equivalent equals the tabulated diameter.

Penny size	Length L (in)	Shank D (in)	Steel Wire Gauge	Head H (in)	D (mm)	L (mm)
2d	1	0.072	15	0.188 [VERIFY]	1,83	25,4
3d	1¼	0.083 [VERIFY]	~13¾ [VERIFY]	0.219 [VERIFY]	2,11	31,8
4d	1½	0.099	12½	0.250 [VERIFY]	2,51	38,1
5d	1¾	0.099 [VERIFY]	12½	0.250 [VERIFY]	2,51	44,5
6d	2	0.113	11½	0.266	2,87	50,8
7d	2¼	0.113	11½	0.266	2,87	57,2
8d	2½	0.131	10¼	0.281	3,33	63,5
9d	2¾	0.131 [VERIFY]	10¼ [VERIFY]	0.281 [VERIFY]	3,33	69,9
10d	3	0.148	9	0.312	3,76	76,2
12d	3¼	0.148	9	0.312	3,76	82,6
16d	3½	0.162	8	0.344	4,11	88,9
20d	4	0.192	6	0.406	4,88	101,6
30d	4½	0.207	5	0.438	5,26	114,3
40d	5	0.225	4	0.469	5,72	127,0

Penny size	Length L (in)	Shank D (in)	Steel Wire Gauge	Head H (in)	D (mm)	L (mm)
50d	5½	0.244	3	0.500	6,20	139,7
60d	6	0.263	2	0.531 [VERIFY]	6,68	152,4

Notes to Table 3-1

- **2d, 3d, 5d and 9d are not in NDS Table L4.** Their values come from a stainless common-nail catalogue and from a defence stock-number cross-reference to the F1667 PIN, not from a code source. Treat them as indicative.
- **3d gauge.** The trade labels 3d as "14 gauge", but 0.083 in is 13¾ gauge on the true Washburn & Moen scale (A510 14 ga = 0.080 in). The trade label is loose.
- **60d head diameter.** NDS Table L4 gives 0.531 in; some manufacturer tables give 0.500 in. Confirm before use.
- **60d shank diameter.** NDS gives 0.263 in; a defence stock record against F1667 NLCMS-16 gives 0.262 in. The difference is within the ±0.004 in shank tolerance.

NOTICE — two incompatible "common nail" tables are in circulation, and one of them is wrong.

Family A (used above, and in ASTM F1667, NDS Table L4, the IRC fastening schedule, and major connector manufacturers): 6d 0.113, 8d 0.131, 10d 0.148, 16d 0.162, 20d 0.192, 30d 0.207, 40d 0.225, 60d 0.263.

Family B (widely copied hardware charts): 6d 0.120 at "11 ga", 8d 0.134 at "10 ga", 16d 0.165 at "8 ga", 20d 0.203 at "6 ga", 30d 0.220 at "5 ga", 40d 0.238 at "4 ga".

The test that settles it: Family B's own gauge column does not match the Washburn & Moen decimal equivalents in ASTM A510 Table 1. A510 gives 8 ga = 0.162 (not 0.165), 6 ga = 0.192 (not 0.203), 5 ga = 0.207 (not 0.220), 4 ga = 0.225 (not 0.238) and 11½ ga = 0.113 (not 0.120). **Family A matches A510 exactly; Family B is internally inconsistent. Use Family A.**

3.1.2 Steel Wire Gauge

Table 3-2 — Steel Wire Gauge decimal equivalents, ASTM A510/A510M-20, Table 1. Footnote A to that table records that the gauge "has been taken from the original Washburn and Moen Gauge chart."

Ga	in	Ga	in	Ga	in
2	0.262	8½	0.155	11½	0.113
3	0.244	9	0.148	12	0.106
4	0.225	9½	0.142	12½	0.099
5	0.207	10	0.135	13	0.092

Ga	in	Ga	in	Ga	in
6	0.192	10¼	0.131	14	0.080
7	0.177	10½	0.128	15	0.072
8	0.162	11	0.120		

ASTM A510 clause 3.1.1.1 itself advises against the gauge: “*Since the many gauge systems in use may cause confusion, the purchaser is encouraged to specify wire diameters in inches, decimal parts, or metric equivalents.*” Follow that advice.

3.1.3 Count per unit mass

Count per pound is **not a specified requirement**. ASTM F1667 lists it as “*approximate count per pound*”. It varies with coating and manufacturer, and published sources disagree by up to about 25 %.

Table 3-3 — Approximate count per pound, three published sources. All values [VERIFY].

Penny	Source A (connector mfr)	Source B (engineering reference)	Source C (calculator)
2d	807	876	796
3d	473	568	474
4d	228	316	278
6d	144	181	164
8d	94	106	99
10d	67	69	66
16d	44	49	47
20d	25	31	29
40d	19	18	16
60d	—	11	10

NOTICE — do not use count per unit mass as an acceptance criterion. It is an estimating aid only. For ordering, allow a margin: a 50 lb carton of 16d common holds somewhere between about 2 200 and 2 450 nails on these figures.

3.2 Dimensional data — metric series [EU/UK]

3.2.1 Shank and head diameters

Table 3-4 — EN 10230-1 nominal shank diameter d and head diameter D_h , mm. All values [VERIFY].

d	1,0	1,2	1,4	1,6	1,8	2,0	2,2	2,4	2,7	3,0
D_h	2,8	3,3	3,9	4,0	4,5	5,0	5,5	5,9	6,1	6,8

d	3,4	3,8	4,2	4,6	5,0	5,5	6,0	7,0	8,0
D_h	7,7	7,6	8,4	9,2	10	11	12	14	16

[VERIFY] — this table is single-sourced and contains a known anomaly. The pair $d = 3,4 \rightarrow D_h = 7,7$ followed by $d = 3,8 \rightarrow D_h = 7,6$ is **non-monotonic**, which is almost certainly a transcription error in the database from which it was taken. No independent corroboration was obtained. **Do not use this table for design or procurement without checking it against a purchased copy of EN 10230-1.**

3.2.2 Common commercial sizes

Round wire nails are traded as $d \times L$. The following sizes are stocked across the European market.

$d \times L$ (mm)	Approx. pieces per kg (supplier data)	Cross-check by shank volume at 7,85 g/cm ³
2,0 × 40	1 000	1 014 — consistent
2,5 × 55	500	472 — consistent
2,5 × 60	430	433 — consistent
3,1 × 70	250	241 — consistent
3,1 × 80	220	211 — consistent
3,4 × 90	160	156 — consistent
3,8 × 100	110	112 — consistent
4,2 × 120	75	77 — consistent
5,5 × 160	32	34 — consistent

NOTICE — two published rows fail the physics check and have been omitted. Supplier tables listing 2,5 × 50 at 650 pcs/kg and 4,6 × 130 at 45 pcs/kg cannot be reconciled with the density of steel (the calculated values are about 519 and 59 respectively) and are probably row-misalignment in the catalogue. Likewise,

small-size rows from a second supplier (1,2 × 20 at "2 500/kg", 1,4 × 25 at "1 300/kg") are wrong by a factor of two to four. **Sanity-check any pieces-per-kg figure against shank volume before using it to order.**

The cross-check above ignores head mass, so true counts are a few per cent lower than the calculated column.

A Nordic design reference lists the common metric nail dimension set as $d = 1,4 / 1,7 / 2,0 / 2,3 / 2,5 / 2,8 / 3,1 / 3,4 / 3,7 / 4,0 / 4,3 / 4,7 / 5,1 / 5,5 / 6,0 / 6,5 / 7,0 / 8,0$ mm, and $L = 25 / 35 / 40 / 50 / 60 / 75 / 100 / 125 / 150 / 175 / 200 / 225 / 250 / 300$ mm.

3.2.3 Which metric size is the workhorse

NOTICE — no market data exists. No trade association or public dataset gives production or shipment volumes by nail size in Europe, and this manual makes no quantitative claim. What can be stated from supplier catalogues is:

- **Germany and Austria: 3,1 × 80 mm** countersunk (the DIN 1151 Form B shape) is the ubiquitously stocked general-construction size, carried by every major builders' merchant and fastener wholesaler and catalogued under the carpentry and façade trade branch.
- **United Kingdom:** the everyday stocked round wire nail is **100 × 4,5 mm**, not 4,0 mm. UK trade references describe round wire nails as "*the workhorse*" for studwork, joists, sheathing and general first fix, in a range of roughly 2,65–6,0 mm diameter by 40–150 mm long, and give 75 mm or 90 mm (3,35 mm or 3,75 mm diameter) as standard for structural timber framing.

3.3 Dimensional tolerances

Table 3-5 — ASTM F1667 dimensional requirements and tolerances (clause 8).

Item	Requirement
Length measurement (8.1.1)	Nails with flat heads or parallel shoulders are measured from under the head to the tip of the point . All others are measured overall.
Diameter measurement (8.1.2)	Measured away from the gripper marks , and prior to application of, or after removal of, any coating .
Length tolerance (8.2.1)	±1/32 in up to and including 1 in; ±1/16 in over 1 in to 2½ in ; ±3/32 in over 2½ in to 7 in ; ±1/8 in over 7 in.
Shank diameter tolerance (8.2.2)	±0.002 in below 0.076 in; ±0.004 in at 0.076 in and larger .
Head diameter tolerance, hand driven (8.2.3.1)	±10 % of nominal head diameter , on an individual measurement, for all brads, nails and

Item	Requirement
	spikes other than roofing nails.
Head out-of-round (8.2.3.1)	The long-axis diameter shall not exceed the short-axis diameter by more than 10 % (20 % for roofing nails).
Fillet (8.2.3.1)	<i>"A fillet shall be provided under the head if not otherwise specified."</i>
Head diameter, power driven (8.2.3.2)	Per the tool and fastener manufacturer's specification.
Workmanship (9.1)	Fasteners <i>"shall be true to shape, well-finished, free from imperfections, clean, and free of corrosion."</i>

Applied to the reference unit, a conforming 16d common measures **3.4375 to 3.5625 in** long and **0.158 to 0.166 in** on the shank, with a head between **0.310 and 0.378 in**.

NOTICE — length is not measured the same way in the two systems. ASTM F1667 measures a flat-headed nail *under the head*; European practice and the metric $d \times L$ convention describe overall length. For a full-head common nail the head is thin and the practical difference is small, but it is not zero, and it matters when a penetration calculation is close to its limit.

[VERIFY] — EN 10230-1's own tolerance classes could not be read and are not reproduced here.

NOTICE — the diameter is measured with the coating off. A hot-dip galvanized nail is physically fatter than its nominal diameter, by roughly twice the coating thickness — about 0.003 in (86 μm) on the diameter for an A153 Class D coating. This is why galvanized nails feel tighter to drive, and why the pre-drill diameters in Section 7.9 are expressed as a fraction of the **nominal** shank diameter.

3.4 Coating specification

Table 3-6 — Minimum zinc coating mass on nails, ASTM A641/A641M-19(2025), Supplementary Requirements Table S1.1. Values are the minimum weight of zinc per unit area of uncoated nail surface. Class 1 is the ASTM F1667 default; Class 3S is set at 1.00 oz/ft² specifically to match A153 Class D.

Nail shank diameter (in)	Class 1 (oz/ft ²)	Class 1 (g/m ²)	Class 2 (oz/ft ²)	Class 3S (oz/ft ²)
0.035 – 0.062	0.15	45	0.30–0.35	—
0.076	0.20	60	0.40	—
0.080	0.25	75	0.45	—
0.092	0.28	85	0.50	—

Nail shank diameter (in)	Class 1 (oz/ft ²)	Class 1 (g/m ²)	Class 2 (oz/ft ²)	Class 3S (oz/ft ²)
0.099	0.28	85	0.50	1.00
0.113 – 0.135	0.30	92	0.50	1.00
0.148	0.35	105	0.60	1.00
0.162	0.35	105	0.70	1.00
0.192	0.50	150	0.70	1.00
0.207 and larger	0.53	160	0.75	1.00

Supporting requirements: A641 clause 9.1 permits an individual result up to 10 % below the tabulated minimum provided the average of at least two samples from the same coil meets it. Clause 9.2 records that “regular coating” carries **no specified minimum coating weight at all**. Clause 10 requires an adherence test — wrapping in a close helix at not more than 15 turns per minute around a specified mandrel without cracking or flaking.

Comparison of the four zinc routes at the reference diameter (0.162 in):

Route	Zinc, oz/ft ²	Zinc, μm	Relative to A153 Class D
A641 Class 1 — the F1667 default	0.35	≈ 15	35 %
A641 Class 2	0.70	≈ 30	70 %
B695 Class 40 — the F1667 default for mechanically deposited zinc	≈ 0.93	40	93 %
A641 Class 3S	1.00	≈ 43	100 %
A153 Class D — hot dip after forming	1.00 avg / 0.85 individual	43 avg / 36 individual	100 %
B695 Class 55	≈ 1.24	53	123 %

ASTM B695 also specifies salt-spray minimum hours to red rust for Type I coatings: Class 55 and above, none required; Class 50, 300 h; **Class 40, 250 h**; Class 25, 192 h; Class 12, 96 h.

3.5 Mechanical properties

3.5.1 Ductility

ASTM F1667 clause 7.1: *“The fasteners shall be sufficiently ductile to withstand cold bending without fracture, as specified in Table 2 ... utilizing the conventional bend test described in Test Methods F680. Mandrel diameter used in this test shall be [equal to the] nail/wire diameter. The cold bend test shall not apply to unhardened nails with deformed shanks.”*

Table 3-7 — Required cold bend angle, ASTM F1667 Table 2.

Material	Bend angle
Steel wire — low-carbon, medium-low, medium-carbon, unhardened	180°
Stainless steel wire	180°
Copper (min 98 %)	180°
Copper-clad wire (min 20 %)	180°
Brass wire	180°
Sheet steel for cut nails and cut spikes	90°
Aluminium alloy wire	90°
Hardened steel fasteners	20°

The 180°-versus-20° contrast is the clearest single expression of the difference between a common nail and a hardened nail, and it is the reason a common nail bends when it meets a knot instead of shattering.

3.5.2 Bending yield strength

Bending yield strength F_{yb} is **not** a default property of a common nail. It applies only when the nail is ordered to **ASTM F1667 Supplementary Requirement S1**, which is invoked for *“nails used for engineered construction”*. Testing is to **ASTM F1575/F1575M-24**, on at least five nails from each lot of 100 individual containers, and conforming nails are labelled *“Engineered Construction Nails, ASTM F1667”* (clause S1.5).

Table 3-8 — Minimum average bending yield strength, ASTM F1667 Table S1.1 (low to medium carbon steel). These are the same bands the NDS assumes for its tabulated lateral design values.

Nominal diameter D (in)	Minimum F_{yb} (psi)	(MPa)
0.099 – 0.142	100 000	690

Nominal diameter D (in)	Minimum Fyb (psi)	(MPa)
0.142 – 0.177 — includes the 16d reference unit	90 000	620
0.177 – 0.254	80 000	550
0.254 – 0.273	70 000	480
0.273 – 0.344	60 000	415
0.344 – 0.375	45 000	310

Table S1.2 covers hardened medium-carbon nails: 0.120–0.142 in → 130 000 psi; 0.142–0.192 in → 115 000 psi; 0.192–0.207 in → 100 000 psi.

NOTICE — a plain commodity nail carries no declared Fyb. If a design calculation relies on Fyb, the nail must be **ordered to Supplementary Requirement S1** and the label must say so. An unmarked carton of “16d common” is not evidence of 90 000 psi.

3.5.3 Test methods

Standard	Title	Covers
ASTM F680-20	Standard Test Methods for Nails	Dimensional (§5), tension (§6), conventional bend (§7), impact bend (§8), Rockwell hardness (§9), coating weight (§10), coating adherence for zinc-coated nails (§11)
ASTM F1575/F1575M-24	Determining Bending Yield Moment of Nails, Spikes, and Dowel-type Threaded Fasteners	Fyb for Supplementary Requirement S1
ASTM D1761-20(2025)	Standard Test Methods for Mechanical Fasteners in Wood and Wood-Based Materials	Withdrawal and lateral resistance in wood — see Section 3.6.4
ASTM D1037 §15	—	Nail-head pull-through. This is not a D1761 test.
ASTM F547-22	Standard Terminology of Nails for Use with Wood and Wood-Base Materials	Definitions
EN 1382 / EN 1383 / EN 409 / EN	—	Withdrawal capacity, pull-

Standard	Title	Covers
14358 / EN 15737		through resistance, yield moment, statistical derivation of characteristic values, torsional resistance — the EN 14592 test suite

NOTE — there is no head-to-shank integrity test. ASTM F680-20's scope lists all seven of its test methods and no such test appears, and none was found in F1667. The nearest requirements are the fillet under the head (clause 8.2.3.1) and the general workmanship clause (9.1). **Do not specify a head-to-shank integrity requirement against these standards** — it does not exist.

Likewise, **no hardness value is specified for a finished bright common nail.** F680 contains a Rockwell hardness method, but F1667 sets no hardness requirement for unhardened nails. The only hardness figure in F1667 is the 37 HRC minimum for hardened-nail wire (clause 6.3). **[VERIFY]** — no published hardness value for a finished common nail could be found.

3.6 Rated performance [US]

All values in this subsection are **reference design values** in the NDS allowable stress design framework. They must be multiplied by the applicable adjustment factors of NDS Table 11.3.1 before use.

3.6.1 Withdrawal

NDS 12.2.3.1 defines the reference withdrawal design value **W, in pounds per inch of penetration**, for a plain-shank nail driven into the **side grain** with its axis perpendicular to the fibres:

$$W = 1380 \cdot G^{2.5} \cdot D$$

where G is the specific gravity from NDS Table 12.3.3A and D is the nail diameter in inches. NDS 12.2.3.2 gives the total withdrawal design value in pounds as this unit value multiplied by the length of penetration.

Table 3-9 — Reference withdrawal design value W for the 16d reference unit (D = 0.162 in), NDS Table 12.2C.

Species group	G	W (lb per inch of penetration)	Total W at 2 in penetration (lb)
Southern Pine	0.55	50	100
Douglas Fir-Larch	0.50	40	80
Hem-Fir	0.43	27	54
Spruce-Pine-Fir	0.42	26	52

DANGER — withdrawal from end grain is prohibited. NDS 12.2.3.5 states without qualification: “Nails and spikes shall not be loaded in withdrawal from end grain of wood ($C_{eg} = 0.0$).” NDS 12.2.3.6 applies the same prohibition to the end grain of CLT laminations.

Note the contrast with other fasteners: a lag screw in end-grain withdrawal is given $C_{eg} = 0.75$; a wood screw is likewise prohibited at $C_{eg} = 0.0$. For **lateral** loading into end grain, $C_{eg} = 0.67$.

For background only, and not for design: the FPL Wood Handbook reports that a bright nail in end grain retains only 50–75 % of its side-grain withdrawal resistance. **The code value is zero.**

3.6.2 Lateral

Lateral capacity is governed by the yield limit equations of **NDS Table 12.3.1A**, covering six modes — **Im, Is, II, IIIm, IIIs, IV**. Single shear uses Equations 12.3-1 to 12.3-6; double shear uses 12.3-7 to 12.3-10 (modes Im, Is, IIIs and IV only). The reference lateral design value **Z is the minimum computed yield mode value.**

Two inputs matter for nails.

Dowel bearing strength. NDS Table 12.3.3, footnote 2, gives for **all fasteners with $D < 1/4$ in:**

$$F_e = 16\,600 \cdot G^{1.84} \text{ (psi)}$$

with **no grain-direction dependence** — F_e is isotropic for small-diameter dowels. Spot values: $G = 0.50 \rightarrow 4\,650$ psi; $G = 0.64 \rightarrow 7\,300$ psi; $G = 0.73 \rightarrow 9\,300$ psi.

Reduction term. NDS Table 12.3.1B: for **$D < 0.25$ in**, a single value applies to all six modes, **$R_d = K_D$** , where **$K_D = 2.2$ for $D \leq 0.17$ in** and **$K_D = 10D + 0.5$ for $0.17 \text{ in} < D < 0.25 \text{ in}$** . The 16d reference unit at 0.162 in falls in the $K_D = 2.2$ band.

Table 3-10 — Reference lateral design value Z, single shear, 16d common (D 0.162 in, L 3½ in), NDS Table 12N. Both members of identical specific gravity; penetration $p = 10D$; $F_{yb} = 90\,000$ psi. Values in pounds.

Side member thickness t_s	DF-L (G 0.50)	SPF (G 0.42)	Southern Pine (G 0.55)	Hem-Fir (G 0.43)
3/4 in	121	96	138	99
1 in	141	109	154	113
1¼ in	141	120	154	122
1½ in — nominal 2× framing	141	120	154	122
1¾ in	141	120	154	122

Table 12N assumes nails inserted in side grain with the axis perpendicular to the fibres, and bending yield strengths of 100 000 psi for $0.099 \leq D \leq 0.142$ in, **90 000 psi for $0.142 < D \leq 0.177$ in**, 80 000 psi for $0.177 < D \leq 0.236$ in and 70 000 psi for $0.236 < D \leq 0.273$ in.

The single most useful comparison in this manual. A 16d common in single shear through nominal 2× Douglas Fir-Larch has a reference lateral design value of **141 lb**, and in Spruce-Pine-Fir **120 lb**, before any adjustment. Its withdrawal value in DF-L is 40 lb per inch of penetration. **The nail is three to four times more useful in shear than in tension.** Design accordingly.

3.6.3 Penetration and the adjustment chain

Minimum penetration. NDS 12.1.6.4 (12.1.6.5 in the 2015 edition): *“The minimum length of nail or spike penetration, p_{min} , including the length of the tapered tip, where part of the penetration into the main member for single shear connections and the side members of double shear connections shall be $6D$.”*

An exception applies to symmetric double-shear connections where nails of **0.148 in diameter or smaller** extend at least three diameters beyond the side member **and are clinched**, with side members at least 3/8 in thick. The NDS Commentary identifies 0.148 in as the 12d common, 20d box or 16d sinker.

The 10D basis. Table 12N is tabulated at $p = 10D$. Footnote 3: *“Where the nail or spike penetration, p , is less than $10D$ but not less than $6D$, tabulated lateral design values, Z , shall be multiplied by $p/10D$, or lateral design values shall be calculated using the provisions of 12.3 for the reduced penetration.”*

For the 16d reference unit: $p_{min} = 6 \times 0.162 = \mathbf{0.97 \text{ in}}$; the tabulation basis is $10 \times 0.162 = \mathbf{1.62 \text{ in}}$.

NOTICE — “Cd” for nails is obsolete terminology. There is no penetration depth factor C_d for nails in the current NDS; C_d exists only for split rings and shear plates. Older course material describing “ $C_d = p/10D$ ” for nails reflects the 2001 edition. The current mechanism is the Table 12N footnote multiplier.

Adjustment factors. NDS Table 11.3.1:

Lateral: $\mathbf{Z' = Z \cdot CD \cdot CM \cdot Ct \cdot Cg \cdot CA \cdot Ceg \cdot Cdi \cdot Ctn}$

Withdrawal: $\mathbf{W' = W \cdot CD \cdot CM \cdot Ct \cdot Ceg \cdot Ctn}$

Two nail-specific points:

- **NDS 12.5.1.1: “For dowel-type fasteners where $D < 1/4$ in., $CA = 1.0$.”** The geometry factor never reduces nail capacity. Placement is controlled by the requirement not to split the timber (Section 6.7), not by a numerical penalty.
- Table 11.3.1, footnote 2: *“The wet service factor, CM , shall not apply to toe-nails loaded in withdrawal.”*

Toe-nail factors (Section 7.5): **$C_{tn} = 0.67$** for withdrawal (NDS 12.5.4.1) and **$C_{tn} = 0.83$** for lateral (NDS 12.5.4.2).

3.6.4 How the numbers are obtained

ASTM D1761-20(2025), *Standard Test Methods for Mechanical Fasteners in Wood and Wood-Based Materials*, is the test method behind the withdrawal and lateral values. Scope §1.1: *“These test methods*

provide a basic procedure for evaluating the withdrawal and lateral resistance of fasteners installed in wood and wood-based materials. Spikes are included as nails in this standard."

Parameter	Requirement
Withdrawal loading rate (§11.4.1)	<i>"a uniform rate of platen separation of 0.10 in. (2.54 mm)/min ± 25 %"</i>
Conditioning (§9.1)	<i>"a controlled temperature of 20 °C ± 3 °C (68 °F ± 6 °F) and a controlled relative humidity of 65 % ± 3 % ... The fasteners shall not be installed in the wood members until the moisture equilibrium is attained."</i> No target moisture content is stated.
Penetration (§10.1.2)	<i>"Fasteners shall be driven to penetrate the holding member at least 9 times the nail diameter ... (penetration measurement includes the nail or staple tip length)."</i>
Timing (§11.1)	Withdraw <i>"as soon as practical after installation, and within 1 h."</i>
Lead holes	None for nails or staples.
Scatter (Note 1)	<i>"coefficient of variation for fastener tests ranges from 15 % to 30 %."</i>

NOTE — head pull-through is not a D1761 test. D1761 §11.2.2 states that if the head passes through the attached member the result *"shall not be recorded as the fastener withdrawal from the holding member and an additional specimen shall be tested."* The standardised head pull-through method is **ASTM D1037 §15**. Separately, the 2018 and later NDS added head pull-through design provisions at §12.2.5 (Equation 12.2-6a, $WH = 690 \cdot \pi \cdot DH \cdot G^2 \cdot tns$ for $tns \leq 2.5 DH$, with Table 12.2F); these do **not** exist in NDS-2015.

[VERIFY] — the lateral-test loading rate and specimen geometry in circulation are verbatim from D1761-88(R2000); the corresponding pages of the current edition are paywalled. The fixed withdrawal specimen geometry (a 2 × 2 × 6 in prism) was **removed** in the 2020 revision.

NOTICE — the 15–30 % coefficient of variation is the most important number in this section. Nailed-joint capacity is inherently scattered because wood is a variable material. This is why codes work in populations of fasteners rather than single nails, why Eurocode 5 requires *"at least two nails in a connection"* (8.3.1.1(9)), and why a single nail should never be relied on for a critical load path.

3.7 Rated performance [EU/UK]

Eurocode 5 works in characteristic values and derives connection capacity from the fastener's yield moment, the timber's embedment strength, and the joint geometry. Clause references below are to BS EN 1995-1-1:2004+A1:2008.

3.7.1 Yield moment

Clause 8.3.1.1(4): “For smooth nails produced from wire with a minimum tensile strength of 600 N/mm², the following characteristic values for yield moment should be used:”

My,Rk = 0,3 · fu · d^{2,6} for round nails (8.14)

My,Rk = 0,45 · fu · d^{2,6} for square and grooved nails

where My,Rk is in N·mm, **d** is the nail diameter as defined in EN 14592 in mm, and **fu** is the tensile strength of the wire in N/mm².

NOTICE — 600 N/mm² is a validity threshold, not a value to substitute. The expression is only valid for wire at or above 600 N/mm²; **fu in the formula is the actual wire tensile strength**, taken from the manufacturer’s declaration of performance. Substituting 600 where the true value is higher is conservative; using the formula at all where the true value is lower is invalid.

3.7.2 Embedment strength

Clause 8.3.1.1(5), for nails up to 8 mm diameter:

Without pre-drilled holes: **fh,k = 0,082 · pk · d^{-0,3}** (8.15)

With pre-drilled holes: **fh,k = 0,082 · (1 – 0,01 d) · pk** N/mm² (8.16)

For d > 8 mm the bolt provisions of 8.5.1 apply (8.3.1.1(6)).

3.7.3 Axial (withdrawal) capacity

DANGER — a smooth nail may not be used for permanent axial load. Clause **8.3.2(1)P** is a principle, not a recommendation: “Nails used to resist permanent or long-term axial loading shall be threaded.” Clause **8.3.2(3)**: “Nails in end grain should be considered incapable of transmitting axial load.”

Where a smooth nail carries short-term axial load, clause 8.3.2(4) gives Fax,Rk as the **smaller** of:

(a) **fax,k · d · tpen**

(b) **fax,k · d · t + fhead,k · dh²**

where tpen is the pointside penetration length, t the thickness of the headside member, and dh the nail head diameter. Expression (a) is shank pull-out; expression (b) is shank pull-out over the headside thickness plus head pull-through. **The joint fails by whichever comes first.**

Clause 8.3.2(6), for smooth nails with pointside penetration of at least 12 d:

fax,k = 20 × 10⁻⁶ · pk² (8.25)

fhead,k = 70 × 10⁻⁶ · pk² (8.26)

with pk the characteristic timber density in kg/m³ and the result in N/mm².

Clause 8.3.2(7): “For smooth nails, the pointside penetration tpen should be at least 8 d. For nails with a pointside penetration smaller than 12 d the withdrawal capacity should be multiplied by (tpen/4d – 2).”

Clause 8.3.2(8): where timber is installed at or near fibre saturation and is likely to dry under load, **multiply both $f_{ax,k}$ and $f_{head,k}$ by 2/3.**

Clause 8.3.2(10): for slant nailing, the distance to the loaded end shall be at least 10 d, and at least two slant nails are required.

3.7.4 Combined loading

Clause 8.3.3, expression (8.27), for smooth nails — a **linear** interaction:

$$F_{ax,Ed} / F_{ax,Rd} + F_{v,Ed} / F_{v,Rd} \leq 1$$

Non-smooth nails use the quadratic form (8.28). The linear rule for smooth nails is markedly more punishing, which is a further reason not to combine axial and lateral demand on a plain shank.

3.7.5 Penetration, end grain and minimum numbers

Clause	Requirement
8.3.1.2(1)	Smooth nails — pointside penetration length at least 8 d
8.3.1.2(2)	Non-smooth nails — at least 6 d
8.3.1.2(3)	Nails in end grain are not capable of transmitting lateral forces
8.3.1.2(4)	Limited exception for non-smooth nails in secondary members: penetration $\geq 10 d$, at least three nails, laterally loaded only, not service class 3 — capacity one third of side-grain smooth nails
8.3.1.1(7)	In three-member connections nails may overlap in the central member provided $(t - t_2) > 4 d$
8.3.1.1(9)	<i>"There should be at least two nails in a connection."</i>
10.4.2(1)	Nails <i>"should be driven in at right angles to the grain and to such depth that the surfaces of the nail heads are flush with the timber surface."</i>

3.7.6 Row effect

Where nails act in a row parallel to the grain, the effective number is reduced. **Table 8.1**, applied through expression (8.17):

Spacing a_1	kef, not pre-drilled	kef, pre-drilled
$\geq 14 d$	1,0	1,0
10 d	0,85	0,85
7 d	0,7	0,7
4 d	—	0,5

Linear interpolation is permitted for intermediate spacings. The reduction is **not required** where nails in a row are staggered perpendicular to the grain by at least 1 d.

[VERIFY] — a published reproduction error. At least one widely used national design guide reproduces the last row of Table 8.1 as “ $a_1 = 5 d$ ” rather than 4 d. **The standard reads 4 d.** Use 4 d.

[VERIFY] — edition currency. The clauses quoted above are verbatim from BS EN 1995-1-1:2004+A1:2008. The current first-generation edition is **+A2:2014**, and BSI has published **BS EN 1995-1-1:2025**, with withdrawal of the first-generation Eurocodes scheduled for **30 March 2028**. Whether A2:2014 amended any clause in Section 8.3, and how the second-generation edition rennumbers and restates these expressions, was not established. Confirm against the edition your project’s National Annex invokes.

3.8 Operating envelope

Table 3-11 — Rated operating conditions. Outside these, the values of Sections 3.6 and 3.7 do not apply.

Parameter	Rated condition	Consequence of exceeding it
Load direction	Lateral (shear across the shank)	Axial load is permitted only in the short term and at much reduced values. Permanent axial load on a smooth nail is prohibited in Eurocode 5 and structurally unwise everywhere.
Grain orientation	Driven into side grain , axis perpendicular to the fibres	End grain: withdrawal capacity is zero (NDS 12.2.3.5); lateral is reduced ($C_{eg} = 0.67$ in NDS) or prohibited for smooth nails (EN 1995-1-1 8.3.1.2(3)).
Penetration into the main member	$\geq 6D$ (NDS minimum); 10D is the tabulation basis; $\geq 8 d$ (Eurocode 5, smooth)	Below 6D the yield equations are not valid. Between 6D and 10D, multiply Z by $p/10D$.
Timber moisture content at	Seasoned. ASTM D1761	Nails driven into green timber

Parameter	Rated condition	Consequence of exceeding it
Installation	conditions test specimens at 20 °C / 65 % RH. US framing practice for gypsum-clad work requires not more than 19 % (PS 20-20 “dry lumber”).	that subsequently dries can retain as little as 25 % of their initial withdrawal resistance. Lateral values for unseasoned wood that stays wet or is loaded before seasoning should be reduced by 25 % .
Service condition	Dry, covered. Eurocode service class 1 or 2.	Service class 3, treated timber, coastal or de-icing-salt exposure require the coatings of Section 2.8 and the compatibility matrix of Section 6.4.
Substrate	Solid sawn timber, structural composite lumber, wood structural panels	Steel, masonry, concrete and hardened materials are out of scope and require a different fastener.
Seating	Head flush with the surface	IBC 2304.10.3 and SDPWS require sheathing fasteners to be driven flush. Overdriving triggers the remediation rules of Section 10.2.
Number of fasteners	At least two per connection (EN 1995-1-1 8.3.1.1(9))	A single nail is not a connection.
Re-use	Single use only	See Section 8.6.

3.9 Prohibited applications

DANGER — do not use a plain-shank common wire nail for any of the following.

Prohibited	Reason	Use instead
Permanent or long-term axial (withdrawal) load	EN 1995-1-1 8.3.2(1)P requires threaded nails. A smooth shank holds by friction alone and that friction decays with moisture cycling and creep.	Ring-shank or helical nail, screw, bolt, or a framing anchor
Withdrawal load from end	NDS 12.2.3.5 sets the design	Redesign the joint; use a

Prohibited	Reason	Use instead
grain	value to zero	connector
Overhead applications relying on withdrawal resistance	Same mechanism; failure is a falling load	Screws or purpose-made hangers
Suspending anything from a ceiling or overhead member	As above	Rated anchor
Fastening to steel, masonry, concrete or stone	The nail will buckle or the head will mushroom; strike fragments are a ricochet hazard	Hardened pin, masonry anchor, or drilled fixing
Structural connections where a specific fastener is scheduled	Substitution changes capacity. A box nail is not a common.	The scheduled fastener
Preservative-treated timber, unless correctly coated	Copper-based preservatives drive galvanic attack on unprotected steel. Codes require hot-dip galvanized, stainless, silicon bronze or copper — see Section 6.4.	HDG to A153 Class D, or stainless
Re-use of a withdrawn nail in a structural joint	The shank is work-hardened, bent and scored; the surface that generated the friction is damaged	A new nail
Lifting, rigging or fall-arrest anchorage of any kind	Not a rated anchor under any standard	Certified anchorage
Any joint where a designer has specified a screw or a bolt	The specification is the requirement	The specified fastener

NOTICE — the most common misuse in practice is the quietest. A plain-shank nail used to hold something that hangs — a batten carrying a load, a plate resisting uplift, a member subject to wind suction — is being loaded in withdrawal. It may hold for years and then let go after a few seasons of moisture cycling. If the load pulls along the shank, the fastener is wrong.

4 Theory of operation

4.1 The holding principle

A nail does not cut a hole. It **displaces** wood.

As the point advances, it wedges the fibres apart radially and crushes them locally. Nothing is removed. The wood immediately around the shank is therefore left in a state of radial compression, and it presses back onto the shank. That radial clamping pressure, multiplied by the coefficient of friction between steel and wood and by the embedded surface area, is the entire withdrawal resistance of a plain-shank nail.

Three consequences follow directly, and they explain most of what this manual has to say.

First, holding power depends on the wood, not the nail. The steel contributes almost nothing to withdrawal resistance. This is why the withdrawal formula, $W = 1380 \cdot G^{2.5} \cdot D$, is dominated by $G^{2.5}$ — the specific gravity of the timber raised to the power of two and a half. Going from Spruce-Pine-Fir (G 0.42) to Southern Pine (G 0.55) nearly doubles the withdrawal value for the same nail.

Second, anything that relaxes the clamp destroys the hold. Wood shrinks as it dries, principally across the grain. A nail driven into green timber sits in a hole that gets wider, in relative terms, as the timber seasons around it. The FPL Wood Handbook is unambiguous:

"if common smooth-shank nails are driven into green wood that is allowed to season, or into seasoned wood that is subjected to cycles of wetting and drying before the nails are pulled, they lose a major part of their initial withdrawal resistance. The withdrawal resistance for nails driven into wood that is subjected to changes in moisture content may be as low as 25 % of the values for nails tested soon after driving."

Third, splitting is not a cosmetic defect — it is the failure of the holding mechanism. A split is the wood relieving the radial pressure that was supposed to grip the shank. A nail in a split board may be visually perfect and structurally worthless.

Lateral resistance works on a completely different principle and is far more robust. There, the shank acts as a dowel in bearing: load is transferred by the shank pressing sideways against the hole walls, and the timber's embedment strength and the nail's bending strength govern. That mechanism does not depend on residual clamping pressure, which is precisely why a nail is a good shear connector and a poor tension connector.

4.2 The impact chain

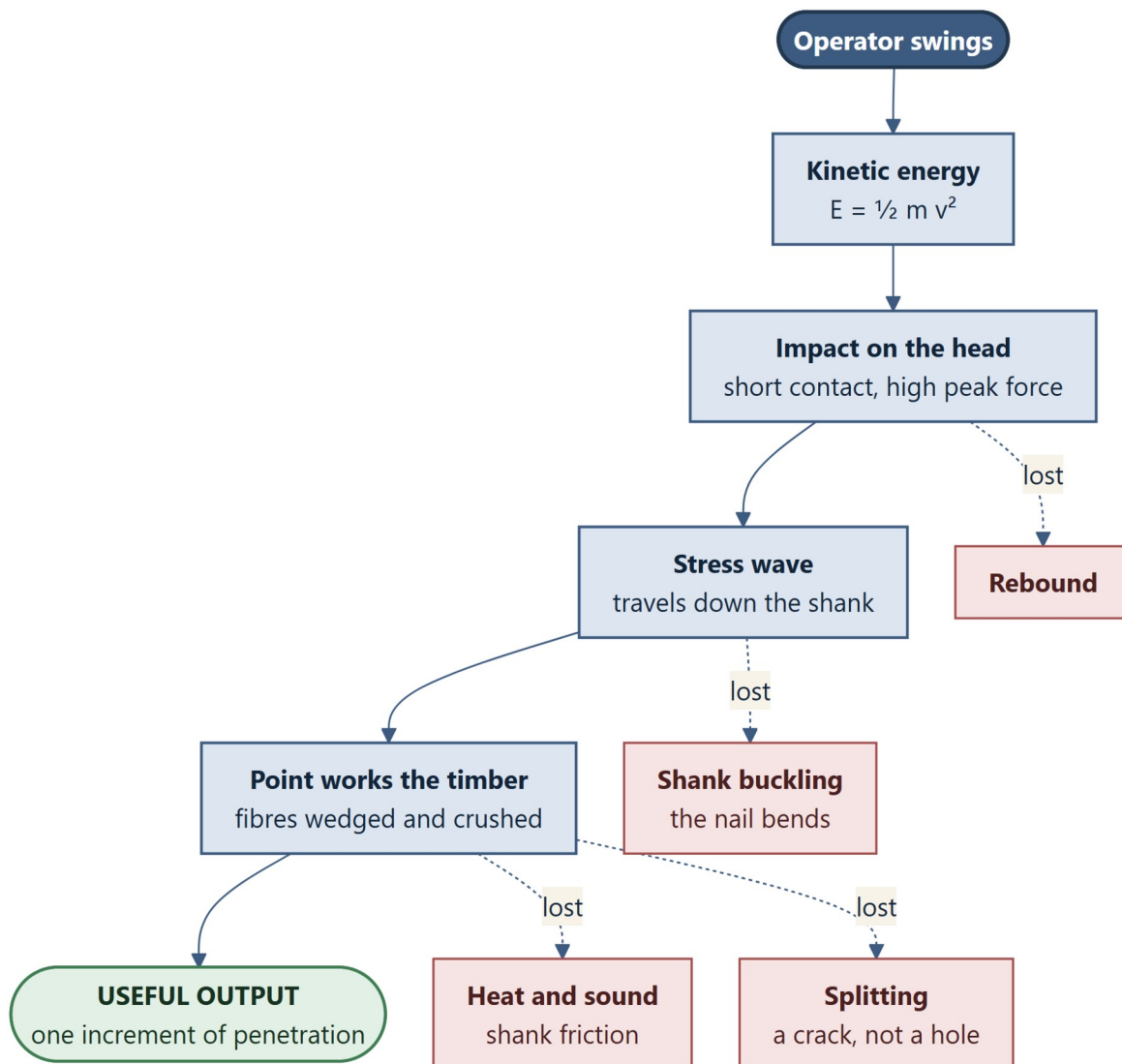


Figure 4-1 — Where the energy in a hammer blow goes. Only the green path is useful work.

Because kinetic energy scales with the **square** of head velocity but only linearly with head mass, a fast swing delivers more than a heavy one. But velocity is harder to control, and an off-square fast blow is what bends nails and misses heads. This is the practical tension behind hammer selection in Section 6.5.

The two loss paths that matter operationally are **L2 (buckling)** and **L4 (splitting)**. Both are self-reinforcing: once a nail starts to bend, the eccentricity grows and each subsequent blow bends it further; once a split starts, it runs. Both therefore require the operator to **stop** rather than hit harder. That is the logic behind the stop-conditions in Figure 7-2.

NOTICE — an unsupported workpiece absorbs the blow. If the timber can move, the energy goes into moving it rather than into penetration. The head then mushrooms while the nail makes no progress. Always back the work against a solid mass.

4.3 Load paths and failure modes

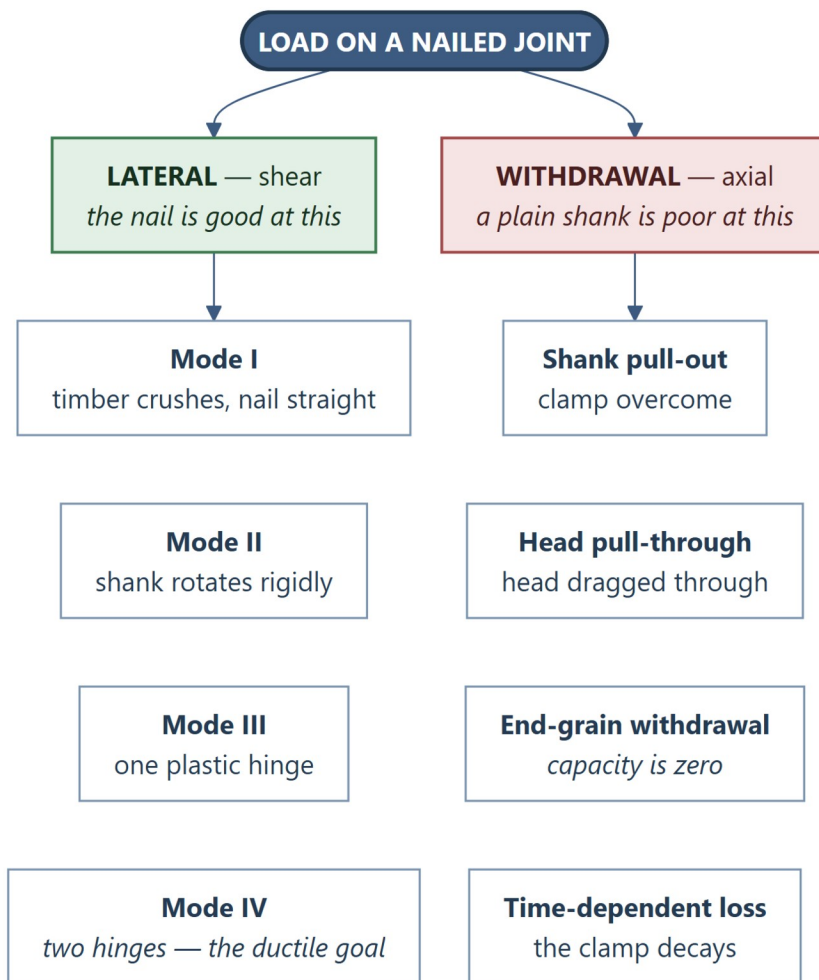


Figure 4-2 — The two load paths and the failure modes available to each. Design capacity is the lowest of the applicable modes.

4.3.1 Why Mode IV is the goal

The six yield modes describe increasingly ductile behaviour. In **Mode I** the timber simply crushes and the nail does not deform — brittle from the joint's point of view, because there is no warning and no energy absorption. In **Mode IV** two plastic hinges form in the shank and the nail folds into an S-shape while continuing to carry load.

Slender fasteners in relatively soft timber are driven towards Mode IV, and this is deliberate. A joint that yields ductilely gives visible deflection before it fails, redistributes load to neighbouring fasteners, and absorbs energy — which is why nailed shear walls perform as well as they do in earthquakes. **The nail's ability to bend is a design feature, not a weakness.** It is also why the 180° cold-bend requirement of ASTM F1667 Table 2 matters so much.

4.3.2 Why head pull-through is a separate check

Eurocode 5 expression (8.24) makes this explicit: the axial capacity is the **lesser** of shank pull-out over the full pointside penetration and the combination of shank pull-out over the headside thickness plus head pull-through. A nail can be perfectly gripped along its shank and still fail because its head pulled through a thin side member.

This is the whole reason a common nail has a large flat head, and the reason a finish nail is unsuitable for structural work: $f_{head,k} = 70 \times 10^{-6} \cdot p k^2$ is three and a half times $f_{ax,k} = 20 \times 10^{-6} \cdot p k^2$, but it acts on $d h^2$ rather than on $d \cdot t_{pen}$. Shrink the head and the second term collapses.

4.4 Why penetration depth matters

Both codes set a minimum penetration into the far member, and both do it for the same reason: the yield equations assume the nail is restrained at both ends. A nail that barely reaches the main member cannot develop a plastic hinge there, so the modes the calculation relies on are not available.

	NDS	Eurocode 5
Absolute minimum	6D , including the tapered tip	8 d pointside, smooth nails
Basis of tabulated values	10D	—
Between the two	Multiply Z by p/10D	Multiply withdrawal capacity by ($t_{pen}/4d - 2$) below 12 d

For the 16d reference unit driven through nominal 2× framing (1½ in side member), the nail has 3½ – 1½ = **2 in** available for penetration, less the tapered tip. Against a 10D basis of 1.62 in, that is comfortable. Drive the same nail through two 2× members and there is nothing left — which is why the fastening schedules call for a longer nail or a different method in that case.

4.5 The splitting mechanism

Splitting is the wedging action of the shank overcoming the tensile strength of the wood perpendicular to the grain — which is the weakest direction wood has. It is governed by:

- **Nail diameter.** More displacement, more wedge, more split. This is the entire reason box nails exist.
- **Point geometry.** A long sharp point concentrates the wedging over a shorter advance.
- **Distance to a free edge or end.** The nearer a free surface, the less material there is to resist the wedge and the shorter the crack path to relief.
- **Density.** Denser species split more readily. FPL: *“As a rule, the less dense species do not split as readily as the denser ones, thus offering an opportunity for increasing the diameter, length, and number of the nails to compensate for the wood’s lower resistance to nail withdrawal.”*
- **Moisture content.** Dry timber splits more readily than green.

- **Grain alignment.** Two nails on the same fibre line share one potential split plane; staggering breaks that.

NOTE — the codes treat splitting empirically, not analytically. The NDS Commentary records that “Absence of splitting has been the performance criterion for placement of nails and spikes since the 1944 edition.” The normative rule (NDS 12.1.6.5) is a single sentence: “Edge distances, end distances, and fastener spacings shall be sufficient to prevent splitting of the wood.” No quantitative fracture-mechanics criterion for end-of-board splitting exists in any authoritative source consulted. The recommended spacings of Section 6.7 are exactly that — recommendations derived from test experience.

4.6 Degradation in service

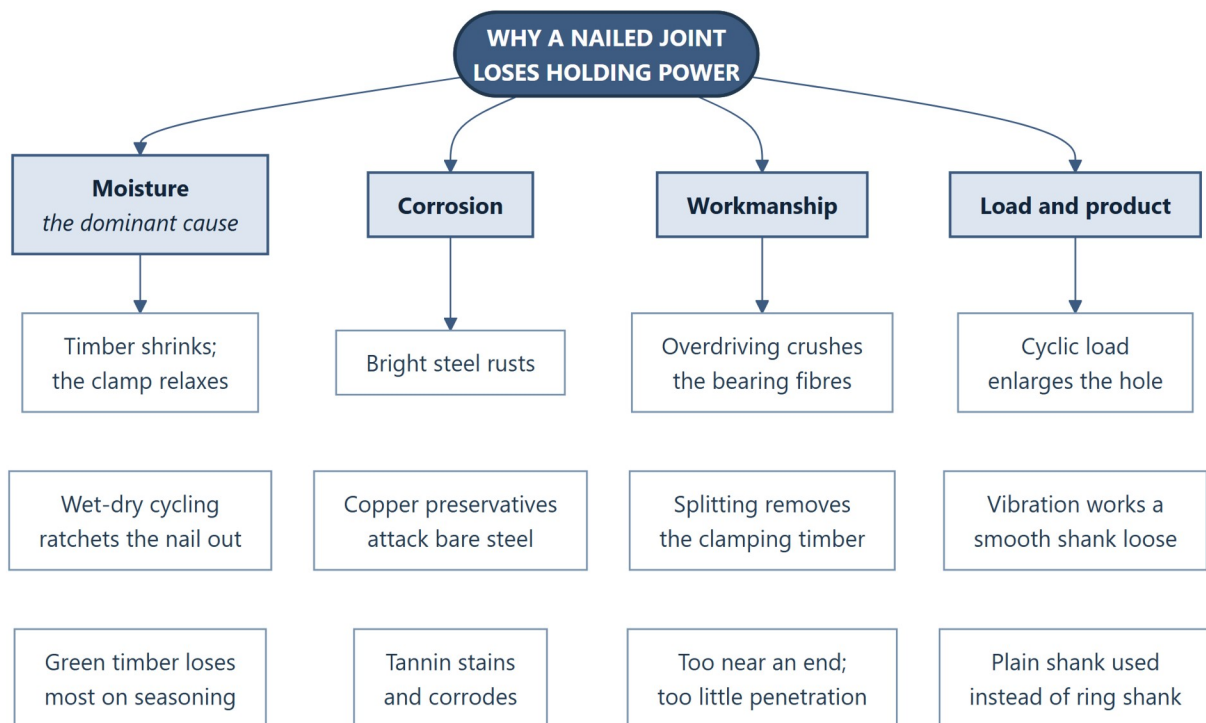


Figure 4-3 — Degradation mechanisms. Most in-service problems trace to the moisture branch.

4.6.1 Moisture — the dominant mechanism

The quantified position, from the FPL Wood Handbook:

- Nails driven into green wood and pulled **before any seasoning** offer about the same withdrawal resistance as nails in seasoned wood pulled soon after driving.
- Nails driven into green wood that is then allowed to season, or into seasoned wood then subjected to wet-dry cycling, **lose a major part of their initial withdrawal resistance — possibly down to 25 %.**
- For lateral loads, values obtained for seasoned wood “*should be reduced by 25 % for unseasoned wood that will remain wet or be loaded before seasoning takes place.*”

- Recovery is possible but must not be relied upon: *“if the wood fibers deteriorate or the nail corrodes under some conditions of moisture variation and time, withdrawal resistance is erratic; resistance may be regained or even increased... However, such sustained performance should not be relied on in the design of a nailed joint.”*

The FPL’s practical conclusion is the basis of Section 9: *“Structural joints should be inspected at intervals, and if it is apparent that the joint has loosened during drying, the joint should be reinforced with additional nails.”*

4.6.2 Corrosion in preservative-treated timber

Modern copper-based preservatives — ACQ (alkaline copper quaternary) and CA-B / copper azole — are **markedly more aggressive to steel than the CCA they replaced**, because they are specified to retain considerably more copper.

The mechanism is electrochemical. Research at the Forest Products Laboratory concludes the data are *“congruent with previous theories that the cathodic corrosion reaction is the reduction of cupric ions”* — $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}$ — and that accelerated corrosion *“can occur in conjunction with the spontaneous (galvanic) electrochemical reduction of cupric ions present in preservative-treated wood.”* The effect switches on above roughly 18–20 % timber moisture content. Differences between preservative systems are attributed to **fixation** — how tightly the copper is bound and how readily it is released.

Comparative findings, all from accelerated testing to **AWPA E12**, *Standard Method of Determining Corrosion of Metal in Contact with Treated Wood*:

Finding	Source
ACQ and copper azole are <i>“roughly twice as corrosive as CCA”</i> to hot-dip galvanized steel	Connector manufacturer study, >6 000 replicates
ACQ-D induced zinc corrosion rates twice those for CCA-C; mild steel metal loss increased by about a factor of five in ACQ relative to untreated and CCA-treated timber	Connector manufacturer, AWPA E12-94
<i>“ACQ was found to be the most corrosive to both steel and galvanized steel”</i> ; ACQ-D and CA were each more than twice as corrosive as CCA-C ; ACZA more than three times	FPL
No significant corrosion of either Type 304 or Type 316 stainless in ACQ-D or CCA-C	Connector manufacturer, AWPA E12

NOTICE — a counter-intuitive research finding. In FPL gravimetric exposure work, *“in all cases, the galvanized fasteners had a higher corrosion rate than the steel fasteners.”* Zinc’s normal barrier passivation does not form under sustained wet conditions inside treated wood. Galvanizing is still the right specification — it is sacrificial and buys time — but it is not a licence to ignore detailing that keeps the joint dry.

NOTICE — the accelerated test is a comparator, not a predictor. The FPL states that the high-temperature, high-humidity AWWA E12 method *“has been shown to have poor correlation with in-service performance.”* Use E12 results to rank materials, not to predict service life.

[VERIFY] — no absolute corrosion rate in μm per year for a galvanized nail in ACQ could be obtained from a primary table. Only ratio comparisons are reported above. Whether AWWA **U1** contains a normative fastener clause (as opposed to E12, which is the confirmed test method) was also not established.

4.7 Product lifecycle

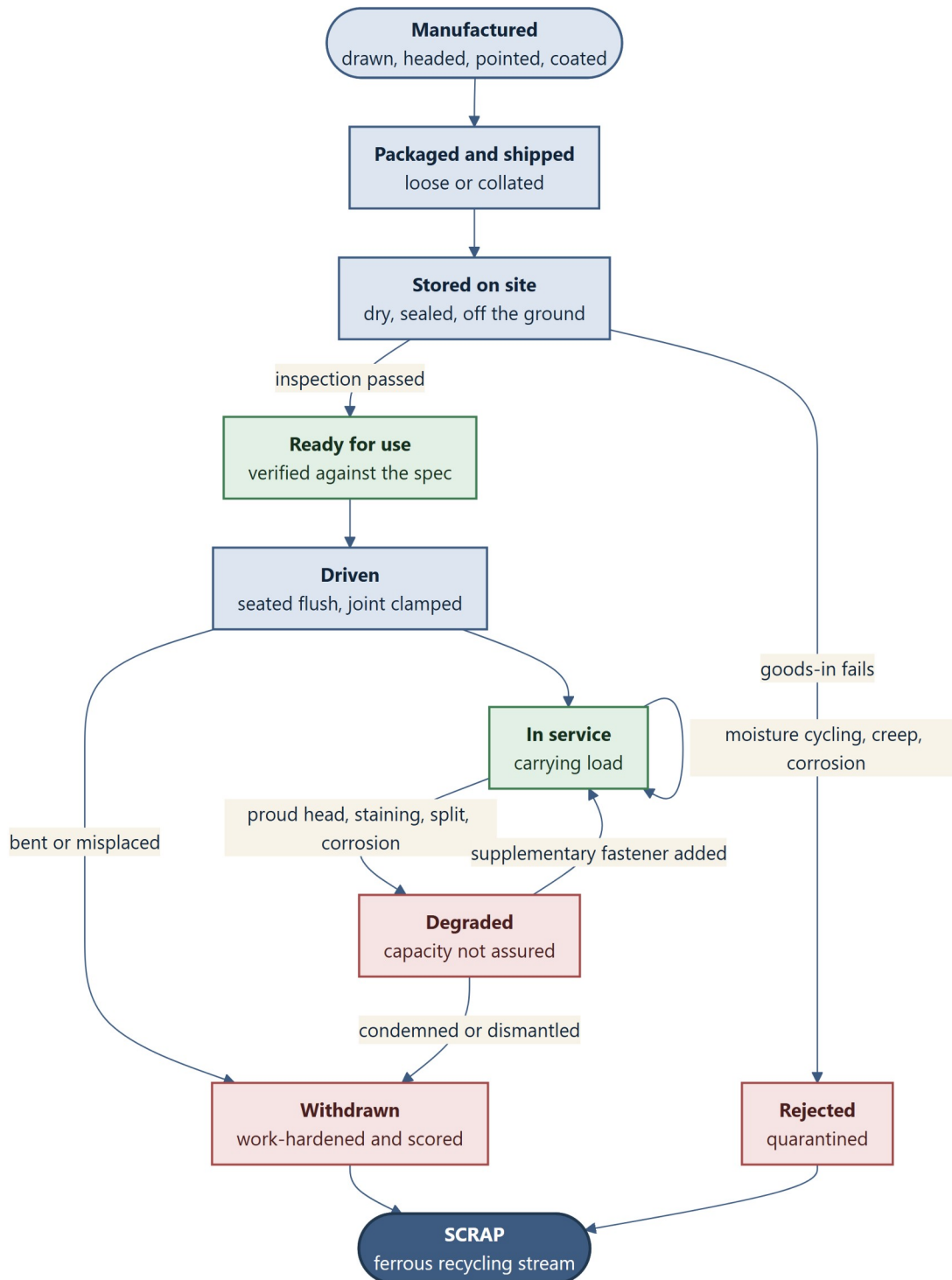


Figure 4-4 — Lifecycle states. Note that there is no path from *Withdrawn* back to *Ready*: a withdrawn nail is scrap, not stock. See Section 8.6.

4.8 Clinching

Bending the protruding point over — clinching — substantially increases withdrawal resistance. FPL data:

- *"In dry or green wood, a clinched nail provides 45 % to 170 % more withdrawal resistance than an unclinched nail when withdrawn soon after driving. In green wood that seasons after a nail is driven, a clinched nail gives 250 % to 460 % greater withdrawal resistance than an unclinched nail."*
- *"Nails clinched across the grain have approximately 20 % more resistance to withdrawal than nails clinched along the grain."*

Two cautions apply, both from the same source.

NOTICE — clinching is not a design credit. There is **no withdrawal credit for clinching in the NDS, the IBC or the IRC**. The NDS recognises clinching only as a **penetration exemption**: in symmetric double-shear connections, nails of 0.148 in diameter or smaller that extend at least three diameters beyond the side member and are clinched, with side members at least 3/8 in thick, need not meet $p_{min} = 6D$. The FPL percentages above are descriptive test data, not design values.

The FPL adds the operational caveat: *"this improved strength of a clinched-nail joint does not justify the use of green lumber, because the joints may loosen as the lumber seasons... Clinching of nails is generally confined to such construction as boxes and crates and other container applications."*

Where clinching is used, clinch **across** the grain, not along it.

5 Safety

5.1 Hazard summary

Hazard	Mechanism	Primary control
Eye injury	Fragments from a chipped hammer face, a shattered hardened nail, a ricocheting nail, or a struck tool	Eye protection with side shields, worn by the operator and everyone in the work area
Struck hand or finger	The supporting hand is still on the nail when the blow force increases	Set the nail with light taps, then remove the hand before driving (Section 7.2)
Puncture wound	Standing on, kneeling on or brushing against a protruding nail	Housekeeping; withdraw or bend over every protruding nail
Unintended discharge	Powered tool double-fire, knocked contact element, penetration through the workpiece, ricochet, missed workpiece	Full sequential actuation; training; the six-step programme in Section 5.5
Tool fragment	Mushroomed struck tool, chipped hammer face, cracked claw, loose head	Pre-use inspection; discard damaged tools
Concealed services	Nail penetrates a cable, pipe or duct inside a cavity	Scan before driving (Section 5.6)
Noise	Peak emission from pneumatic nailers measured at 109 to 136 dBA	Hearing protection. The NIOSH and OSHA limit for impulse noise is 140 dB .
Hazardous dust	Lead paint or asbestos-containing material disturbed when nailing into or dismantling old work	Survey before work; separate control regime
Musculoskeletal	Repetitive high-force swinging; awkward-position nailing	Tool selection, job rotation

5.2 Personal protective equipment

Item	When	Standard
Eye protection with side shields	Always , hand or powered driving, operator and bystanders	ANSI/ISEA Z87.1 (US) or EN 166 (Europe)
Hearing protection	Powered driving; enclosed spaces	Per site risk assessment
Gloves	Handling; consider removing for precision hand nailing where grip on a small nail matters	—
Safety footwear with penetration-resistant sole	Any site with nail-bearing debris	Per site risk assessment
Head protection	Overhead work; site rule	Per site rule
Knee protection	Floor and deck nailing	—

DANGER — eye protection is not optional and not only for the operator.

OSHA 29 CFR 1926.102(a)(1) (construction): *“The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.”*

1926.102(a)(2): *“The employer shall ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g. clip-on or slide-on side shields) meeting the pertinent requirements of this section are acceptable.”*

29 CFR 1910.133(a)(1) and (a)(2) impose identical duties in general industry. Both also require, at (a)(4), that eye and face PPE *“shall be distinctly marked to facilitate identification of the manufacturer.”*

ANSI/ISEA SNT-101 clause 4.1.5 requires tool use *“only when the tool operator and all other personnel in the work area are wearing appropriate eye protection equipment”*, and clause 4.2.1 requires devices conforming to ANSI Z87.1 that *“provide protection against flying particles both from the front and side.”*

5.2.1 A live discrepancy in the eye-protection standard

NOTICE — the regulation and the current standard are out of step, and you must specify against the regulation.

The current consensus standard is **ANSI/ISEA Z87.1-2025**, *American National Standard for Occupational and Educational Personal Eye and Face Protection Devices* — the sixth revision, published 8 January 2026, revising ANSI/ISEA Z87.1-2020.

OSHA, however, still incorporates by reference only ANSI/ISEA Z87.1-2010, ANSI Z87.1-2003, and ANSI Z87.1-1989 (R-1998) — 29 CFR 1910.133(b)(1). Paragraph (b)(2) permits protectors demonstrated to be equally effective.

In practice, protectors marked to a current edition satisfy (b)(2) comfortably. But if a specification cites “ANSI Z87.1” without a year, be explicit about which edition is intended and why.

Marking. Basic **Z87** denotes compliance with the drop-ball impact test. **Z87+** additionally denotes high-mass and high-velocity impact ratings. For nailing work, **specify Z87+.** **[VERIFY]** — the detailed test parameters behind these marks were available only from PPE manufacturers’ literature; the standard itself is paywalled.

In Europe the equivalent is **EN 166:2001**, *Personal eye-protection — Specifications* (second edition, replacing EN 166:1995), adopted in the UK as BS EN 166:2002.

5.3 Striking and struck tools

DANGER — a nail hammer is for unhardened nails and nothing else.

The Hand Tools Institute states the permitted use precisely: *“Nail hammers are intended for driving and pulling common, unhardened nails only, and for ripping apart wooden structures. They may be used to strike nail sets with the center of the striking face.”*

And the prohibition: *“Never strike one hammer with or against another hammer or a hatchet. Never strike nail pullers, steel chisels or other hardened objects with a nail hammer as the face may chip, possibly resulting in eye or other serious injury.”*

And on technique: *“Strike squarely and avoid glancing blows that may cause the edge of the face to chip, possibly resulting in eye or other serious injury. Never strike with or against the side, or cheek, of any hammer.”*

Manufacturer literature is consistent with this. One major hammer maker’s safety sheet reads: *“Never strike a hammer or any striking tool against another tool or hardened object”; “Nail Hammers are for driving and withdrawing common nails only”; “Drilling Hammers are intended to be used for striking chisels, punches, star drills and hardened nails.”* The same maker’s warranty defines misuse to include *“Striking other hardened objects such as other tools, hardened nails, drill or chisels”* and *“Pulling (attempting to withdraw) hardened nails, screws, or nail sets.”*

The US Army technical manual for hand tools puts it in one line: *“Never use a claw hammer on a steel punch or on hardened steel-cut or masonry nails. The face is too soft and could chip.”*

The face-size rule for struck tools. Where a hammer must strike another tool — a nail set, a cat’s paw, a chisel — *“the striking face of the hammer should have a diameter at least 3/8” larger than the struck face of the tool.”* And it should be a ball pein or drilling hammer, not a nail hammer.

A hardness threshold. One manufacturer of hammers made to BS 876 prints an explicit limit: head *“induction case hardened 50-58 HRC”*, with the warning *“Do not strike objects harder than 46 HRC. Striking items of a greater hardness is liable to cause fracture or chipping. Do not use a claw hammer for striking cold chisels or for pulling out masonry nails.”* **[VERIFY]** — no hardness or chip-resistance figure could be obtained from ASME B107.400 itself, which is paywalled. Do not attribute a hardness number to that standard.

5.3.1 Pre-use tool inspection

Discard the hammer if any of the following is present:

- Chips or dents on the striking face
- A mushroomed face
- A crack in the claw section
- A cracked, splintered or loose handle, or a dent in a steel handle
- Any looseness between head and handle

OSHA 29 CFR 1926.301 is the governing rule for hand tools on a US construction site:

- (a) *"Employers shall not issue or permit the use of unsafe hand tools."*
- (b) *"Impact tools, such as drift pins, wedges, and chisels, shall be kept free of mushroomed heads."*
- (c) *"The wooden handles of tools shall be kept free of splinters or cracks and shall be kept tight in the tool."*

NOTICE — a frequent misquotation. 1926.301(c) applies to **struck** tools — drift pins, wedges, chisels — **not** to hammer faces. Do not cite it as a hammer-face rule. The hammer-face duty comes from 1926.301(a), from 29 CFR 1910.242(a) (*"Each employer shall be responsible for the safe condition of tools and equipment used by employees, including tools and equipment which may be furnished by employees"*), and from the manufacturer's own instructions.

OSHA Publication 3080 explains the hazard and gives the five basic rules: *"Keep all tools in good condition with regular maintenance. Use the right tool for the job. Examine each tool for damage before use and do not use damaged tools. Operate tools according to the manufacturers' instructions. Provide and use properly the right personal protective equipment."*

5.3.2 Applicable tool standards

Standard	Title	Covers
ASME B107.400-2018 (R2023)	Striking Tools	Nail hammers and other striking tools. Consolidated the former B107.41 Nail Hammers, B107.53 Ball Peen Hammers, B107.54 Heavy Striking Tools and others.
ASME B107.410-2018 (R2023)	Struck Tools	Nail sets, nail-puller bars, pry bars , chisels, punches, drift pins, wedges. Consolidated the former B107.52 Nail Puller Bars and Pry Bars.
ASME B107.41-2004	Nail Hammers — Safety Requirements	Superseded by B107.400

Standard	Title	Covers
BS 876:1995	Specification for hand hammers	Current. Covers adze-eye claw hammers, steel-shafted claw hammers, joiners', ball pein, cross pein, club, sledge and brick hammers, with tests.
ANSI/HTI B173.1	American National Safety Requirements for Nail Hammers	[VERIFY] — designation confirmed only via a manufacturer's reference page, which itself contains a typographical error.

5.4 Powered fastener-driving tools

5.4.1 The governing standard

ANSI/ISANTA SNT-101, 2024, *Safety Requirements for Portable Compressed-Air-Actuated Fastener Driving Tools*. ANSI approval 19 September 2024; effective 19 September 2025; replaces the 2015 edition. The developer is the International Staple, Nail and Tool Association. The related international standard is **ISO 11148-13:2017**, *Hand-held non-electric power tool — Safety Requirements — Part 13: Fastener driving tools*.

The prior edition, ANSI SNT-101-2015, is freely published and is the source of the definitions below.

5.4.2 Actuation systems

SNT-101-2015 defines five actuation systems, not four. Quoting clause 2.3 and its subclauses:

System	Definition (verbatim)
2.3 actuation system	"A trigger, workpiece contact and/or other operating control, used separately or in some combination or sequence, to actuate the tool."
2.3.1 single-sequential	"...the workpiece contact must be activated before the trigger for the tool to actuate. Additional actuation can occur when a specific operating control, other than a workpiece contact, is released and re-activated."
2.3.2 full-sequential	"...the workpiece contact must be activated before the trigger for the tool to actuate. Additional actuation can occur only when all operating

System	Definition (verbatim)
	<i>controls are released and re-activated in the same sequence."</i>
2.3.3 contact actuation	<i>"...the operating controls can be activated in any sequence to actuate the tool. Additional actuation can occur when any operating control is released and re-activated."</i>
2.3.4 selective actuation	<i>"...allows discrete selection of two or more of the following actuation systems: single-sequential actuation, full-sequential actuation or contact actuation. One or more of the selections shall be single-sequential actuation or full-sequential actuation."</i>
2.3.5 automatic reversion	<i>"...can be activated in any sequence to actuate the tool. Regardless of the initial sequence, the actuation system is designed to automatically revert to single-sequential actuation, full-sequential actuation, neutral or off."</i>

NOTICE — SNT-101 has no mode called "single actuation". That term belongs to the NIOSH/OSHA vocabulary, where the four trigger types are **full sequential, contact, single sequential and single actuation**. NIOSH describes single actuation as firing *"a single nail when the safety contact and trigger are activated in any order... Note that some manufacturers refer to these triggers as 'single sequential triggers', but they are different. The first nail can be bump fired with a single actuation trigger but not with a true single sequential trigger."* Be precise about which vocabulary a document is using.

SNT-101-2015 clause 3.1.3 requires that all tools other than light-duty tools, heavy-duty staplers and coil nailers be manufactured with single-sequential, full-sequential, selective or automatic-reversion actuation, and clause 3.1.3.1 requires selective-actuation tools to be **shipped set to a sequential mode, neutral or off**. Clause 3.1.2 requires that the tool *"cannot be actuated unless both the trigger and the workpiece contact have been activated."*

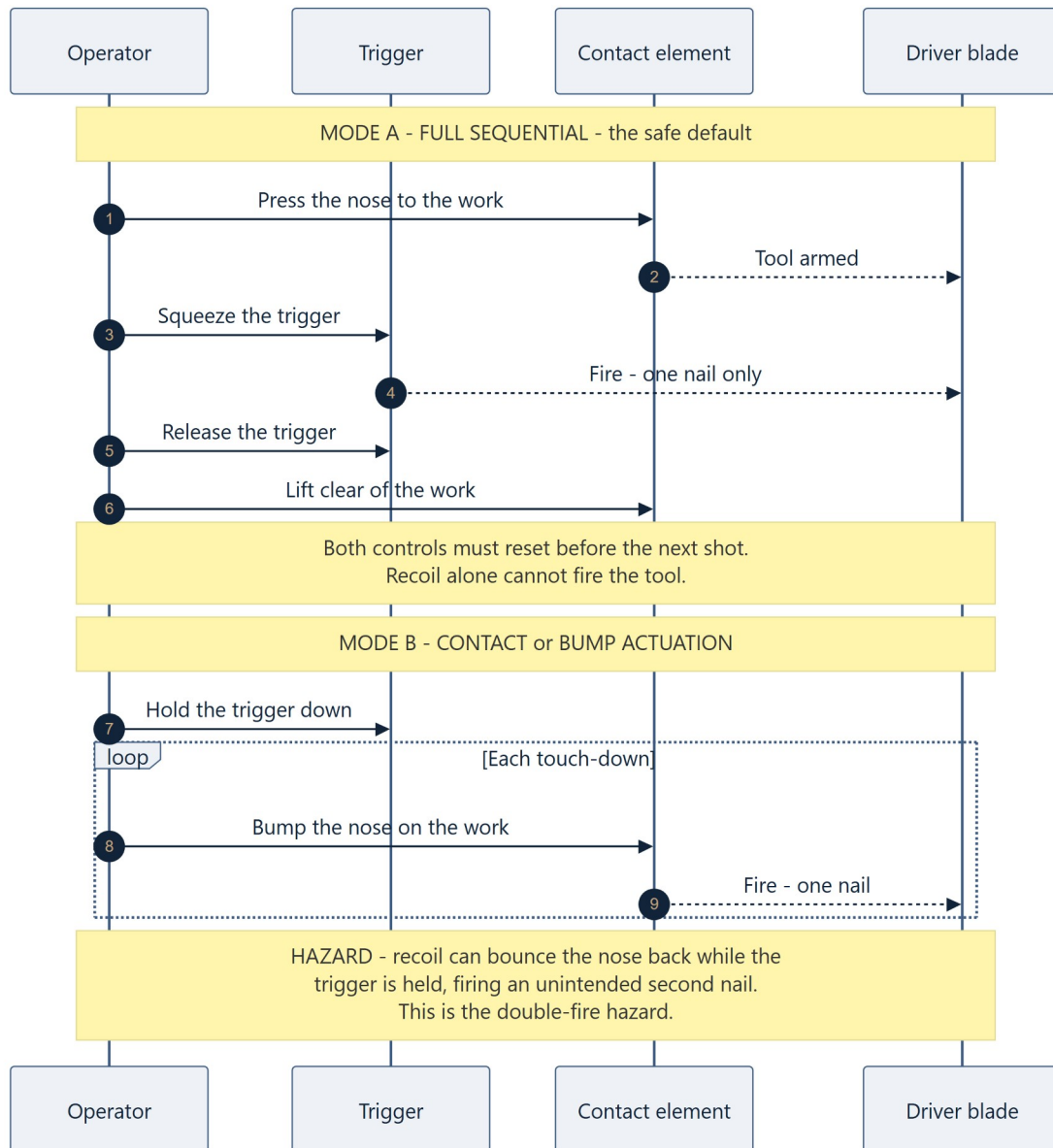


Figure 5-1 — The two actuation modes compared. Mode A cannot be fired by recoil; Mode B can.

5.4.3 The double-fire hazard

DANGER — a contact-trigger tool can fire a second nail faster than you can react.

NIOSH/OSHA: “A double fire occurs when a second nail unintentionally fires because the nailer re-contacted the work piece after recoil. It can also occur if the safety contact slips while the user is positioning the nail gun.”

“The Consumer Product Safety Commission (CPSC) found that contact trigger nailers are susceptible to double firing, especially when trying to accurately place the nailer against the work piece. They found that a second unintended firing can happen faster than the user is able to react and release the trigger.”

SNT-101-2015 clause 7.4.9.14.3 states the mechanism directly: *"In 'Contact Actuation Mode,' if workpiece contact is allowed to re-contact work surface before the trigger is released, an unintended discharge of a fastener will occur."*

5.4.4 Injury data

From the NIOSH/OSHA guide *Nail Gun Safety: A Guide for Construction Contractors* (DHHS (NIOSH) 2011-202 / OSHA 3459), and the NIOSH 2015 bulletin:

- Nail guns are *"responsible for an estimated 37,000 emergency room visits each year"* in the United States, of which **68 % involve workers** and 32 % consumers.
- *"Injuries resulting from use of nail guns hospitalize more construction workers than any other tool-related injury."*
- **The risk ratio:** *"The risk of a nail gun injury is twice as high when using a multi-shot contact trigger as when using a single-shot sequential trigger nailer."* NIOSH restates this in 2015: *"Substantial evidence shows that the overall risk of nail gun injury is twice as high with a contact actuation ('bump') trigger nail gun as with a sequential actuation trigger nail gun."*
- **Training is not a substitute:** *"Training does not trump triggers: trained workers using contact triggers still have twice the overall risk of injury as trained workers using sequential triggers."*
- Among apprentice carpenters: *"2 out of 5 were injured using a nail gun during their 4 years of training. 1 out of 5 were injured twice. 1 out of 10 were injured three or more times."*
- *"More than half of reported nail gun injuries are to the hand and fingers. One-quarter of these hand injuries involve structural damage to tendons, joints, nerves, and bones."*
- *"About two-thirds of these injuries occur in framing and sheathing work."*
- *"two-thirds of nail gun injury claims involved some type of unintended nail gun discharge or misfire."*
- *"About 1 in 10 nail gun injuries happen to co-workers."*
- On the productivity argument for bump firing: *"Average nailing time using the contact trigger was 10% faster, which accounted for less than 1% of the total building time when cutting and layout was included."*

The productivity case for contact triggers does not survive contact with the data. Under 1 % of total build time, against double the injury risk.

NIOSH also recorded that *"the revised ANSI standard does not reflect current scientific research evidence and is therefore not sufficiently protective of workers."* Where a site can choose, choose full sequential.

5.4.5 The seven risk factors and the six steps

NOTICE — these are two different lists and are frequently conflated.

NIOSH lists seven risk factors:

1. Unintended nail discharge from **double fire** — *"Occurs with CONTACT triggers."*
2. Unintended discharge from **knocking the safety contact with the trigger squeezed** — *"Occurs with CONTACT and SINGLE ACTUATION triggers."*

3. **Nail penetration through the lumber workpiece** — all trigger types
4. **Nail ricochet** after striking a hard surface or metal feature — all trigger types
5. **Missing the workpiece** — all trigger types
6. **Awkward position nailing** — all trigger types
7. **Bypassing safety mechanisms** — all trigger types

And six prevention steps: “1) Use full sequential trigger nail guns; 2) Provide training; 3) Establish nail gun work procedures; 4) Provide personal protective equipment (PPE); 5) Encourage reporting and discussion of injuries and close calls; and 6) Provide first aid and medical treatment.”

5.4.6 OSHA requirements for pneumatic tools

29 CFR 1926.302(b), verbatim:

(b)(1) “Pneumatic power tools shall be secured to the hose or whip by some positive means to prevent the tool from becoming accidentally disconnected.” (b)(2) “Safety clips or retainers shall be securely installed and maintained on pneumatic impact (percussion) tools to prevent attachments from being accidentally expelled.” (b)(3) “All pneumatically driven nailers, staplers, and other similar equipment provided with automatic fastener feed, which operate at more than 100 p.s.i. pressure at the tool shall have a safety device on the muzzle to prevent the tool from ejecting fasteners, unless the muzzle is in contact with the work surface.” (b)(4) “Compressed air shall not be used for cleaning purposes except where reduced to less than 30 p.s.i. and then only with effective chip guarding and personal protective equipment...” (b)(5) “The manufacturer’s safe operating pressure for hoses, pipes, valves, filters, and other fittings shall not be exceeded.” (b)(6) “The use of hoses for hoisting or lowering tools shall not be permitted.” (b)(7) “All hoses exceeding 1/2-inch inside diameter shall have a safety device at the source of supply or branch line to reduce pressure in case of hose failure.”

An OSHA letter of interpretation permits a quick disconnect with a pull-down sleeve to satisfy (b)(1). 29 CFR 1926.300(a) additionally requires that “All hand and power tools and similar equipment, whether furnished by the employer or the employee, shall be maintained in a safe condition.”

5.4.7 Operator rules from SNT-101

- Do not drive fasteners into other fasteners.
- Do not hold or carry the tool with a finger on the trigger.
- Do not actuate the tool unless it is placed firmly against the workpiece.
- Do not lift, pull or lower the tool by the hose.
- “NEVER use oxygen or other bottled gasses. Explosion may occur.”

Required tool markings (clause 3.2.1): manufacturer or distributor identity, model number, serial number or date code, and **maximum air pressure**. Required warnings (3.2.3) include “Operators and others in work area **MUST** wear safety glasses with side shields.” Selective-actuation tools must be marked to show the mode selected; colour is an acceptable means (3.2.6).

Design requirements worth knowing when assessing a tool: the pressure vessel must withstand “hydrostatic pressure of five (5) times the maximum air pressure” for two minutes (3.3.1), and must not self-

actuate for two minutes at *"1.5 times the maximum air pressure or 200 psig (13.8 bar), whichever is greater"* (3.3.2).

5.5 Concealed services

DANGER — a nail driven into a wall cavity can strike a live electrical cable, a gas pipe or a water pipe. The nail conducts. The operator is holding it.

Before driving into any wall, floor or ceiling that may contain services:

1. **Consult the drawings** for cable and pipe routes, and for the safe zones defined by the local wiring regulations.
2. **Scan** with a cable and pipe detector, in more than one orientation, over the full area to be nailed — not only at the marked point.
3. **Isolate** the affected circuits where the risk cannot be eliminated.
4. **Assume the worst about existing buildings.** Concealed work is often not in a safe zone and often not on the drawings.
5. **Limit penetration.** Select the shortest nail that satisfies the penetration requirement, so a nail that misses its target does not reach a service behind it.

5.6 Emergency procedures

5.6.1 Struck finger or thumb

Cool, elevate, and assess. A subungual haematoma under pressure, an obvious deformity, loss of movement or a wound over a joint all require medical assessment.

5.6.2 Puncture wound from a nail

WARNING — do not treat a nail puncture as trivial. The entrance wound is small and the injury is deep. Contamination is carried in.

1. Control any bleeding with direct pressure.
2. **Clean the wound.** CDC guidance for wound management: *"Clean all wounds. Remove dirt or foreign material. Remove or debride necrotic material."*
3. **Do not apply prophylactic antibiotics on your own initiative.** CDC: *"Healthcare providers shouldn't use antibiotics (topical or systemic) to try to prevent tetanus after a wound injury."*
4. Seek medical assessment and address tetanus status (Section 5.6.4).
5. Record the incident.

Puncture through footwear is a specific and recognised risk. The clinical literature is consistent: *"Puncture wounds in the foot, especially in children, can lead to infection with Pseudomonas... A classical scenario is a nail or glass injury through rubber shoes or soles."* A study of 77 children with proven *Pseudomonas* osteochondritis or septic arthritis after nail puncture found 70 had been wearing trainers at the time. *"Osteomyelitis of foot bones and septic arthritis may complicate foot puncture wounds."* A separate

adult series found that of 96 patients, 60 were treated surgically and a quarter of those had a retained foreign body extracted.

Any nail puncture through a shoe warrants medical review, even if it looks clean.

5.6.3 Nail embedded in the body, or fired by a tool

DANGER — do not remove an embedded nail.

NIOSH/OSHA on nail gun injuries: *"Materials such as nail strip glue or plastic or even clothing can get embedded in the injury and lead to infection. Barbs on the nail can cause secondary injury if the nail is removed incorrectly."*

1. **Leave the nail in place.** Do not pull, twist or cut it unless a trained responder directs otherwise.
2. Stabilise it with padding so it cannot move.
3. Control bleeding around it, without pressing on the object.
4. **Get emergency medical help.** Nail gun injuries to the head, neck, chest, abdomen, eye or a joint are potentially life-threatening regardless of how small the entry wound looks.
5. Preserve the tool and the nail strip for investigation, and isolate the tool from use.

5.6.4 Tetanus

CDC clinical guidance classifies wounds into two categories, and **penetrating or puncture wounds are explicitly in the higher-risk group**: *"Clean and minor wounds don't pose a major risk. Dirty or major wounds pose an increased risk"* — the latter expressly including *"Penetrating or puncture wounds"* and *"Wounds containing dirt, soil, feces, or saliva."*

Situation	Action
Complete primary series and last dose < 5 years ago	No vaccination needed, either wound type
Dirty or major wound (includes any nail puncture), complete series, last dose 5 or more years ago	Vaccinate
Clean and minor wound, complete series, last dose 10 or more years ago	Vaccinate
Unknown vaccination history, unvaccinated, or incomplete primary series	Vaccinate — for all wounds
Dirty or major wound and unknown history / never vaccinated / incomplete series / HIV / severe immunodeficiency	Vaccinate and administer TIG — <i>"If indicated, administer 250 international units of TIG intramuscularly."</i>

"TIG is never indicated for clean and minor wounds." CDC also recommends routine adult vaccination "every 10 years for all adults to maintain protection against tetanus."

In the UK, NHS guidance directs an urgent GP appointment or NHS 111 contact where *"a wound has soil, pus or body fluids in it, or it's still dirty after cleaning it"*, where *"a cut is swollen, red and getting more painful or pus is coming out of it"*, or where the person *"feel[s] generally unwell or ha[s] a high temperature."* Call 999 or attend A&E if bleeding cannot be stopped, the wound is very large or deep, or *"there's something stuck in the cut... do not try to take it out yourself."*

This manual is not medical advice. Follow your site's first-aid arrangements and the direction of a qualified clinician.

5.6.5 Eye injury

Do not rub. Do not attempt to remove an embedded fragment. Cover both eyes lightly to reduce movement and obtain immediate medical attention.

5.7 Housekeeping — protruding nails

DANGER — the most common nail injury on a site has nothing to do with driving one. It is standing on a nail in discarded timber.

OSHA makes this a legal duty:

29 CFR 1926.25(a): *"During the course of construction, alteration, or repairs, form and scrap lumber with protruding nails, and all other debris, shall be kept cleared from work areas, passageways, and stairs, in and around buildings or other structures."*

29 CFR 1926.25(b): *"Combustible scrap and debris shall be removed at regular intervals during the course of construction."*

29 CFR 1926.250(b)(8)(i): *"Lumber: (i) Used lumber shall have all nails withdrawn before stacking."*

Practical rules:

- Withdraw or bend over **every** protruding nail as the timber comes off, not at the end of the shift.
 - Never stack, carry or store timber with nails protruding.
 - Keep a dedicated closed metal container for scrap nails at each work face.
 - Sweep work areas and access routes at each break, not only at the end of the day.
 - Account for dropped nails. A nail on a floor becomes a nail in a foot.
-

6 Receiving, storage, selection and preparation

6.1 Receiving inspection

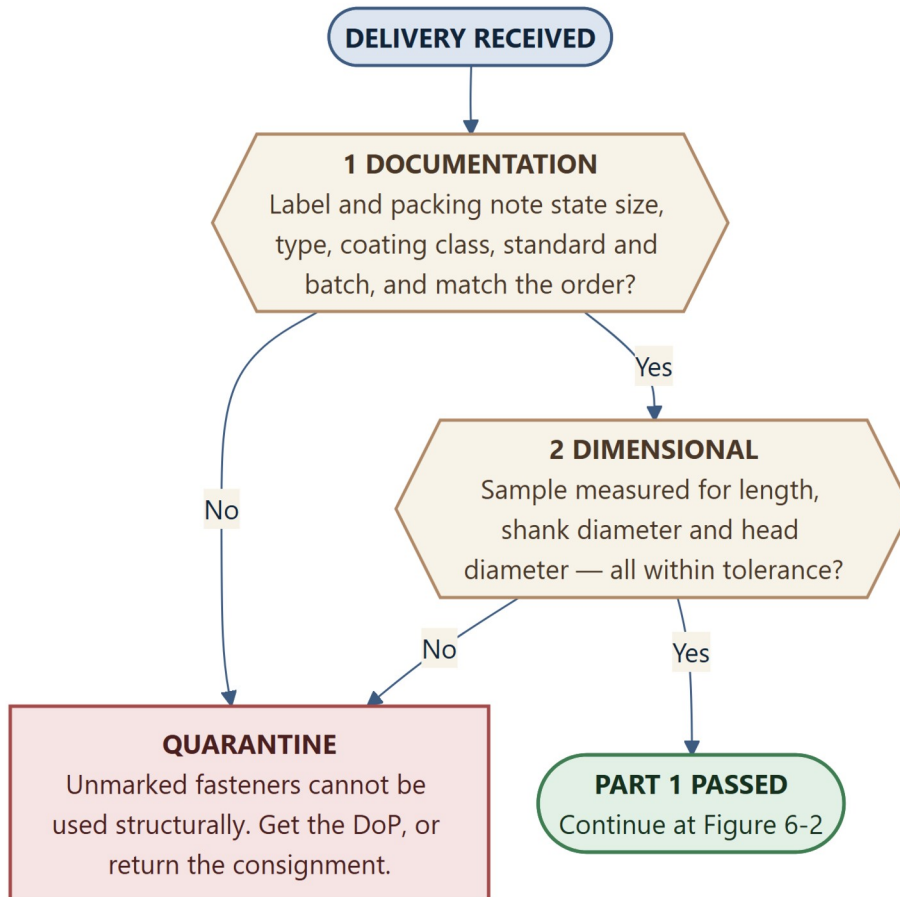


Figure 6-1 — Goods-in inspection, part 1: documentation and dimensions.

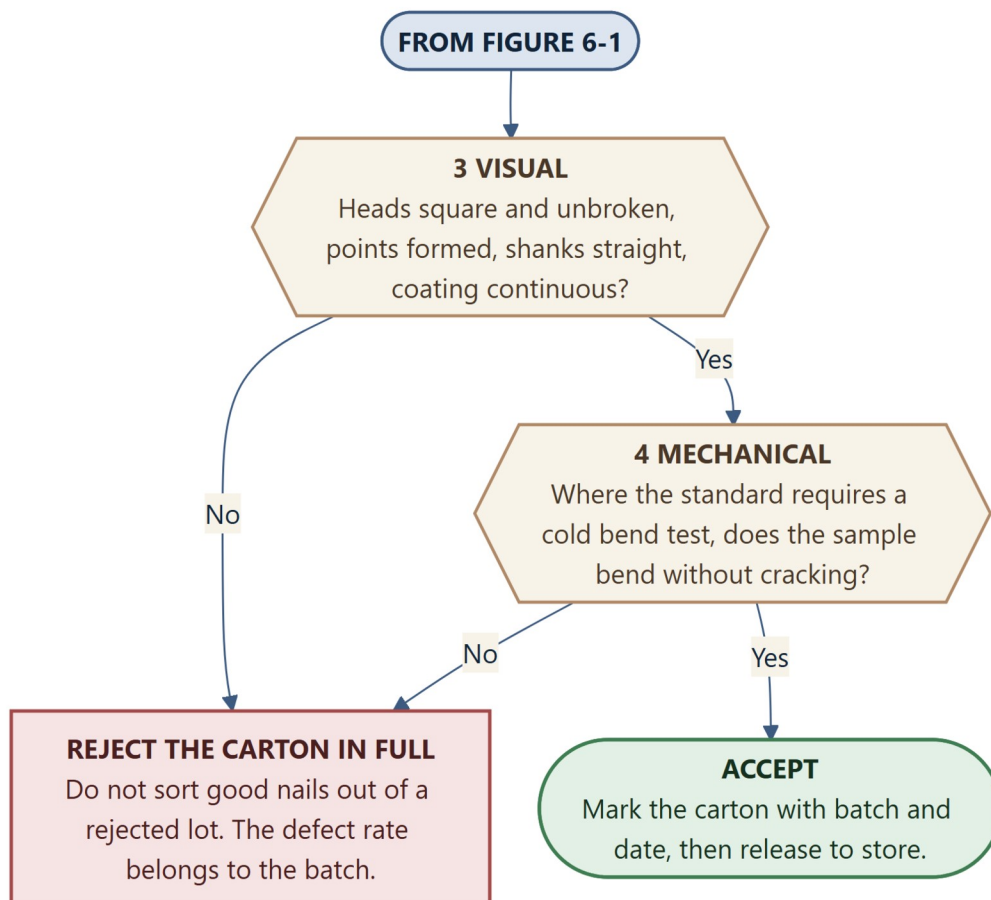


Figure 6-2 — Goods-in inspection, part 2: condition and mechanical checks.

6.1.1 Acceptance criteria

Table 6-1 — Receiving inspection acceptance criteria.

Check	Criterion	Reference
Label completeness	All eight items of Section 2.9 present	This manual
Length	Within the tolerance of Table 3-5	ASTM F1667 clause 8.2.1
Shank diameter	± 0.004 in at 0.076 in and larger, measured away from gripper marks and clear of coating	ASTM F1667 clauses 8.1.2, 8.2.2
Head diameter	± 10 % of nominal, individual measurement; out-of-round ≤ 10 %	ASTM F1667 clause 8.2.3.1

Check	Criterion	Reference
Fillet under head	Present	ASTM F1667 clause 8.2.3.1
General condition	<i>"true to shape, well-finished, free from imperfections, clean, and free of corrosion"</i>	ASTM F1667 clause 9.1
Ductility	180° cold bend without fracture for unhardened steel wire, mandrel diameter equal to nail diameter	ASTM F1667 clause 7.1 and Table 2; test per ASTM F680
Coating continuity	Continuous over head, shank and point; no flaking; heads not clogged	Visual
[EU/UK] CE / UKCA marking and DoP	Present and referencing the correct harmonised standard	Section 12

NOTICE — the ASTM workmanship clause is an as-supplied criterion. *"Free of corrosion"* in clause 9.1 governs the condition in which fasteners are delivered. It is **not** a statement about in-service condition or about already-driven fasteners. **[VERIFY]** — this wording was read in the 2005 edition; its currency in F1667/F1667M-21a was not confirmed.

NOTICE — do not cherry-pick from a rejected lot. If a sample fails, the defect rate is a property of the batch. Sorting through a rejected carton for acceptable nails defeats the purpose of sampling and leaves no defensible record.

6.2 Storage and handling

Requirement	Reason
Store indoors , dry, under cover	Bright steel has no corrosion protection at all
Keep off concrete floors , on pallets or shelving	Concrete wicks moisture and is alkaline
Keep cartons sealed until required	Limits condensation and contamination
Store one size and one batch per container	Traceability, and prevents wrong-size installation
Retain the original label with the stock	It is the only identification the product has
Rotate stock first in, first out	Limits time at risk
Return part-used cartons to store at the end of the shift	Avoids overnight condensation cycles

Requirement	Reason
Segregate coated from bright, and stainless from carbon steel	Prevents mixing, and prevents contact corrosion in storage

[VERIFY] — there is no authoritative published storage specification for bright nails. No standards body, trade institute or major manufacturer publishes storage conditions or a shelf life for nails. The requirements above are engineering good practice consistent with general fastener handling, not a citable requirement.

6.2.1 Rusted stock

NOTICE — a widely repeated claim about rust is wrong, and the misunderstanding is worth correcting.

It is sometimes said that light surface rust on fasteners is acceptable. The nearest authoritative treatment — the RCSC *Specification for Structural Joints Using High-Strength Bolts* — says the opposite. Its clause 2.10.5 requires that bolting components “that accumulate rust or dirt shall not be incorporated into the work unless they are cleaned and lubricated, if necessary”, and clause 2.10.6 requires components for pretensioned or slip-critical joints to be cleaned **and retested**. Clause 2.10.1 requires “protected storage”, and 2.10.3 requires unused components to be returned to it at the end of each shift.

The “rust is acceptable” idea properly concerns **faying surfaces** — the connected plies, where clean mill scale or blast-cleaned surfaces are classified for slip resistance. **It does not concern the fasteners.** Do not conflate the two.

Applied to nails:

- Loose, flaking or pitting rust: **reject**. Section loss and coating breakdown are both possible, and neither can be assessed on site.
- Light surface bloom on bright nails: assess against ASTM F1667 clause 9.1 (“free of corrosion”) as an as-supplied criterion. If the consignment is being accepted against that clause, bloom is a non-conformity.
- Any rust on a **coated** nail means the coating is breached. Reject; the corrosion protection the specification relied on is gone.

[VERIFY] — no data on the effect of surface rust on drivability, and no IBC or IRC provision on the acceptance of corroded fasteners, could be located.

6.3 Selecting the right nail

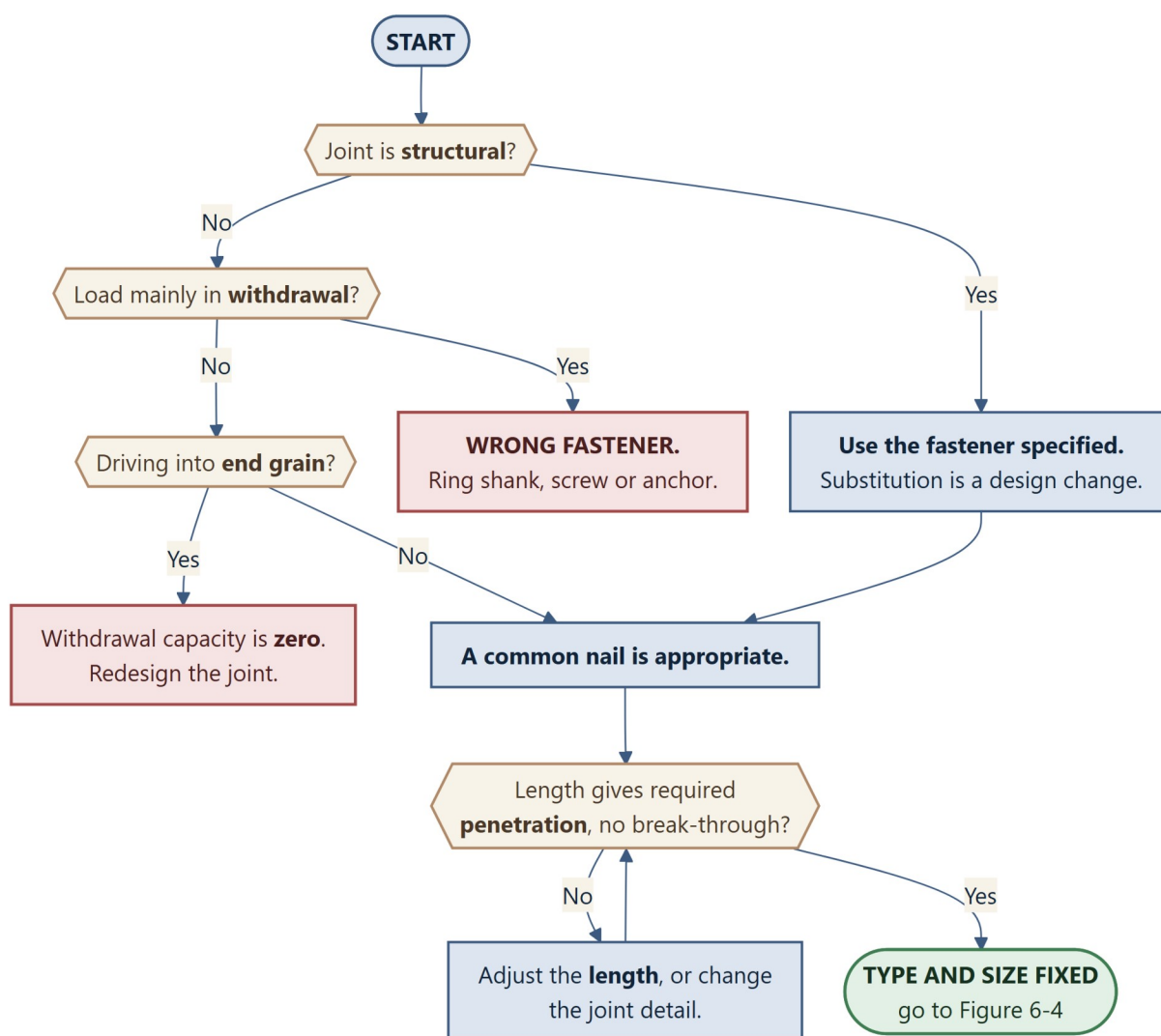


Figure 6-3 — Selection, part 1: is a plain-shank common nail the right fastener at all, and what length?

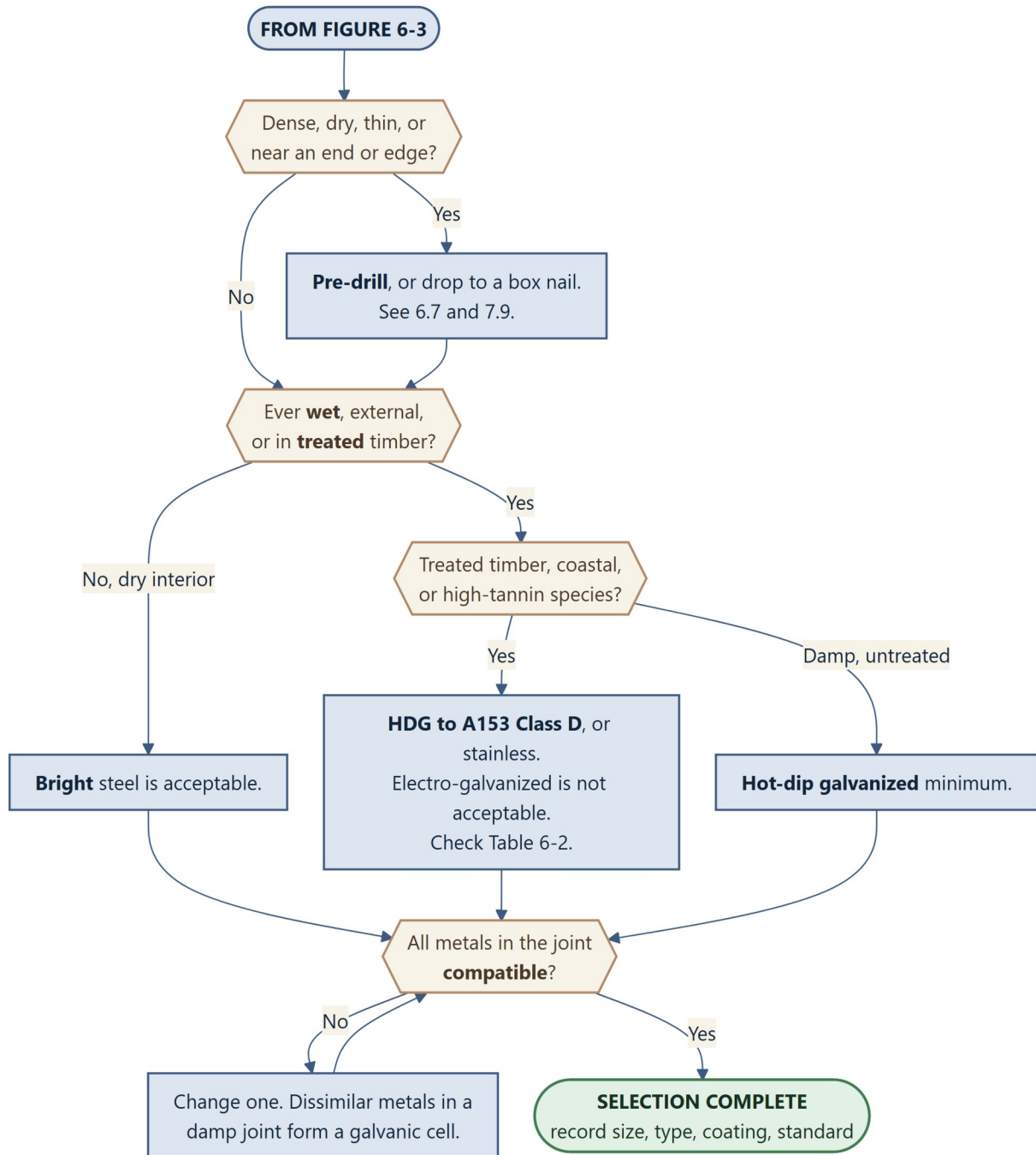


Figure 6-4 — Selection, part 2: splitting risk, coating and metal compatibility.

6.4 Substrate and coating compatibility

Table 6-2 — Compatibility matrix. "HDG" means hot-dip galvanized to ASTM A153 Class D or, in Europe, to the coating class declared for the service class.

Substrate / environment	Bright	Electro-galv	Mech. deposited zinc	HDG (A153 Class D)	Stainless 304	Stainless 316
Dry heated interior, untreated timber	OK	OK	OK	OK	OK	OK
Interior, risk of condensation	No	Marginal	OK	OK	OK	OK
Covered exterior, untreated	No	No	Marginal	OK	OK	OK
Exposed exterior, untreated	No	No	No	OK	OK	OK
ACQ / CA-B treated timber	PROHIBITED	PROHIBITED	PROHIBITED for nails	OK — required minimum	OK	OK
Permanent wood foundation, below grade	No	No	No	No	Required	Required
Coastal / salt spray	No	No	No	Marginal	Marginal	Preferred
Oak, western red cedar, redwood (high tannin)	No — staining	No	No	OK	OK	OK
In contact with a galvanized steel connector	—	—	—	Compatible	Note galvanic pairing	Note galvanic pairing

Substrate / environment	Bright	Electro-galv	Mech. deposited zinc	HDG (A153 Class D)	Stainless 304	Stainless 316
SBX/DOT or zinc borate treated, interior dry	Permitted by code	OK	OK	OK	OK	OK

6.4.1 The code requirement for treated timber [US]

DANGER — nails are specifically carved out of the concession that applies to other fasteners.

IRC Section R317.3: “Fasteners, including nuts and washers, and connectors in contact with preservative-treated wood and fire-retardant-treated wood shall be in accordance with this section. The coating weights for zinc-coated fasteners shall be in accordance with ASTM A153.”

IRC Section R317.3.1: “Fasteners, including nuts and washers, for preservative-treated wood shall be of hot-dipped, zinc-coated galvanized steel, stainless steel, silicon bronze or copper. Staples shall be of stainless steel. Coating types and weights for connectors in contact with preservative-treated wood shall be in accordance with the connector manufacturer’s recommendations. In the absence of manufacturer’s recommendations, not less than ASTM A653 type G185 zinc-coated galvanized steel, or equivalent, shall be used.”

The three exceptions:

1. Steel bolts of ½ in diameter or greater.
2. “Fasteners **other than nails, staples and timber rivets** shall be permitted to be of mechanically deposited zinc-coated steel with coating weights in accordance with ASTM B695, Class 55 minimum.”
3. “Plain carbon steel fasteners in SBX/DOT and zinc borate preservative-treated wood in an interior, dry environment shall be permitted.”

IBC Section 2304.10.6.1 is materially identical, excluding “nails, staples, timber rivets, wood screws and lag screws” from the mechanically-deposited-zinc concession.

The consequence in one sentence: a nail in ACQ or CA-B treated timber must be hot-dip galvanized to ASTM A153 (Class D), stainless steel, silicon bronze or copper. Mechanically deposited zinc is not permitted for nails, and electro-galvanized is not on the permitted list at all.

Stainless grades. ASTM F1667 clause 6.2 permits Types 302, 304, 305 and 316. Industry guidance requires stainless for **permanent wood foundations below grade** and recommends it for severe exterior exposure such as swimming pools and saltwater; **Types 304 and 316** are the recommended grades, with **316 for seaside applications**.

Ammoniacal preservatives. Hot-dip galvanized fasteners are recommended for use with all preservatives, including ammonia-containing systems such as ACQ and ACZA; testing has found “no

significant difference in corrosion activity in galvanized steel in contact with treatments with or without ammonia."

6.4.2 Service classes [EU/UK]

Match the coating to the Eurocode 5 service class using Table 4.1 (Section 2.8.2). For nails of $d \leq 4$ mm: service class 1 requires no protection, service class 2 requires Fe/Zn 12c, and service class 3 requires Fe/Zn 25c. For $d > 4$ mm, service class 3 requires Fe/Zn 25c and classes 1 and 2 require none. *"For especially corrosive conditions consideration should be given to heavier hot dip coatings or stainless steel."*

6.5 Tool selection

6.5.1 Hammers

Head mass	Typical application
7–13 oz (200–370 g)	Pins, brads, small finish nails, cabinet work
16 oz (450 g)	The general-purpose claw hammer. Nails to roughly 8d–10d.
20–24 oz (560–680 g)	Framing. 16d common and comparable.
28–32 oz (790–900 g)	Heavy framing, spikes, demolition

A public-domain hand-tool manual records that *"Hammers come in 7, 13, 16 and 20 ounce sizes"* and that *"The straight claw is generally used for ripping and framing. The curved claw is preferred for general use."* Manufacturer catalogues give paired values — 16 oz / 448 g for a general claw hammer, and framing hammers at 20 oz / 560 g through 30 oz / 840 g. A hammer maker describes framing hammers as *"typically 20-32 oz for steel, 12-16 oz for titanium"* with *"longer handles (14-18 inches)"*, suited to *"any application involving 16d nails or larger."*

[VERIFY] — no standard maps hammer mass to nail size. ASME B107.400, BS 876 and ANSI/HTI B173.1 specify hammer construction and safety, not the size of nail a given hammer suits. The table above is trade practice.

6.5.2 Face type

Face	Use	Note
Smooth (plain or bell)	Finish and exposed work; anywhere a mark is unacceptable	<i>"bell face for finishing work where you don't want dents in the finish"</i>
Milled / waffle	Rough and structural framing	<i>"a textured striking surface that grips nail heads and reduces</i>

Face	Use	Note
		<i>slippage... increases driving efficiency but leaves distinctive marks on wood surfaces, making them unsuitable for finish work"</i>

6.5.3 Pre-use checks

1. Head tight on the handle; no movement.
2. Handle free of splinters, cracks and dents.
3. Striking face free of chips, dents and mushrooming.
4. Claw not cracked and not deformed.
5. **Powered tools:** correct actuation mode selected and marked; contact element moves freely and returns fully; hose secured by a positive means; air pressure within the marked maximum; magazine correct for the fastener; no bypassed or taped safety.

6.6 Preparing the work

1. **Confirm the fastening schedule.** Size, type, count, spacing, method (face, toe, end).
2. **Check the timber.** Correct species and grade; moisture content within the assumption of Section 3.8; no splits, shakes or large knots at the intended nail positions.
3. **Scan for concealed services** (Section 5.5).
4. **Support the work solidly.** An unsupported member absorbs the blow instead of transmitting it, and it is the usual reason a nail refuses to advance while its head deforms.
5. **Bring the members into contact** and clamp or cramp if necessary. A nail cannot pull a gap closed; it will simply hold the gap.
6. **Mark out** entry points, respecting the geometry of Section 6.7.
7. **Plan the escape of the point.** Know what is behind the far face.

6.7 Placement geometry

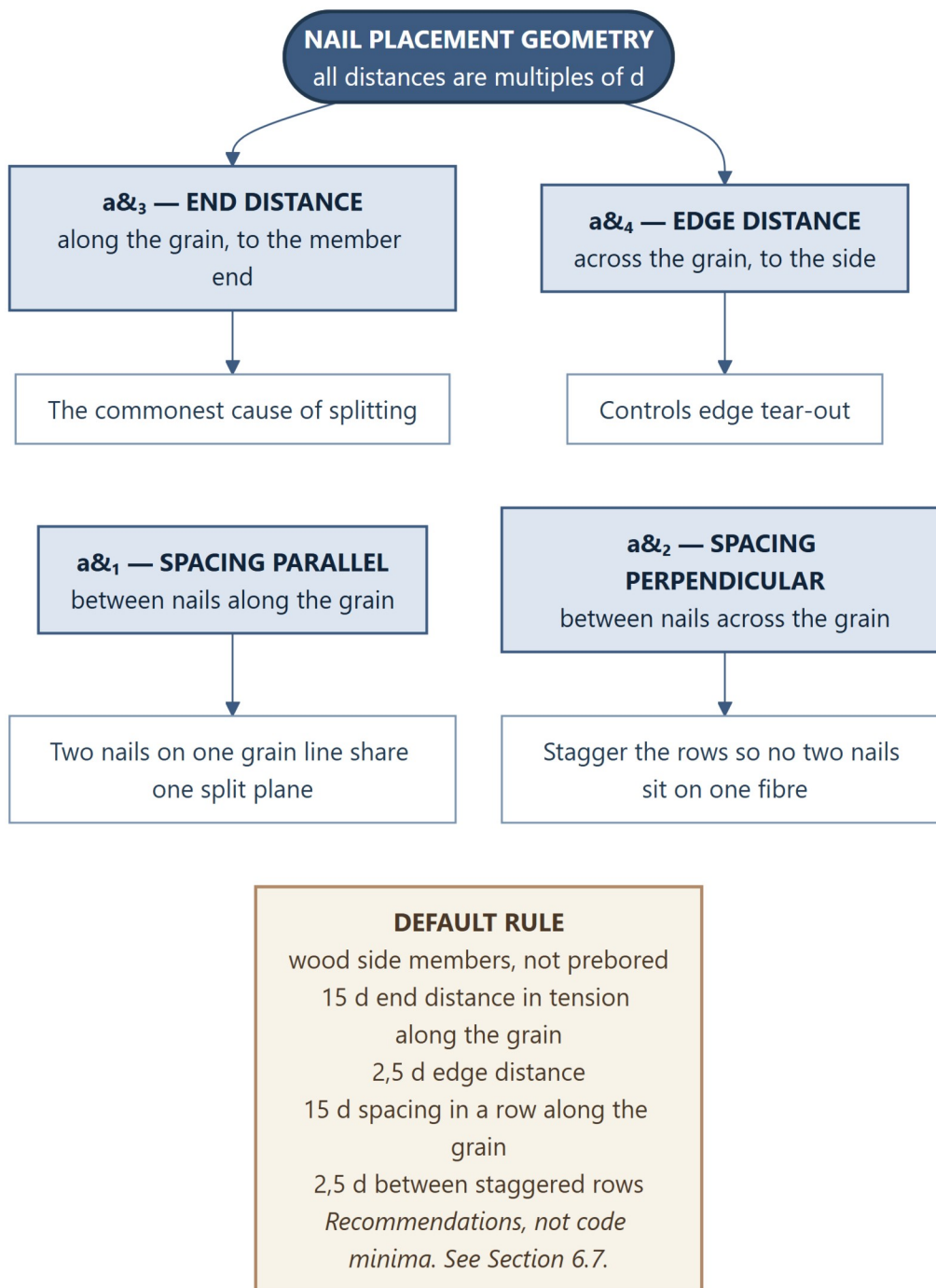


Figure 6-5 — The four placement distances and what each one controls.

6.7.1 The US position [US]

The **normative** NDS requirement for nails is a single sentence, NDS 12.1.6.5: “Edge distances, end distances, and fastener spacings shall be sufficient to prevent splitting of the wood.” And NDS 12.5.1.1

confirms **CA = 1.0 for D < ¼ in** — there is no numerical penalty for close spacing, only the qualitative prohibition on splitting.

The numbers live in the **Commentary** and are explicitly non-mandatory. Commentary C12.1.6.5: *“For diameters less than ¼”, specific requirements are not provided; however, Table C12.1.6.6 may be used to establish nail placement recommendations. Designers should note that wood species, moisture content, and grain orientation will impact spacing effects between fasteners in a row.”*

Table 6-3 — Recommended minimum spacing for nails, NDS Commentary Table C12.1.6.6. Non-mandatory. D = nail diameter.

	Wood side members, not prebored	Wood side members, prebored	Steel side members, not prebored	Steel side members, prebored
Edge distance	2.5 D	2.5 D	2.5 D	2.5 D
End distance — tension load parallel to grain	15 D	10 D	10 D	5 D
End distance — compression load parallel to grain	10 D	5 D	5 D	3 D
Spacing in a row — parallel to grain	15 D	10 D	10 D	5 D
Spacing in a row — perpendicular to grain	10 D	5 D	5 D	2.5 D
Spacing between rows — in line	5 D	3 D	3 D	2.5 D
Spacing between rows — staggered	2.5 D	2.5 D	2.5 D	2.5 D

For the 16d reference unit (D = 0.162 in), the not-prebored column becomes: edge 0.41 in, end in tension 2.43 in, spacing in a row along the grain 2.43 in, staggered rows 0.41 in.

[VERIFY] — internal numbering inconsistency. The printed 2018 NDS Commentary contains paragraph C12.1.6.5 referring to Table C12.1.6.6, and AWC errata renumber these. Cite against your specific printing.

A useful practical rule from the FPL, independent of the table: *“nails should be driven no closer to the edge of the side member than one-half its thickness and no closer to the end than the thickness of the piece. Smaller nails can be driven closer to the edges or ends than larger ones because they are less likely to split the wood.”*

6.7.2 The European position [EU/UK]

Eurocode 5 makes spacing **mandatory** and tabulates it. **Table 8.2**, clause 8.3.1.2(5), where α is the angle between the force and the grain:

Distance	Angle	No pre-drilling, $pk \leq 420 \text{ kg/m}^3$	No pre-drilling, $420 < pk \leq 500$	Pre-drilled
a₁ parallel to grain	$0^\circ \leq \alpha \leq 360^\circ$	$d < 5 \text{ mm: } (5 + 5 \cos \alpha)d$; $d \geq 5 \text{ mm: } (5 + 7 \cos \alpha)d$	$(7 + 8 \cos \alpha)d$	$(4 + \cos \alpha)d$
a₂ perpendicular to grain	$0^\circ \leq \alpha \leq 360^\circ$	$5d$	$7d$	$(3 + \sin \alpha)d$
a_{3,t} loaded end	$-90^\circ \leq \alpha \leq 90^\circ$	$(10 + 5 \cos \alpha)d$	$(15 + 5 \cos \alpha)d$	$(7 + 5 \cos \alpha)d$
a_{3,c} unloaded end	$90^\circ \leq \alpha \leq 270^\circ$	$10d$	$15d$	$7d$
a_{4,t} loaded edge	$0^\circ \leq \alpha \leq 180^\circ$	$d < 5 \text{ mm: } (5 + 2 \sin \alpha)d$; $d \geq 5 \text{ mm: } (5 + 5 \sin \alpha)d$	$d < 5 \text{ mm: } (7 + 2 \sin \alpha)d$; $d \geq 5 \text{ mm: } (7 + 5 \sin \alpha)d$	$d < 5 \text{ mm: } (3 + 2 \sin \alpha)d$; $d \geq 5 \text{ mm: } (3 + 4 \sin \alpha)d$
a_{4,c} unloaded edge	$180^\circ \leq \alpha \leq 360^\circ$	$5d$	$7d$	$3d$

Modifiers. Nailed panel-to-timber: spacings $\times 0,85$, end and edge distances unchanged (8.3.1.3). Nailed steel-to-timber: spacings $\times 0,7$, end and edge distances per Table 8.2 unchanged (8.3.1.4).

NOTICE — at least one widely circulated online reproduction of Table 8.2 is wrong in three places (a_1 for $420 < pk \leq 500$, a_2 pre-drilled, and cos versus sin in the $a_{4,t}$ rows). Take Table 8.2 from the standard or from a reputable national design guide, not from a web reference.

NOTICE — Eurocode 5 sets no minimum headside member thickness for nails. t_1 is only *defined* in 8.3.1.1(1). Do not state one as a Eurocode requirement.

7 Operation — driving

7.1 Prerequisites

Do not begin until all of the following are true.

- Eye protection with side shields is worn by the operator **and by everyone in the work area.**
- The cavity has been scanned for concealed services, or there is none.
- The workpiece is supported solidly against a mass.
- The members are in contact; any gap has been closed by clamping.
- The nail has been verified against the fastening schedule for size, type and coating.
- The tool has passed the pre-use check of Section 6.5.3.
- The entry point respects the geometry of Section 6.7.

7.2 Hand driving — the standard sequence

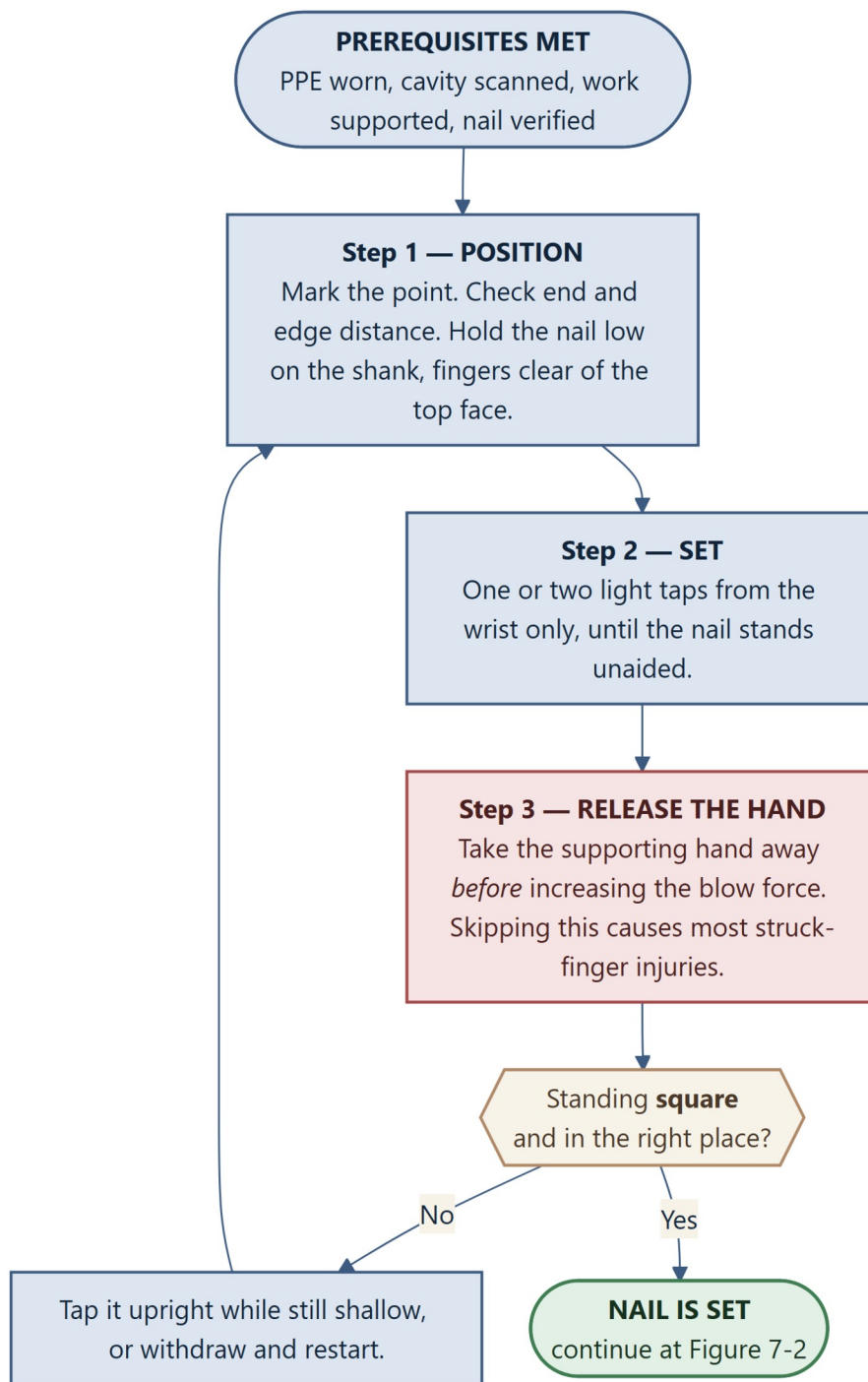


Figure 7-1 — Driving, part 1: positioning and setting the nail.

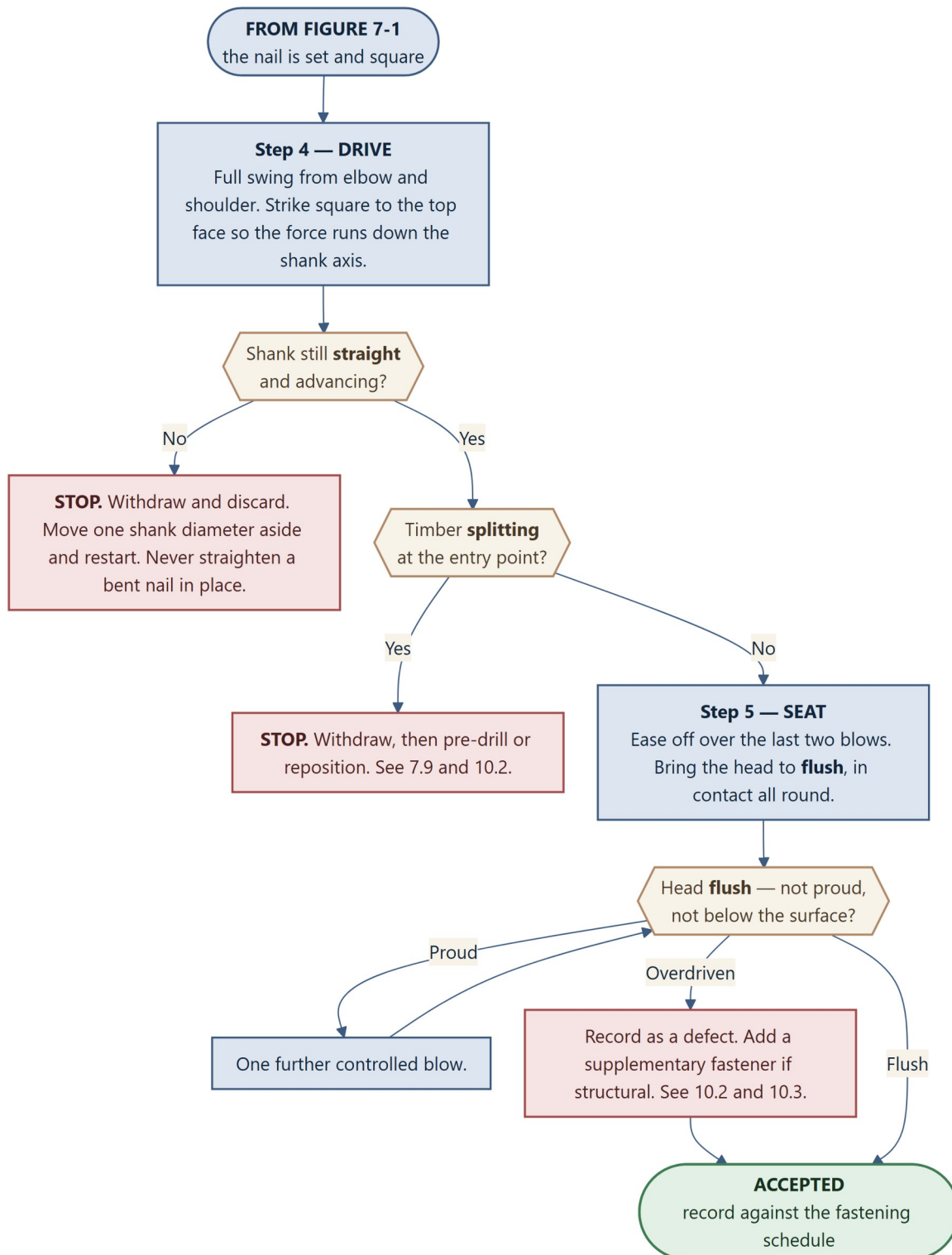


Figure 7-2 — Driving, part 2: driving, seating and acceptance.

7.2.1 Notes on the five steps

Step 1 — Position. Hold the nail **low on the shank**, close to the work, not up near the head. A low grip means a mis-hit strikes the timber rather than the fingers, and it steadies the nail better.

Step 2 — Set. Light taps **from the wrist only**. The objective is a nail standing unaided, not progress.

Step 3 — Release. This is the step that prevents the injury. Take the supporting hand away **before** the blow force increases. If the nail is too short to grip safely, use a nail holder, a strip of card, or long-nosed pliers — never fingers.

Step 4 — Drive. Full swing from elbow and shoulder. **Strike square to the top face.** The force must run down the axis of the shank; any off-axis component is what bends nails. Watch the nail head, not the hammer.

Step 5 — Seat. Ease off over the last two blows. The target is **flush**: the underside of the head in firm contact with the surface all round, with no crushing.

CAUTION — never straighten a bent nail in place. A bend is a permanent stress concentration and the nail will fold again at the same point. Withdraw it, discard it, and start a fresh nail at least one shank diameter away.

WARNING — never strike a nail with the side or cheek of the hammer, and never use a nail hammer on a nail set or a cat's paw. See Section 5.3.

7.3 Face nailing

The default method: the nail is driven perpendicular to the face of the side member, through it, and into the main member.

- Confirm the length gives at least the minimum penetration into the main member — 6D under the NDS, 8 d under Eurocode 5 for smooth nails.
- Keep the shank perpendicular to the surface, and the surface flat.
- Stagger successive nails so no two share a fibre line (Section 6.7).
- Where the schedule gives a spacing "o.c.", measure it; do not eye it.

7.4 End nailing

The nail is driven through the face of one member into the **end grain** of the other — for example a stud end-nailed through a plate.

DANGER — an end-nailed joint has zero rated withdrawal capacity. NDS 12.2.3.5 sets $C_{eg} = 0.0$ for nails in end-grain withdrawal. Eurocode 5 8.3.2(3) states that nails in end grain "*should be considered incapable of transmitting axial load*", and 8.3.1.2(3) that smooth nails in end grain cannot transmit lateral force either.

End nailing is nevertheless permitted and scheduled by the IRC — for example, top or bottom plate to stud, "*3-16d box (3½"×0.135"); or 2-16d common (3½"×0.162"); or 3-10d box (3"×0.128"); or 3-3"×0.131" nails*", end nail. It is used where the code has evaluated the assembly as a whole, not because the

individual joint has withdrawal capacity. **Do not extrapolate from a scheduled end-nailed connection to an unscheduled one.**

7.5 Toe nailing

The nail is driven at an angle through the face of one member into the face of another, typically to fix a member that cannot be end-nailed.

7.5.1 Geometry

NDS 12.1.6.3 (12.1.6.4 in the 2015 edition) states it exactly:

"Toe-nails shall be driven at an angle of approximately 30° with the member and started approximately 1/3 the length of the nail from the member end."

For the 16d reference unit: start **1.17 in** from the end of the member, at approximately **30°** to the face.

NOTE — 30° is "approximately", not a maximum. No maximum toe-nail angle is stated in the NDS, the IRC or the IBC. Searches of IRC Chapter 6 and IBC Chapter 23 find no toe-nail angle, no edge distance and no end distance for nails anywhere in either code. The geometry is an NDS provision, and it has been *"part of the Specification since the 1952 edition."*

7.5.2 Capacity factors

Loading	Factor	Reference
Withdrawal	Ctn = 0.67	NDS 12.5.4.1. <i>"The wet service factor, CM, shall not apply."</i>
Lateral	Ctn = 0.83	NDS 12.5.4.2

NDS 12.3.10.2 adds that *"For toe-nailed connections, the minimum of ts or L/3 shall be used for ls."*

The NDS Commentary makes the dependency explicit: *"The toenail factors of NDS 12.5.4.1 and NDS 12.5.4.2 presume use of these driving procedures and the absence of excessive splitting. If such splitting does occur, predrilling or a smaller nail should be used."*

The factors are conditional on the geometry. A toe nail driven at 45° from an arbitrary start point is not a toe nail within the meaning of the NDS, and Ctn does not apply to it.

Worked values for the 16d reference unit, from an AWC design aid, with Ctn already applied ($\ell_s = 1.17$ in, $\ell_m = 1.86$ in):

Species	Lateral Z (lb)	Withdrawal Wp (lb)
Douglas Fir-Larch	117	57
Spruce-Pine-Fir	99	37

Species	Lateral Z (lb)	Withdrawal Wp (lb)
Southern Pine	128	72
Hem-Fir	101	39

7.5.3 Technique

1. Start the nail at the marked distance from the end, roughly perpendicular, with two light taps.
2. Bring the hammer round and lay the nail over to about 30°.
3. Drive. Expect the member to want to slide away — block it, or drive an opposing toe nail first.
4. Drive toe nails **in opposing pairs** where possible, so the lateral components cancel.
5. Seat the head flush. On a toe nail the head bears on a sloping surface; do not overdrive to make it look neat.

The IRC pattern for a rafter or truss to plate illustrates the balancing principle: *“2 toe nails on one side and 1 toe nail on opposite side.”*

7.6 Skew and dovetail nailing

Two nails driven at opposing angles through the same joint form a mechanical dovetail: each resists the other's tendency to withdraw, and the pair resists separation far better than two parallel nails. This is the standard method for holding a joint that would otherwise creep apart under vibration, and it costs nothing.

Angle each nail 10–20° off perpendicular in opposite directions. Keep both within the edge and end distances of Section 6.7.

7.7 Clinching

Where the point protrudes and the application permits (Section 4.8):

1. Confirm at least three diameters of point protrude beyond the far face.
2. Support the head side against a solid mass — an iron block or a heavy hammer head.
3. Bend the point over **across the grain**, not along it, and dress it flat into the surface.

NOTICE — clinching earns no design credit. See Section 4.8. In the NDS it is a penetration exemption for symmetric double-shear connections with nails of 0.148 in diameter or smaller, side members at least 3/8 in thick, nothing more.

7.8 Setting below the surface

Common nails are seated **flush** and are not normally set below the surface — that is the province of finish and casing nails. Where a common nail must be set:

- Use a **nail set** of the correct tip size, struck with a **ball pein or drilling hammer**, not a nail hammer (Section 5.3).
- Recognise that setting a full-head common nail crushes the fibres under the head and reduces its bearing.
- **Never do this on a structural connection.** See the overdriving rules in Section 10.2.

7.9 Pre-drilling

7.9.1 When

Trigger	US practice	Eurocode 5
Dense timber	Recommended; the NDS never makes it mandatory	Mandatory where $p_k > 500 \text{ kg/m}^3$ (8.3.1.1(2))
Large diameter	—	Mandatory where $d > 6 \text{ mm}$ (8.3.1.1(2))
Thin member	Judgement	Mandatory where thickness $< t = \max\{7d ; (13d - 30) \cdot p_k / 400\}$ (8.18)
Species sensitive to splitting	Judgement	Mandatory where thickness $< t = \max\{14d ; (13d - 30) \cdot p_k / 200\}$ (8.19). Named species: fir (<i>Abies alba</i>), Douglas fir (<i>Pseudotsuga menziesii</i>), spruce (<i>Picea abies</i>).
Near an end or edge	Recommended; reduces the required distances (Table 6-3)	Reduces the required distances (Table 8.2)
Splitting observed	<i>"If such splitting does occur, predrilling or a smaller nail should be used."</i>	—

Expression (8.19) may be replaced by (8.18) if $a_4 \geq 10d$ for $p_k \leq 420 \text{ kg/m}^3$, or $a_4 \geq 14d$ for $420 \leq p_k \leq 500 \text{ kg/m}^3$.

7.9.2 Lead hole diameter

NOTICE — the two codes express this rule in opposite forms. Read carefully.

NDS 12.1.6.3: *"Reference design values herein apply to nailed and spiked connections either with or without bored holes. When a bored hole is desired to prevent splitting of wood, the diameter of the bored hole shall not exceed 90% of the nail or spike diameter for wood with $G > 0.6$, nor 75% of the nail or spike diameter for wood with $G \leq 0.6$."*

Eurocode 5, 10.4.2(3): “The diameter of pre-drilled holes should not exceed 0,8d.”

Code	Condition	Maximum lead hole
NDS	$G > 0.6$ (dense)	90 % of D
NDS	$G \leq 0.6$	75 % of D
Eurocode 5	All	80 % of d

The NDS rule is the reverse of the common paraphrase. It is **90 % for dense wood** and 75 % for everything else — not the other way round. And both codes state a **maximum**, not a target.

Table 7-1 — Maximum lead hole diameters for the common sizes, NDS rule.

Nail	D (in)	Max lead hole, $G \leq 0.6$ (75 %)	Max lead hole, $G > 0.6$ (90 %)
6d	0.113	0.085	0.102
8d	0.131	0.098	0.118
10d	0.148	0.111	0.133
16d	0.162	0.122	0.146
20d	0.192	0.144	0.173

7.9.3 Effect on capacity

- **Under the NDS, pre-drilling changes nothing.** Reference design values “*apply to nailed and spiked connections either with or without bored holes.*” It is never mandatory and produces no design-value change. What it does change are the **recommended spacings** — Table 6-3’s prebored column is markedly less demanding.
- **Under Eurocode 5 it changes everything.** Pre-drilling gives a different embedment strength expression (8.16 rather than 8.15) and a different, less demanding spacing table.
- **The FPL reports a benefit in both withdrawal and stiffness:** “Nails driven into lead holes with a diameter slightly smaller (approximately 90 %) than the nail shank have somewhat greater withdrawal resistance than nails driven without lead holes. Lead holes also prevent or reduce splitting of the wood, particularly for dense species.” A 90 % lead hole also raises the elastic bearing constant from $k_0 = 2\,144\,000\text{ G}$ to $k_0 = 3\,200\,000\text{ G}$ — about **49 % more initial lateral bearing stiffness**. These are research findings, not design credits.
- Note that **ASTM D1761 uses no lead holes for nails**, so the tabulated test-derived values correspond to the not-prebored case.

7.9.4 Procedure

1. Select the drill from Table 7-1 or the Eurocode 0,8d rule, and **round down**.
2. Drill perpendicular to the surface, to a depth not exceeding the intended penetration. A hole deeper than the nail is a void.
3. Clear the swarf.
4. Drive normally. The nail should still require force; if it drops in, the hole is oversize and the joint has lost its clamp.

7.10 Adverse conditions

Condition	Effect	Response
Cold	Steel is less ductile; timber is stiffer and more brittle; the operator's grip and dexterity are reduced	Pre-drill more readily; expect more splitting; take more care over the set
Dense hardwood	High splitting risk; nails buckle	Pre-drill; consider a smaller diameter and more fasteners
Green or wet timber	Drives easily; withdrawal capacity will decay as it dries	Design for the seasoned condition; reduce lateral values by 25 % where the timber will remain wet or be loaded before seasoning; apply the Eurocode 5 8.3.2(8) factor of 2/3 to $f_{ax,k}$ and $f_{head,k}$
Knots	The nail deflects or bends abruptly	Do not nail into a knot. Move at least one shank diameter aside.
Engineered timber (LVL, PSL, glulam)	Higher density; higher splitting risk near edges	Follow the manufacturer's nailing schedule, which overrides generic guidance
Overhead	Poor control; debris falls into the eyes; recognised nail-gun risk factor	Eye protection is mandatory; reposition the work if at all possible
Galvanized nails	The coating adds diameter and friction; harder to drive	Expect it; do not compensate by hitting the head off-square

7.11 Post-drive inspection and acceptance

Table 7-2 — Acceptance criteria for a driven nail.

Criterion	Accept	Reject / remediate
Head seating	Flush , in firm contact all round	Standing proud → drive further. Below the surface → Section 10.2.
Shank alignment	Straight, at the intended angle	Bent, or angle materially wrong → withdraw and replace
Timber condition	No split at entry, edge or end	Any split → withdraw, reposition or pre-drill; record
Penetration	Meets the code minimum into the main member	Short → add a longer fastener; record
Point	Not protruding where protrusion is unacceptable	Protruding → clinch, or change to a shorter nail
Position	Within the scheduled spacing and edge/end distance	Out of position → add a correctly placed fastener; leave the misplaced one unless it splits the timber
Count	Matches the fastening schedule	Short count → complete it
Timber contact	Members drawn tight, no gap	Gap → the nail is holding the gap open. Dismantle, clamp, re- nail.

NOTICE — the code rule on seating is binary. IBC 2304.10.3: *“Sheathing nails or other approved sheathing connectors shall be driven so that their head or crown is flush with the surface of the sheathing.”* The wind and seismic provisions say the same: *“Nails shall be driven with the head of the nail flush with the surface of the sheathing.”* There is no tolerance band in the code. The quantitative allowances in Section 10.2 come from APA research, not from the code.

The IRC contains no equivalent provision — searches of IRC Chapter 6 for “flush” and “overdriven” return nothing.

Record acceptance against the fastening schedule. The inspection record form in Appendix G is suitable.

8 Removal and reversal

8.1 Extraction procedure

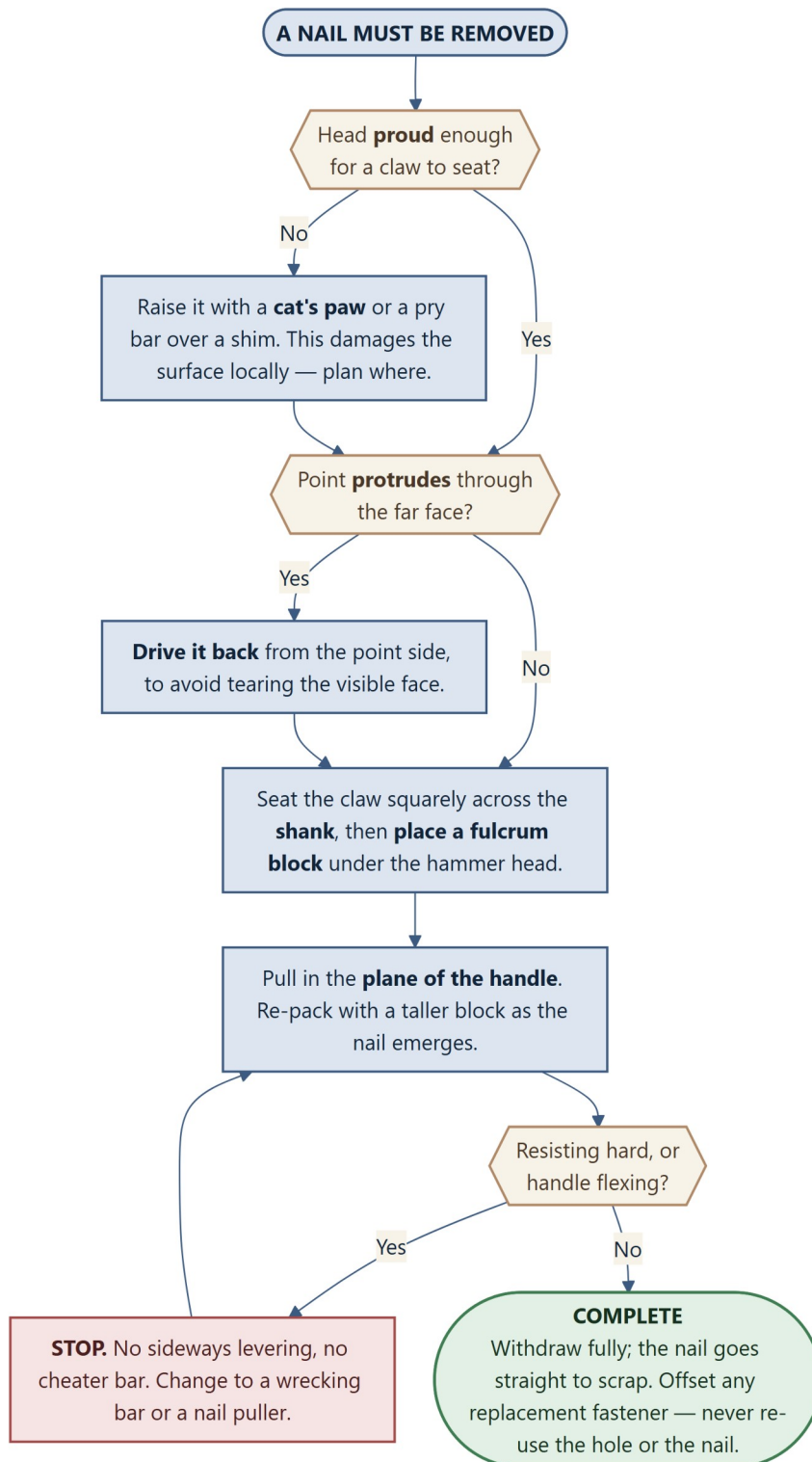


Figure 8-1 — Nail extraction decision and procedure.

8.2 The fulcrum block

The single most useful technique in nail removal, and the one most often skipped. The authoritative statement is from the US Army hand-tool manual:

"The claw end of the hammer is for pulling nails or prying boards. Slip the claw under the nail head as far as it will go, to prevent bending the head up." "Pull the handle to a vertical position to withdraw the nail." "For longer nails, place a block of wood under the head for better leverage."

A block of scrap timber under the hammer head does four things at once:

1. **Protects the work surface** from the crushing that the hammer head would otherwise cause.
2. **Increases leverage** by raising the pivot point.
3. **Extends the travel**, so a long nail comes out in one movement rather than three.
4. **Keeps the load in the plane of the handle**, which is the direction the handle is designed to take.

As the nail emerges, re-pack with a **taller** block rather than continuing to rotate the hammer to a steeper angle.

8.3 What a claw hammer may and may not pull

WARNING — a nail hammer is rated for unhardened nails only. The Hand Tools Institute: *"Nail hammers are intended for driving and pulling common, unhardened nails only, and for ripping apart wooden structures."*

Manufacturers' warranties define as misuse: *"Pulling (attempting to withdraw) hardened nails, screws, or nail sets", and for titanium heads, striking against "hardened steel tools (cats' paws, chisels, bolts, steel form stakes, and concrete form retainer pins, etc.)."* One BS 876-conforming hammer carries the instruction *"Do not use a claw hammer... for pulling out masonry nails."*

[VERIFY] — a commonly repeated warning that is not manufacturer-sourced. The instruction "never pry sideways with a claw hammer" is widely given, and it is sound engineering advice: the claw is designed to be loaded in the plane of the handle. However, **no manufacturer or Hand Tools Institute text warning against lateral prying could be found**, and at least one respected trade demonstration shows side prying being used deliberately. The side-related warnings that do exist concern **striking**, not prying: *"Never strike with or against the side, or cheek, of any hammer."*

The defensible position, and the one taken by this manual: pull in the plane of the handle because that is what the tool is designed for, and because manufacturers list *"crack in the claw section"* among their discard criteria. Do not attribute a lateral-loading prohibition to a manufacturer.

8.4 Dedicated pulling tools

Tool	Use	Standard
Cat's paw / nail puller	Driven under a flush or set head to raise it. Destructive to the surface.	ASME B107.410 (formerly B107.52)

Tool	Use	Standard
Pry bar / wrecking bar	Long-leverage extraction; dismantling	ASME B107.410
Nail kicker / punch	Driving nails back out from the point side	—
End-cutting nippers	Gripping and rolling out a headless or broken nail	—

Hand Tools Institute guidance on bars: proper use is *"to lift and move heavy objects and to pry where leverage is needed... also used to remove nails and spikes during wrecking operations."* Abuse is *"Never use like a striking tool or pound like a chisel. They should not be struck against metal, stone, or concrete. Do not add extensions or stand on bar for extra leverage. Do not use cracked or deformed bars."*

DANGER — a cat's paw is a hardened struck tool. It must be struck with a **ball pein or drilling hammer** whose face is at least 3/8 in larger in diameter than the struck face — **never with a nail hammer**. Striking a hardened cat's paw with a nail hammer chips the hammer face and throws fragments.

8.5 Repairing the workpiece

- Fill the hole only after confirming the joint will not be re-made through it.
- Where the surface has been crushed by the hammer or the puller, dress it back or accept and record the damage.
- **Do not re-use the original hole** for a replacement fastener. It has no clamp left. Offset the new nail by at least one shank diameter, respecting Section 6.7.

8.6 Re-use policy

NOTICE — a withdrawn nail is scrap, not stock.

A nail that has been driven and withdrawn has been:

- **cold-worked** at every point where it bent, whether or not the bend is visible;
- **scored** along the shank, damaging the surface that generated friction;
- **potentially cracked** at the head fillet;
- **stripped of coating** wherever the shank rubbed on the way in and on the way out.

Do not re-use a withdrawn nail in any structural joint. Put it in the scrap container immediately — not on the floor, and not back into the nail bag where it will be picked up again.

For temporary works — formwork, bracing, hoarding — re-use may be tolerated by site policy, but only for nails that are straight, uncorroded and were never bent. **Duplex (double-headed) nails exist precisely for that duty and should be used instead.**

9 In-service inspection and maintenance

9.1 Maintenance philosophy

The nail requires no maintenance. The joint does.

There is no lubrication, no adjustment, no torque check and no scheduled replacement. Everything in this section is about detecting a joint whose capacity has decayed, and restoring it.

The governing recommendation is from the FPL: *“Structural joints should be inspected at intervals, and if it is apparent that the joint has loosened during drying, the joint should be reinforced with additional nails.”*

Note the remedy — **add fasteners**. You cannot re-tighten a nail. Driving a proud nail back down does not restore the clamp; the timber that used to grip it has already moved.

9.2 Inspection intervals

Trigger	Timing	Scope
Post-installation	Before the work is closed up or covered	100 % against the fastening schedule
After the first heating season	The point of maximum shrinkage in framing	Visible framing joints; gypsum surfaces
Routine	Per the asset’s inspection regime	Visible structural connections
After an extreme event	Wind, seismic, flood, impact	All affected load paths
On any water ingress	Immediately, and again after drying	The wetted zone and its surroundings
Before alteration	Prior to any change of loading	The affected joints

9.3 Condition assessment

Table 9-1 — In-service condition criteria.

Observation	What it means	Action
Head standing proud, timber sound	Timber shrinkage has moved the member relative to the nail. The clamp has relaxed.	Do not simply re-drive. Assess the joint; add fasteners if structural.

Observation	What it means	Action
Rust staining around the head	Moisture has reached the fastener. Corrosion is under way and section is being lost.	Trace and stop the moisture source. Assess for section loss. Consider replacement with a correctly coated fastener.
Black staining in oak, cedar, redwood	Tannin reacting with iron. The shank is also being attacked.	Replace with stainless. Bright and even galvanized steel are the wrong specification here.
Split radiating from the nail	The holding mechanism has failed at that fastener.	Treat that nail as ineffective. Add a fastener clear of the split.
Visible gap between members	The joint never closed, or has opened.	Investigate. A nail cannot close a gap; something has to draw the members together.
Nail head crushed into the surface	Overdriven at installation, or subsequently.	Apply the rules of Section 10.2.
Member movement under load	The connection is yielding.	Structural assessment required. Do not simply add nails without understanding why.
Coating flaking or absent	The corrosion protection has failed.	Assess the environment and the remaining section.
Nail pop through a finish	See Section 9.4.	See Section 9.4.

9.4 Nail pop in gypsum finishes

9.4.1 Cause

Gypsum Association GA-222-2019, *Repairing Screw or Nail Pops*, lists the causes:

"Lumber shrinkage occurring after gypsum panel product application. Loose attachment of the gypsum panel product to the framing. Improperly aligned, twisted, bent, warped, or bowed framing. Incorrect fastener length. Improper fastening. Drywall construction adhesive shrinkage."

And the dominant one:

"Fastener pops are largely caused by lumber shrinkage due to initial high moisture content in the lumber. Overly long fastener length contributes to the problem. Use fasteners that provide the minimum recommended depth of penetration into framing members."

A major manufacturer's handbook names the mechanism "*nail creep*" — "*movement of nail resulting from lumber shrinkage... when shrinkage of the wood framing exposes nail shank and consequently loosens panel.*"

NOTE — a longer nail makes nail pop worse, not better. The pop is caused by the framing shrinking behind a fixed panel surface. The deeper the nail sits in the shrinking member, the more relative movement accumulates at the head. Use the **minimum** recommended penetration.

Prevention starts with the timber. Framing should be at **not more than 19 % moisture content** at the time of gypsum board application — the "dry lumber" definition in the US voluntary product standard PS 20-20, which the gypsum application standard incorporates by reference.

9.4.2 Remedy

GA-222-2019, verbatim:

"Fastener pops are repaired by reattaching the gypsum panel product to the framing by driving a new screw or nail of the proper length into the same framing member about 1-1/2 in. (40 mm) from the protruding fastener. Apply sufficient pressure to the gypsum panel to bring the back surface into firm contact with the framing member to which it is being reattached. Remove the fastener or reseal the protruding fastener so that it is just below the face of the gypsum panel. Remove any loose material before treating with joint compound and redecorating."

The offset is 1-1/2 in (40 mm). The frequently quoted "1.5 to 2 inches" is unsupported; GA-222 gives a single figure, and a major manufacturer's handbook independently gives the same 38 mm.

9.4.3 Timing

"Fastener pops that appear either before or during decoration should be repaired immediately. Those that appear one or more months into the heating season are usually a result of lumber shrinkage and should not be repaired until the end of the heating season."

Repairing mid-season simply invites a second pop, because the shrinkage is not finished.

9.4.4 What counts as a defect

Criterion	Source
<i>"Repairs usually are necessary only for pops which protrude 0.13 mm (0.005 in.) or more from face of board."</i>	Manufacturer's construction handbook
<i>"Nail pops are a defect only when there are signs of spackle compound cracking or falling away."</i> Corrective measure: <i>"One time only during the warranty period... Correcting the drywall near the end of the warranty period provides the consumer with the best possible solution."</i>	NAHB Residential Construction Performance Guidelines, 6th Ed., §10-6-2

Criterion	Source
<i>"Five or more nail pops within an area of 1 square metre is considered to be excessive."</i>	A Canadian provincial new-home warranty performance guide — cite as provincial guidance, not as a general standard

NOTICE — two frequent misattributions. GA-214 does **not** mention nail pops; do not cite it for this. GA-216 does **not** itself state a moisture-content limit; it cross-references PS 20. ASTM C840 is paywalled and its clause numbers are not quoted here.

9.5 Remediation of structural joints

1. **Establish the cause before adding fasteners.** A joint loosened by shrinkage needs different treatment from one overloaded or corroded.
2. **Add, do not replace.** Withdrawing an existing nail removes what capacity remains and disturbs the timber. Add supplementary fasteners alongside.
3. **Place the new fastener in sound timber,** clear of any split, respecting the spacings of Section 6.7.
4. **Consider a different fastener.** If the joint failed because a plain shank was used where withdrawal was the demand, adding more plain-shank nails repeats the error. Use a ring-shank nail, a screw, or a connector.
5. **Match the corrosion protection** to the environment as it has proved to be, not as it was assumed to be.
6. **Record the remediation** — location, cause, action, date, and who authorised it.

WARNING — where the connection is part of a designated lateral force resisting system, a shear wall, a diaphragm or a hold-down load path, **remediation is a design matter.** Refer it to the engineer of record.

10 Troubleshooting

10.1 Diagnostic tree — the nail will not go in straight

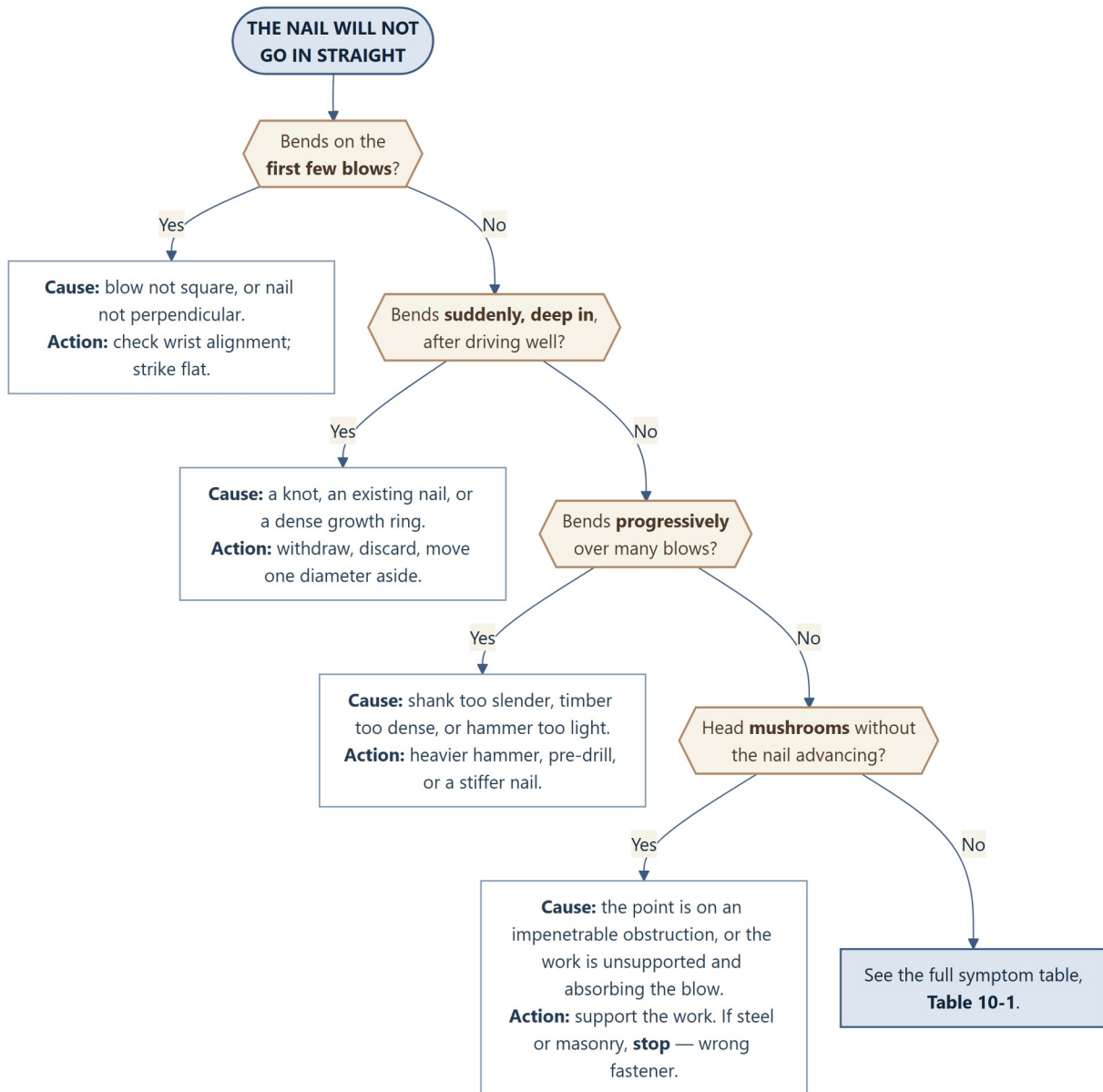


Figure 10-1 — Diagnostic tree for the most common driving fault.

10.2 Symptom table

Table 10-1 — Troubleshooting.

#	Symptom	Probable cause	Diagnostic	Corrective action	Prevention
1	Nail bends on the first blows	Blow not square; nail not perpendicular	Look at where the hammer face contacts the head	Withdraw, discard, restart	Strike square; watch the nail, not the hammer
2	Nail bends suddenly deep in	Knot, existing nail, or dense growth ring	Sudden change in resistance	Withdraw, discard, move $\geq 1 D$ aside	Read the grain; avoid knots
3	Nail bends progressively	Shank too slender; timber too dense; hammer too light	Gradual curvature over many blows	Heavier hammer, pre-drill, or stiffer nail	Match hammer mass to nail size (Section 6.5.1)
4	Head mushrooms, nail does not advance	Workpiece unsupported; point on an impenetrable obstruction	Does the work move on each blow?	Support the work solidly. If steel or masonry, stop	Back the work against a mass
5	Timber splits at the entry point	Diameter too large; too near an end or edge; timber dry or dense; nails on one grain line	Visible crack from the nail	Withdraw; pre-drill or reposition; add a fastener in sound timber	Pre-drill; drop a size or use a box nail; stagger rows; respect Section 6.7
6	Split appears later, not at driving	Timber drying and shrinking around the nail	Crack opens over weeks	Assess the joint; add fasteners in sound timber	Use seasoned timber; pre-drill
7	Head driven below the surface (overdriven)	Excessive final blow; nailer depth set too deep	Head crushed into the surface	See Section 10.3	Ease off the last two blows; set the nailer depth on scrap and re-check
8	Head stands proud	Insufficient final blow; nail bottomed out; obstruction	Head not in contact all round	One further controlled blow. If it will not go, investigate	—
9	Head proud months later (nail pop)	Timber shrinkage; nail too long; loose attachment	Appears through the finish, usually in	Section 9.4 — reattach 1-1/2 in away, reseal or	Framing MC ≤ 19 %; minimum recommended

#	Symptom	Probable cause	Diagnostic	Corrective action	Prevention
			the first heating season	remove the popped fastener	penetration
10	Head shears off	Defective head fillet; badly off-square blow; over-hard material	Clean break at the head	Withdraw the shank if possible; report the batch	Goods-in bend test; strike square
11	Point protrudes through the far face	Nail too long	Visible point	Change to a shorter nail. Clinch only if permitted (Section 4.8)	Check the length against the assembly thickness
12	Insufficient penetration	Nail too short; side member thicker than assumed	Measure the assembly	Longer nail, or add fasteners. Recall the p/10D reduction	Verify against Section 3.6.3
13	Rust staining soon after installation	Bright nail in a damp location; coating breached	Brown streaking from the head	Trace the moisture source; replace with the correct coating	Section 6.4
14	Black staining in oak or cedar	Tannin reacting with iron	Dark halo around the head	Replace with stainless	Specify stainless for tannin-rich species
15	Nail loosens under vibration	Plain shank in a vibrating assembly	Movement audible or visible	Replace with a ring-shank nail or a screw	Do not use a plain shank where vibration is expected
16	Joint gaps despite nailing	Members not drawn together before nailing	Feeler gauge; visual	Dismantle, clamp, re-nail	Clamp before nailing — a nail cannot close a gap
17	Nailer jams	Wrong collation; damaged fasteners; worn driver blade	Inspect the magazine	Disconnect the air supply , then clear	Correct collation; keep strips undamaged
18	Nailer double-fires	Contact actuation mode; recoil	Two nails from one intended shot	Switch to full sequential	Section 5.4

#	Symptom	Probable cause	Diagnostic	Corrective action	Prevention
19	Nailer drives inconsistently	Air pressure low or fluctuating; hose too long or too narrow; worn seals	Gauge at the tool, not at the compressor	Correct the supply	Maintain within the marked maximum pressure
20	Nail ricochets	Struck a hard feature; missed the workpiece	Nail found elsewhere	Stop; check for injury to anyone in the area	Eye protection; keep bystanders clear
21	Corrosion in treated timber	Wrong coating specified	White or brown corrosion product at the head	Replace with A153 Class D HDG or stainless	Section 6.4.1
22	Nails pull out over time	Plain shank loaded in withdrawal	Heads progressively proud	Redesign the connection. Adding more plain-shank nails repeats the error	Sections 3.9 and 6.3

10.3 Overdriven fasteners in sheathing

This deserves its own treatment because it is common, it reduces capacity, and **the codes give a rule but no tolerance.**

10.3.1 What the codes say

IBC 2304.10.3: *"Sheathing nails or other approved sheathing connectors shall be driven so that their head or crown is flush with the surface of the sheathing."*

The wind and seismic provisions repeat it: *"Nails shall be driven with the head of the nail flush with the surface of the sheathing."*

That is all. The commentary to the wind and seismic provisions does not use the word "overdriven" at all. An industry research report states the gap plainly:

"When overdriven fasteners are identified, there is no guidance in the International Building Code (IBC), International Residential Code (IRC) or ANSI/AWC National Design Specification for Wood Construction (NDS) as to what the capacity reduction is for the overdriven fasteners nor what corrective action could be taken to rectify the situation."

The mechanisms it identifies are reduced effective panel thickness, easier pull-through and tear-out at panel edges, and reduced resistance to panel buckling at intermediate framing.

10.3.2 The APA acceptance criteria

The quantitative rules come from **APA Technical Topics TT-012B, *Effect of Overdriven Fasteners on Shear Capacity*, Form No. TT-012B, revised December 2011** — an industry document, **not a code**.

No shear-capacity reduction need be taken if any one of the following applies:

#	Condition
(a)	<i>"If all nails are overdriven into panels by no greater than 1/16 inch during construction under dry conditions (moisture content less than 16 percent)."</i>
(b)	<i>"If no more than 20 percent of the fasteners around the perimeter of panels are overdriven by no greater than 1/8 inch, no reduction in shear capacity needs to be taken."</i>
(c)	All perimeter fasteners overdriven equally after the panels were wetted — the embedment may be attributed to panel thickness swelling. Verify by measurement.
(d)	The installed panel is thicker than the minimum nominal thickness the design shear is based on, and the overdrive does not exceed that difference. APA's worked example: 19/32 in installed where 15/32 in was required, all fasteners overdriven 1/8 in → net 15/32 in, acceptable.

Remedy where none of those applies:

*"If more than 20 percent of the fasteners around the perimeter of panels are overdriven by over 1/16 inch, or if any are overdriven by more than 1/8 inch, additional fasteners must be driven to maintain the required shear capacity. **For every two fasteners overdriven, one additional fastener must be driven.** If nails were used in the original installation, and are spaced too close to allow the placement of additional nails, then approved staples should be used..."*

NOTICE — APA publishes no percentage capacity reduction. TT-012B's logic is **binary**: either no reduction is required, or fasteners must be added at one extra per two overdriven. **Do not attribute a "% reduction" to APA.**

Percentage figures do exist, from a separate testing agency's model derived from published research on 8 × 8 ft walls in 7/16 in OSB: *"Recent studies indicate that overdriven nails reduce shear wall strength from 5 % to 22 % depending on the depth of the overdriven nail head."* Illustrative points from that model: 30 % of fasteners overdriven ≤ 1/16 in → about 3 %; 100 % overdriven ≤ 1/16 in → about 9 %; 20 % overdriven ≤ 1/8 in → about 3 %. **Attribute these to that agency, not to APA or to the code.**

[VERIFY] — whether TT-012 has been substantively revised after TT-012B (December 2011) could not be confirmed; one APA page showed an April 2020 revision date that could not be reconciled to a document face. No ICC-ES acceptance criterion setting an overdrive tolerance was found.

10.3.3 Field procedure

1. **Measure**, do not estimate. A depth gauge or a straightedge and feeler.
 2. **Count** the overdriven fasteners around the panel perimeter and express as a percentage.
 3. **Classify** against the four APA conditions above.
 4. If remediation is required, drive **one additional fastener for every two overdriven**, in sound material, respecting the spacings.
 5. **Record** the panel, the count, the depth and the remediation.
 6. **Fix the cause** — reset the nailer depth on a scrap of the same panel and re-verify. Depth-of-drive drifts with air pressure, temperature and panel density.
-

11 Decommissioning, disposal and recycling

11.1 Removal from service

1. Withdraw or drive back every nail in timber that is being removed. OSHA 29 CFR 1926.250(b)(8)(i):
"Used lumber shall have all nails withdrawn before stacking."
2. Where withdrawal is impractical, bend every protruding point flat.
3. Collect nails into a **closed, rigid, metal container** at the work face. Not a bag; not an open bucket.
4. Sweep the area and the access routes.

11.2 Recycling

Steel nails are fully recyclable and belong in the ferrous scrap stream.

From the World Steel Association's factsheet on scrap:

"Due to its inherent magnetism, steel is very easy to separate and recycle, making steel the most recycled material in the world."

"Every steel plant uses scrap as part of its raw materials mix, and therefore every steel plant is also a recycling plant." In blast-furnace steelmaking each basic-oxygen-furnace charge "typically contains 15%-25% scrap"; in electric steelmaking, "electrical energy is used to re-melt charges of up to 100% scrap."

"every tonne of scrap used for steel production avoids the emission of 1.5 tonnes of CO₂ and the consumption of 1.4 tonnes of iron ore, 740kg of coal and 120 kg of limestone."

"With a total of 720 Mt, ferrous scrap recycling constitutes the largest recycling activity in the world."

The USGS reports that the US scrap recycling rate *"has averaged between 80% and 90% during the past decade"*, with **98 % for structural steel from construction**, and that *"Recycling 1 ton of steel conserves 1.1 tons of iron ore, 0.6 ton of coking coal, and 0.05 ton of limestone."*

11.3 Contamination

NOTICE — copper is the tramp element that matters, and zinc coating is not the problem.

World Steel Association: *"The steelmaking process is able to remove most impurities that may be present in scrap steel. Hence 'downcycling' of steel scrap into lower quality products is not an issue for the steel industry in the same way it can be for glass and aluminium."*

"However, some elements, especially copper, cannot be removed during the steelmaking process. Elevated copper levels in steel can lead to a loss of ductility and resulting surface defects. Copper content is currently carefully managed through a combination of sorting and dilution."

Practical consequence: **keep copper and copper-clad nails out of the carbon steel scrap stream.**
Segregate stainless separately too — it has a higher value and is downgraded by mixing.

11.4 Waste classification

Under the US resource conservation regulations, scrap metal is defined at 40 CFR 261.1(c)(6):

"Scrap metal is bits and pieces of metal parts (e.g., bars, turnings, rods, sheets, wire) or metal pieces that may be combined together with bolts or soldering (e.g., radiators, scrap automobiles, railroad box cars), which when worn or superfluous can be recycled."

40 CFR 261.4(a)(13) excludes from the definition of solid waste *"Excluded scrap metal (processed scrap metal, unprocessed home scrap metal, and unprocessed prompt scrap metal) being recycled."* 40 CFR 261.6(a)(3)(ii) exempts scrap metal not already excluded from the generator, transporter and permitting requirements.

[VERIFY] — no source names nails specifically, and none asserts that ordinary carbon-steel nails are a characteristically hazardous waste. The conclusion that nails going to recycling are not hazardous waste is a reasonable inference from the scrap-metal definition, **not a sourced fact**. Confirm against local regulations. Note also that nails **embedded in preservative-treated or fire-retardant-treated timber** may be governed by the disposal rules for the timber, not for the metal.

11.5 Nails in treated or contaminated timber

- **Preservative-treated timber** is subject to its own disposal regime. Do not burn it, and follow the treatment supplier's disposal instructions.
 - **Timber with lead paint or asbestos-containing coatings** requires the relevant control regime before any dismantling begins.
 - Nails recovered from such timber carry the contamination with them. Handle and dispose of them with the timber unless they can be demonstrably cleaned.
-

12 Compliance and documentation

12.1 United States [US]

There is no CE-equivalent marking regime. Compliance is demonstrated by:

1. **Conformance to ASTM F1667/F1667M** for the product itself.
2. **Conformance to the fastening schedule** — IRC Table R602.3(1) or IBC Table 2304.10.2 for prescriptive work, or the engineer's drawings for designed work.
3. **Where design values are relied upon**, ordering to **ASTM F1667 Supplementary Requirement S1**, so that a minimum bending yield strength is guaranteed and the packaging carries the marking *"Engineered Construction Nails, ASTM F1667."*
4. **For treated timber**, conformance to IRC R317.3 / R317.3.1 or IBC 2304.10.6.1 — Section 6.4.1.

12.2 European Union [EU]

12.2.1 CE marking is mandatory

Structural dowel-type fasteners, including nails, are construction products covered by a harmonised standard. Under Regulation (EU) No 305/2011, the Construction Products Regulation:

Article 4(1): *"When a construction product is covered by a harmonised standard or conforms to a European Technical Assessment which has been issued for it, the manufacturer shall draw up a declaration of performance when such a product is placed on the market."*

Article 8(2): *"The CE marking shall be affixed to those construction products for which the manufacturer has drawn up a declaration of performance in accordance with Articles 4 and 6. If a declaration of performance has not been drawn up by the manufacturer in accordance with Articles 4 and 6, the CE marking shall not be affixed."*

The Article 5 derogations — individually manufactured non-series products for a single identified works, products manufactured on the construction site, and traditional or heritage manufacture — do not apply to industrially produced nails.

12.2.2 Which edition of EN 14592 is harmonised

NOTICE — the current CEN edition is not the harmonised edition, and only the harmonised edition may support a declaration of performance.

EN 14592:2008+A1:2012 is the edition cited in the Official Journal — Commission communication 2018/C 092/06, OJ C 92 of 9 March 2018, page C 92/177 — with a coexistence period that began 1 March 2013 and ended **1 July 2013**.

EN 14592:2022 exists — published by CEN in April 2022 and stated to replace EN 14592:2008+A1:2012 — but **has never been cited in the OJEU**, and does not appear in the Commission's consolidated summary list of harmonised standards.

The Commission's own guidance is explicit: *"Only those versions of standards which are formally cited in the Official Journal of the European Union (OJEU) may serve as the basis for drawing up the Declaration of Performance (DoP) for a construction product and affixing the CE marking to it... As long as the new version is not cited in the OJEU, the old standard is the only standard serving as the basis to draw up the DoP and to CE-mark the product. The manufacturer shall clearly indicate which version he uses to CE mark."*

CPR Article 17(5) puts it in law: *"from the date of the end of the coexistence period, the harmonised standard shall be the only means used for drawing up a declaration of performance for a construction product covered by it."*

For EU CE marking, the version to use is EN 14592:2008+A1:2012.

Regulation (EU) 2024/3110 repeals the CPR with effect from 8 January 2026, but Article 95(3) provides that harmonised standards cited under Article 17(5) and in force on that date *"shall remain valid under Regulation (EU) No 305/2011 until they are withdrawn by the Commission or otherwise repealed."* The EN 14592:2008+A1:2012 citation therefore survives into the new regime.

12.2.3 Assessment and verification of constancy of performance

System 3. The legal basis is Commission Decision 97/176/EC of 17 February 1997 on structural timber products and ancillaries. Its Annex I expressly lists *"Fasteners for structural timber products — Connectors for timber, split ring connectors, cylindrical steel and wood dowels, wood screws, threaded bolts, wood nails"*, and its Annex III assigns attestation **System 3** to them.

Under System 3 the manufacturer operates factory production control and carries out sampling, and a **notified laboratory** determines the product type by initial type testing. There is no notified certification body and no certificate; the declaration of performance names the notified test laboratory. Declarations of performance issued for nails under EN 14592:2008+A1:2012 confirm System 3 in practice.

NOTICE — do not confuse this with Commission Decision 97/638/EC, which assigns System 2+ but only to *"Shear plates, toothed-plate connectors, punched nail plates, nailing plates"* — the nail-plate family, not dowel-type fasteners.

[VERIFY] — Annex ZA of EN 14592:2008+A1:2012 was not read; the standard is paywalled. The System 3 determination rests on Decision 97/176/EC, which is the legally controlling instrument, plus multiple manufacturers' declarations of performance. Whether Annex ZA lists any characteristic under a different system was not confirmed. The contents of Table ZA.1, the Type 1 / Type 2 / Type 3 coating classification introduced in the 2022 edition, and the nail diameter range in scope are likewise unverified.

12.2.4 What the declaration of performance should tell you

For a structural nail: the harmonised standard and edition; the AVCP system; the notified laboratory; and the declared performances — characteristic yield moment M_y, R_k , characteristic withdrawal parameter $f_{ax,k}$, head pull-through parameter $f_{head,k}$, wire tensile strength f_u , and the corrosion protection expressed against the intended service class.

[VERIFY] — no declaration of performance for a **plain smooth round wire nail** declaring M_y, R_k , $f_{ax,k}$ and $f_{head,k}$ was located during preparation of this manual; those retrieved were for screws and bolts. Obtain the specific DoP for the nail being purchased.

12.3 United Kingdom [UK]

12.3.1 Great Britain

BS EN 14592:2008+A1:2012 is a designated standard for England, Wales and Scotland, appearing in the consolidated list of designated standards for construction products. **EN 14592:2022 is not designated.**

UKCA marking is not compulsory, and CE marking remains accepted. Government guidance states that *“The CE mark will continue to be available when placing construction products on the market in Great Britain”,* with no end date. The accepted markings for the GB market are **UKCA, or CE, or CE with UK(NI).**

Guidance also records that *“Upon EU Exit all existing harmonised European standards became UK ‘designated standards’”,* and that *“Where CE marking has been legitimately affixed, the product can continue to be supplied to the GB market. There is no need to affix UK marking in addition to CE marking. To affix the UK marking businesses must comply with all relevant requirements under the Construction Products Regulation 2011 as retained in UK law including that they use a UK approved body.”*

There is a specific enforcement position for System 3 products such as nails: the Office for Product Safety and Standards *“will not take enforcement action against any economic actor solely where the UKCA mark has been used on construction products tested by an EU recognised notified body for the purpose of CE marking, where this testing was done before 31 December 2022.”*

In practice: either UKCA marking against BS EN 14592:2008+A1:2012 through a UK approved body, or CE marking against EN 14592:2008+A1:2012 through an EU notified body. Both are accepted, with no current transition deadline.

12.3.2 Northern Ireland

Northern Ireland follows the EU rules. The EU CPR and the EU harmonised standards list apply, so **EN 14592:2008+A1:2012 as cited in OJ C 92** governs; the GB designated-standards list does not.

CE marking is required. The **UK(NI)** indication is added only where mandatory third-party conformity assessment was carried out by a UK approved body, and *“The UK(NI) indication is not permitted on its own — it must always accompany the EU conformity marking.”* Goods bearing UKCA alone are not accepted on the Northern Ireland market.

[VERIFY] — System 3 involves a notified **laboratory** for initial type testing rather than a certification body. Whether that constitutes “mandatory third-party conformity assessment” for the purpose of triggering UK(NI) marking is a judgement on which no explicit official statement was found.

12.4 Records to retain

Record	Retain for
Delivery note and product label, with batch reference	Life of the structure, or per the project quality plan

Record	Retain for
Declaration of performance [EU/UK]	As above
Receiving inspection record (Appendix G)	As above
Fastening schedule and any approved deviations	As above
Post-installation inspection record	As above
Overdriven-fastener assessment and remediation (Section 10.3)	As above
Non-conformance reports and their close-out	As above

Appendix A — Quick reference: the 16d common

Designation	16d common; F1667 NLCMS-11
Length	3½ in / 88,9 mm
Shank diameter	0.162 in / 4,11 mm — 8 Steel Wire Gauge
Head diameter	0.344 in / 8,74 mm
Head / point	Flat, full, often checkered / diamond
Length tolerance	±3/32 in → 3.4375 to 3.5625 in
Diameter tolerance	±0.004 in → 0.158 to 0.166 in
Head tolerance	±10 % → 0.310 to 0.378 in
Ductility	180° cold bend, no fracture, mandrel = nail diameter
Fyb (S1 only)	90 000 psi / 620 MPa minimum
Reduction term	Rd = KD = 2.2 (D ≤ 0.17 in)
Minimum penetration	6D = 0.97 in
Tabulation penetration	10D = 1.62 in
Withdrawal W	40 lb/in in DF-L; 26 lb/in in SPF
Lateral Z , single shear, 1½ in side member	141 lb DF-L; 120 lb SPF; 154 lb S. Pine; 122 lb Hem-Fir
Toe-nail Z / W	117 lb / 57 lb in DF-L (Ctn applied)
Toe-nail geometry	≈30° to the member, started ≈1.17 in from the end
Max lead hole	0.122 in (G ≤ 0.6); 0.146 in (G > 0.6)
Recommended end distance , not prebored, tension	15D = 2.43 in
Recommended edge distance , not prebored	2.5D = 0.41 in
Count	44–49 per lb (97–108 per kg) [VERIFY]

Designation	16d common; F1667 NLCMS-11
Default “galvanized”	A641 Class 1 = 0.35 oz/ft ² — not A153 Class D
Treated timber	A153 Class D HDG, stainless, silicon bronze or copper only

Appendix B — Unit conversions

Quantity	Conversion
Length	1 in = 25.4 mm exactly
Force	1 lbf = 4.448 N; 1 kN = 224.8 lbf
Force per length	1 lb/in = 0.1751 N/mm
Stress	1 psi = 6.895 kPa; 1 ksi = 6.895 MPa
Coating mass	1 oz/ft ² = 305.15 g/m ²
Coating thickness	1 mil = 25.4 μm
Zinc mass to thickness	1 oz/ft ² ≈ 43 μm (density 7.2 g/cm ³)
Mass	1 lb = 0.4536 kg; 1 kg = 2.2046 lb
Count	nails/kg = nails/lb × 2.2046
Density	1 lb/ft ³ = 16.018 kg/m ³
Specific gravity to density	ρ (kg/m ³) ≈ G × 1000
Pressure	1 psi = 6.895 kPa = 0.0689 bar

Estimating pieces per kg from geometry. For a plain shank of diameter d (mm) and length L (mm), ignoring the head:

$$\text{pieces/kg} \approx 1\,000\,000 / (\pi/4 \cdot d^2 \cdot L \cdot 0.00785)$$

The result is a few per cent high because the head is ignored. Use it as a sanity check on catalogue figures — Section 3.2.2 shows two published rows that fail it.

Appendix C — Worked examples

C.1 Withdrawal capacity [US]

A 16d common is driven 2 in into the side grain of Douglas Fir-Larch. Normal load duration, dry service, face nailed. What is the withdrawal design value?

Step	Working
1. Reference value	Table 12.2C at D = 0.162 in, G = 0.50 → W = 40 lb per inch of penetration
	Check: $W = 1380 \times 0.50^{2.5} \times 0.162 = 1380 \times 0.17678 \times 0.162 = \mathbf{39.5 \text{ lb/in}}$ ✓
2. Total	$W \times p = 40 \times 2 = \mathbf{80 \text{ lb}}$
3. Adjustments	CD = 1.0, CM = 1.0, Ct = 1.0, Ceg = 1.0 (side grain), Ctn = 1.0 (not toe-nailed)
Result	W' = 80 lb

Same nail, toe-nailed: Ctn = 0.67 → W' = **54 lb**, and CM does not apply.

Same nail into end grain: Ceg = **0.0** → W' = **0 lb**. The joint has no rated withdrawal capacity at all.

C.2 Lateral capacity [US]

A 16d common in single shear, 1½ in DF-L side member into a DF-L main member. Normal load duration, dry service.

Step	Working
1. Reference Z	Table 12N, ts = 1½ in, DF-L → Z = 141 lb
2. Check penetration	Available = 3.5 – 1.5 = 2.0 in. Tabulation basis 10D = 1.62 in. 2.0 > 1.62 → no reduction
3. Adjustments	CD = 1.0, CM = 1.0, Ct = 1.0, Cg = 1.0, CA = 1.0 (D < ¼ in), Ceg = 1.0, Cdi = 1.0, Ctn = 1.0
Result	Z' = 141 lb per nail

Variation — a 1 in side member: available penetration = 2.5 in, still above 1.62 in, but Table 12N gives Z = 141 lb at ts = 1 in as well. Result unchanged.

Variation — penetration reduced to 1.2 in: 1.2 in > 6D (0.97 in) so the connection is valid, but 1.2 < 1.62, so multiply by $p/10D = 1.2/1.62 = 0.74 \rightarrow Z = 141 \times 0.74 = \mathbf{104 \text{ lb}}$.

Variation — toe-nailed: $C_{tn} = 0.83$. The AWC design aid gives **117 lb** for DF-L with C_{tn} applied.

C.3 Yield moment [EU/UK]

A 4,0 mm round smooth nail, wire tensile strength declared as $f_u = 700 \text{ N/mm}^2$.

$$M_{y,Rk} = 0,3 \cdot f_u \cdot d^{2,6} = 0,3 \times 700 \times 4,0^{2,6}$$

$$4,0^{2,6} = e^{(2,6 \times \ln 4,0)} = e^{(2,6 \times 1,3863)} = e^{3,6044} = \mathbf{36,76}$$

$$M_{y,Rk} = 0,3 \times 700 \times 36,76 = \mathbf{7\,720 \text{ N}\cdot\text{mm}} \text{ (7,72 N}\cdot\text{m)}$$

Check the validity condition: $f_u = 700 \geq 600 \text{ N/mm}^2 \checkmark$. Had the declared f_u been below 600, expression (8.14) would not apply at all.

C.4 Axial capacity [EU/UK]

The same 4,0 mm nail, head diameter $d_h = 8,4 \text{ mm}$ (Table 3-4), in timber of $\rho_k = 350 \text{ kg/m}^3$. Headside member $t = 22 \text{ mm}$; pointside penetration $t_{pen} = 50 \text{ mm}$.

Step	Working
Withdrawal parameter	$f_{ax,k} = 20 \times 10^{-6} \times 350^2 = 20 \times 10^{-6} \times 122\,500 = \mathbf{2,45 \text{ N/mm}^2}$
Head pull-through	$f_{head,k} = 70 \times 10^{-6} \times 350^2 = \mathbf{8,58 \text{ N/mm}^2}$
Penetration check	$12 d = 48 \text{ mm}$. $t_{pen} = 50 \text{ mm} \geq 48 \text{ mm} \rightarrow \mathbf{\text{no reduction factor}}$
Expression (a) — shank pull-out	$2,45 \times 4,0 \times 50 = \mathbf{490 \text{ N}}$
Expression (b) — shank + head	$(2,45 \times 4,0 \times 22) + (8,58 \times 8,4^2) = 215,6 + 605,4 = \mathbf{821 \text{ N}}$
F_{ax,Rk} = the smaller	490 N

Variation — t_{pen} reduced to 40 mm: $40 < 48$, so apply $(t_{pen}/4d - 2) = (40/16 - 2) = 0,50$. Expression (a) becomes $2,45 \times 4,0 \times 40 \times 0,50 = \mathbf{196 \text{ N}}$. Note that 40 mm still exceeds the $8 d = 32 \text{ mm}$ absolute minimum, so the connection remains valid — but at 40 % of the capacity.

Variation — timber installed near fibre saturation and drying under load: multiply both $f_{ax,k}$ and $f_{head,k}$ by **2/3** per 8.3.2(8).

Reminder. Clause 8.3.2(1)P prohibits the use of smooth nails to resist **permanent or long-term** axial loading, whatever these numbers say.

C.5 Choosing a length

Fixing a 19 mm board to a 45 mm joist. What length of metric round wire nail?

Step	Working
Required pointside penetration	8 d for a smooth nail
Try d = 3,1 mm	$8 \times 3,1 = 24,8 \text{ mm}$
Minimum length	$19 + 24,8 = \mathbf{43,8 \text{ mm}}$
Available without breaking through	$19 + 45 = 64 \text{ mm}$
Selection	3,1 × 50 mm or 3,1 × 60 mm
Check spacing	$p_k \leq 420$, no pre-drilling: $a_{4,c} = 5d = 15,5 \text{ mm}$ minimum edge distance; $a_{3,c} = 10d = 31 \text{ mm}$ minimum unloaded end distance
Check pre-drilling	$d = 3,1 \text{ mm} < 6 \text{ mm}$ and $p_k \leq 500 \rightarrow$ not mandatory. Check (8.18): $t = \max\{7 \times 3,1 ; (13 \times 3,1 - 30) \times 420/400\} = \max\{21,7 ; 10,8\} = 21,7 \text{ mm}$. The 19 mm board is thinner than 21,7 mm → pre-drilling is required.

Note the result. A routine-looking 19 mm board triggers the Eurocode pre-drilling rule. Run expression (8.18) before assuming pre-drilling is optional.

Appendix D — IRC prescriptive fastening schedule, selected rows [US]

Extracted from **IRC Table R602.3(1) — FASTENING SCHEDULE**, 2021 edition. Rows checked against the 2024 edition were identical.

Item	Building element	Number and type of fastener	Spacing and location
2	Ceiling joists to top plate	4-8d box (2½"×0.113"); or 3-8d common (2½"×0.131"); or 3-10d box (3"×0.128"); or 3-3"×0.131" nails	Per joist, toe nail
6	Rafter or roof truss to plate	3-16d box (3½"×0.135"); or 3-10d common (3"×0.148"); or 4-10d box (3"×0.128"); or 4-3"×0.131" nails	2 toe nails on one side and 1 toe nail on the opposite side of each rafter or truss
8	Stud to stud (not at braced wall panels)	16d common (3½"×0.162")	24" o.c. face nail
		10d box (3"×0.128"); or 3"×0.131" nails	16" o.c. face nail
9	Stud to stud, and abutting studs at intersecting wall corners (at braced wall panels)	16d box (3½"×0.135"); or 3"×0.131" nails	12" o.c. face nail
		16d common (3½"×0.162")	16" o.c. face nail
10	Built-up header, 2" to 2" with ½" spacer	16d common (3½"×0.162")	16" o.c. each edge , face nail
		16d box (3½"×0.135")	12" o.c. each edge, face nail
13	Top plate to top plate	16d common (3½"×0.162")	16" o.c. face nail

Item	Building element	Number and type of fastener	Spacing and location
		10d box (3"×0.128"); or 3"×0.131" nails	12" o.c. face nail
14	Double top plate splice	8-16d common (3½"×0.162") ; or 12-16d box; or 12-10d box; or 12-3"×0.131" nails	Face nail each side of the end joint, minimum 24" lap splice each side
15	Bottom plate to joist, rim joist, band joist or blocking (not at braced wall panels)	16d common (3½"×0.162")	16" o.c. face nail
		16d box (3½"×0.135"); or 3"×0.131" nails	12" o.c. face nail
16	Bottom plate to joist / rim / band / blocking (at braced wall panel)	3-16d box (3½"×0.135"); or 2-16d common (3½"×0.162") ; or 4-3"×0.131" nails	16" o.c. face nail
17	Top or bottom plate to stud	4-8d box (2½"×0.113"); or 3-16d box (3½"×0.135"); or 4-8d common (2½"×0.131"); or 4-10d box; or 4-3"×0.131" nails	Toe nail
		3-16d box (3½"×0.135"); or 2-16d common (3½"×0.162") ; or 3-10d box; or 3-3"×0.131" nails	End nail

Wood structural panel sheathing (edges / intermediate supports, inches):

Item	Panel thickness	Fastener	Spacing
31	3/8"–1/2"	6d common or deformed	6 / 12

Item	Panel thickness	Fastener	Spacing
		(2"×0.113"×0.266" head), or 2⅜"×0.113"×0.266" head nail — subfloor and wall	
		8d common (2½"×0.131") or RSRS-01 (2⅜"×0.113") — roof	6 / 6
32	19/32"–3/4"	8d common — subfloor and wall	6 / 12
		8d common or RSRS-01 — roof	6 / 6
33	7/8"–1¼"	10d common (3"×0.148"), or 2½"×0.131"×0.281" head deformed	6 / 12

Relevant footnotes: (c) "Nails shall be spaced at not more than 6 inches on center at all supports where spans are 48 inches or greater." (f) For roof sheathing attached to gable end framing and to intermediate supports within 48 in of roof edges and ridges, nails at **4 inches on center** where the ultimate design wind speed exceeds 130 mph in Exposure B or 110 mph in Exposure C. Item 6 footnote (i) allows the opposite-side toe nail to be omitted where a rafter is fastened to an adjacent parallel ceiling joist in accordance with the schedule.

NOTICE — read this appendix as an illustration, not as the code.

- It is an **extract**. Use the full table from the adopted edition.
- **Exterior wood structural panel wall sheathing is not in this table** — the table header directs to **Table R602.3(3)**, which is keyed to wind speed and exposure.
- **[VERIFY]** — the primary code text could not be fetched directly; these rows come from reproductions of state-adopted editions, cross-checked against each other with no differences found. Verify against a licensed copy before contractual use.
- **[VERIFY]** — the 2024 IRC sheathing sub-rows and footnotes were not verified verbatim.
- **"Stud to sole plate" and "built-up corner studs" are legacy row titles** from the 2009 and earlier editions. In 2021 and 2024 they are Items 17 and 8/9.

Appendix E — Standards register

E.1 Product and material

Reference	Title	Note
ASTM F1667/F1667M-21a	Standard Specification for Driven Fasteners: Nails, Spikes, and Staples	The governing US product standard. Committee F16, Subcommittee F16.05. Originally approved 1995.
ASTM F547-22	Standard Terminology of Nails for Use with Wood and Wood-Base Materials	
ASTM F680-20	Standard Test Methods for Nails	Dimensional, tension, bend, impact bend, hardness, coating weight, coating adherence
ASTM F1575/F1575M-24	Determining Bending Yield Moment of Nails, Spikes, and Dowel-type Threaded Fasteners	Basis of F1667 Supplementary Requirement S1
ASTM A510/A510M-20	General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel, and Alloy Steel	Table 1 is the Steel Wire Gauge
EN 10230-1:1999	Steel wire nails — Part 1: Loose nails for general applications	BS EN 10230-1:2000; DIN EN 10230-1:2000-01
DIN 1151:1973-04	Drahtstifte, Senkkopf	Withdrawn , replaced by EN 10230-1
EN 14592:2008+A1:2012	Timber structures — Dowel-type fasteners — Requirements	The harmonised edition
EN 14592:2022	Timber structures — Dowel-type fasteners — Requirements	Current CEN edition; not cited in the OJEU
EN ISO 16120-2:2017	Non-alloy steel wire rod for conversion to wire — Specific requirements for general purpose wire rod	Superseded EN 10016-2

Reference	Title	Note
EN 1382 / EN 1383 / EN 409 / EN 14358 / EN 15737	Withdrawal capacity / pull-through resistance / yield moment / statistical derivation / torsional resistance	The EN 14592 test suite

E.2 Coatings

Reference	Title	Note
ASTM A153/A153M-23	Zinc Coating (Hot-Dip) on Iron and Steel Hardware	Class D is the nail class
ASTM A641/A641M-19(2025)	Zinc-Coated (Galvanized) Carbon Steel Wire	Class 1 is the F1667 default; Class 3S matches A153 Class D
ASTM B695-21	Coatings of Zinc Mechanically Deposited on Iron and Steel	Class 40 default; Class 55 where the code permits mechanical deposition
ASTM B633-23	Electrodeposited Coatings of Zinc on Iron and Steel	Excludes wire; not cited by F1667
ASTM A653	—	Type G185 referenced by IRC R317.3.1 for connectors
EN ISO 1461:2022	Hot dip galvanized coatings on fabricated iron and steel articles	Excludes continuously galvanized wire
ISO 2081:2025	Electroplated coatings of zinc with supplementary treatments on iron or steel	Basis of the Eurocode 5 Table 4.1 Fe/Zn designations
EN ISO 4042	Fasteners — Electroplated coating systems	The fastener-specific electroplating standard
EN 10346	—	Supersedes EN 10147, which Eurocode 5 Table 4.1 still cites

E.3 Design and construction

Reference	Title	Note
AWC NDS for Wood Construction	National Design Specification	2024 edition, ANSI-approved 16 October 2023, referenced in the 2024 IBC. [VERIFY] the exact designation string "ANSI/AWC NDS-2024". Verbatim clause text quoted in this manual is from NDS-2015 plus the official 2018 Commentary; section numbers were independently confirmed for 2024 where noted.
AWC SDPWS	Special Design Provisions for Wind and Seismic	Flush-driving requirement at §4.2.7.3 (2021)
IRC	International Residential Code	2024 published; 2021 most widely adopted. Table R602.3(1) FASTENING SCHEDULE ; R317.3; R317.3.1
IBC	International Building Code	Table 2304.10.2; §2304.10.3 flush driving; §2304.10.6.1 treated timber
EN 1995-1-1	Eurocode 5: Design of timber structures	+A1:2008 quoted here; +A2:2014 current first generation; BS EN 1995-1-1:2025 published; first generation withdrawn 30 March 2028
ASTM D1761-20(2025)	Test Methods for Mechanical Fasteners in Wood and Wood-Based Materials	Withdrawal and lateral resistance
ASTM D1037 §15	—	Nail-head pull-through
AWPA E12	Determining Corrosion of Metal in Contact with Treated Wood	Comparative, not predictive
PS 20-20	American Softwood Lumber Standard	"Dry lumber" not more than 19 % MC
APA TT-012B	Effect of Overdriven Fasteners on	December 2011. Industry

Reference	Title	Note
	Shear Capacity	document, not code.
GA-222-2019	Repairing Screw or Nail Pops	Gypsum Association
FPL-GTR-282 / -220 / -227	Wood Handbook Ch. 8; corrosion of fasteners in treated wood; materials selection for copper-treated wood	US Forest Products Laboratory

E.4 Safety and tools

Reference	Title	Note
ANSI/ISANTA SNT-101, 2024	Safety Requirements for Portable Compressed-Air-Actuated Fastener Driving Tools	Approved 19 Sep 2024, effective 19 Sep 2025. The 2015 edition is freely published.
ISO 11148-13:2017	Hand-held non-electric power tool — Safety Requirements — Part 13: Fastener driving tools	
ANSI/ISEA Z87.1-2025	Occupational and Educational Personal Eye and Face Protection Devices	Sixth revision, published 8 Jan 2026. OSHA still incorporates the 2010 and older editions.
EN 166:2001	Personal eye-protection — Specifications	BS EN 166:2002
ASME B107.400-2018 (R2023)	Striking Tools	Supersedes B107.41 Nail Hammers
ASME B107.410-2018 (R2023)	Struck Tools	Nail sets, nail-puller bars, pry bars
BS 876:1995	Specification for hand hammers	Current
ANSI/HTI B173.1	Safety Requirements for Nail Hammers	[VERIFY]
29 CFR 1910.133 / 1926.102	Eye and face protection	
29 CFR 1926.300, .301, .302(b)	Tool safety; pneumatic power tools	

Reference	Title	Note
29 CFR 1926.25; 1926.250(b)(8)(i)	Housekeeping; nails withdrawn before stacking	
DHHS (NIOSH) 2011-202 / OSHA 3459	Nail Gun Safety: A Guide for Construction Contractors	
OSHA Publication 3080	Hand and Power Tools	
CDC tetanus clinical guidance	Wound management and TIG indications	Updated 10 June 2025

E.5 Regulatory

Reference	Title
Regulation (EU) No 305/2011	Construction Products Regulation
Regulation (EU) 2024/3110	The replacement CPR, applying from 8 January 2026
Commission communication 2018/C 092/06, OJ C 92, 9.3.2018	Publication of harmonised standard references — the EN 14592 citation at p. C 92/177
Commission Decision 97/176/EC	Structural timber products and ancillaries — AVCP System 3 for wood nails
Commission Decision 97/638/EC	Nail plates and similar — System 2+. Not applicable to nails.
40 CFR 261.1(c)(6), 261.4(a)(13), 261.6(a)(3)	Scrap metal definitions and exclusions

Appendix F — Glossary

Term	Definition
Bright	Uncoated, as-formed steel. No corrosion protection whatever.
Box nail	Same length as a common of the same penny size, thinner shank. Splits less; carries less.
Cement coated	A resin coating applied by tumbling or immersion that increases withdrawal holding strength. Not corrosion protection.
Clinching	Bending the protruding point over. Increases withdrawal resistance; earns no code design credit.
Common nail	Heaviest-gauge flat-head plain-shank nail for a given length. The subject of this manual.
Countersunk head	A head shaped to pull down flush or slightly below the surface. The DIN 1151 Form B and the US sinker.
CA (geometry factor)	NDS adjustment for fastener geometry. Always 1.0 for D < ¼ in.
Ceg (end grain factor)	NDS adjustment for end-grain loading. 0.0 for nails in withdrawal; 0.67 for lateral.
Ctn (toe-nail factor)	0.67 for withdrawal, 0.83 for lateral.
d (penny)	The US length designation, from <i>denarius</i> . Fixes length only, never diameter.
d / D (diameter)	Nominal shank diameter, measured away from gripper marks and clear of coating.
Diamond point	The four-facet ground point standard on common nails.
DoP	Declaration of Performance. The document underpinning CE marking under the CPR.
Dowel bearing strength (Fe)	The timber's resistance to a dowel bearing

Term	Definition
	sideways against the hole wall. Fe = 16 600 G^{1.84} for D < ¼ in.
Drahtstift	German for wire nail.
Embedment strength (fh,k)	The Eurocode 5 equivalent of dowel bearing strength.
End nailing	Driving through the face of one member into the end grain of another.
Face nailing	Driving perpendicular through the face of one member into another.
Fyb	Bending yield strength of the fastener. Only guaranteed if ordered to ASTM F1667 Supplementary Requirement S1.
Fulcrum block	A block placed under the hammer head during extraction, to protect the surface and increase leverage.
HDG	Hot-dip galvanized. For nails, ASTM A153 Class D .
Head pull-through	Failure by the head being dragged through the side member. A distinct check from shank pull-out.
Lead hole / pilot hole	A pre-drilled hole to prevent splitting. Maximum 75 % or 90 % of D (NDS) or 0,8d (Eurocode 5).
My,Rk	Characteristic yield moment of the fastener (Eurocode 5).
Nail pop	A fastener head protruding through a gypsum finish, usually caused by lumber shrinkage.
Overdriven	Head driven below the surface of the sheathing. See Section 10.3.
PIN	Part Identifying Number — the ASTM F1667 designation system, e.g. F1667 NLCMS-11.
Plain / smooth shank	An undeformed cylindrical shank. This product.
Ring shank	An annularly deformed shank, for high withdrawal

Term	Definition
	resistance.
Service class	Eurocode 5 classification of the moisture environment, 1 (dry) to 3 (exposed).
Sinker	Shorter than the nominal penny length, thinner than a common, countersunk head, usually coated.
Specific gravity (G)	Relative density of the timber. Dominates withdrawal capacity as $G^{2.5}$.
Steel Wire Gauge	The Washburn & Moen gauge, tabulated in ASTM A510 Table 1. Higher number = thinner wire.
Toe nailing	Driving at an angle, nominally 30°, started one third of the nail length from the member end.
Withdrawal (W)	Axial resistance to being pulled straight out, in lb per inch of penetration.
Yield mode	One of six mechanisms (Im, Is, II, IIIIm, IIIs, IV) by which a laterally loaded dowel connection fails.

Appendix G — Inspection record forms

G.1 Receiving inspection

Field	Entry
Date received	
Supplier / order reference	
Product described on label	
Nominal size — length × diameter	
Type — common / box / sinker	
Coating and class	
Governing product standard	
Batch / lot reference	
DoP reference [EU/UK]	
Quantity received	
Sample size drawn	
Check 1 — documentation complete and matches order	Pass / Fail
Check 2 — length within tolerance (measured)	Pass / Fail
Check 2 — shank diameter within tolerance (measured)	Pass / Fail
Check 2 — head diameter within tolerance (measured)	Pass / Fail
Check 3 — visual: heads, points, shanks, coating	Pass / Fail
Check 4 — cold bend test, where specified	Pass / Fail / N/A
Disposition	Accept / Quarantine / Reject
Carton marked with batch reference and date	Yes / No

Field	Entry
Inspected by / date	

G.2 Post-installation inspection

Field	Entry
Location / element / grid reference	
Fastening schedule reference	
Specified fastener — size, type, coating	
Fastener actually used	
Specified count and spacing	
Actual count and spacing	
Method — face / toe / end	
Head seating: flush / proud / overdriven — number of each	
Overdriven assessment per Section 10.3, if applicable	
Splits observed — number and location	
Penetration verified	Yes / No / N/A
Members drawn tight, no gap	Yes / No
Remedial action taken	
Disposition	Accept / Remediate / Reject
Inspected by / date	
Countersigned	

G.3 Non-conformance record

Field	Entry
NCR number	
Date raised / raised by	
Location	
Description of non-conformance	
Standard or schedule clause not met	
Immediate action	
Root cause	
Corrective action	
Preventive action	
Design authority consulted	Yes / No — name
Closed by / date	

Appendix H — [VERIFY] register

Every item below is believed correct and is in general circulation, but the primary source could not be read directly during preparation of this manual — in most cases because the standard is behind a paywall or the publisher blocks automated access. **Confirm each against the purchased standard before contractual or design use.**

H.1 Product identification and dimensions

#	Item	Section	What is unverified	How to resolve
1	ASTM F1667 PIN suffix letters — B, Z, C	2.5.2	The key is strongly implied by defence and distributor records (B = bright, Z = zinc, C = cement) but is not confirmed from the standard's text	Purchase ASTM F1667/F1667M-21a
2	EN 10230-1 nail type numbers	2.5.3	Which type number denotes the round plain-shank flat-head nail	Purchase EN 10230-1:1999
3	EN 10230-1 designation string format	2.5.3	The formal designation syntax	Purchase EN 10230-1:1999
4	EN 10230-1 tolerance classes	2.5.3, 3.3	Tolerance classes and their numeric limits on d and L	Purchase EN 10230-1:1999
5	EN 10230-1 Table 1 d / Dh values	3.2.1	Single-sourced, with a known non-monotonic anomaly at d = 3,4 giving 7,7 followed by d = 3,8 giving 7,6	Purchase EN 10230-1:1999

#	Item	Section	What is unverified	How to resolve
6	Existence of "DIN 1151-1"	2.5.3	Frequently cited; only DIN 1151:1973-04 is documented	DIN Media catalogue search
7	Table 3-1 rows for 2d, 3d, 5d, 9d	3.1.1	Not in NDS Table L4; taken from a manufacturer catalogue and a defence stock cross-reference	Purchase ASTM F1667
8	3d shank diameter and gauge	3.1.1	Trade labels 0.083 in as "14 ga"; the true Washburn and Moen value is 13¾ ga	Purchase ASTM F1667
9	60d head diameter	3.1.1	NDS gives 0.531 in; some manufacturer tables give 0.500 in	Cross-check NDS Table L4 and F1667
10	Count per pound, all values	3.1.3	Not a specified requirement; three published sources differ by up to 25 %	Supplier's own figure for the specific product
11	Metric pieces per kg	3.2.2	Two published rows fail the shank-volume check and are omitted here	Supplier data, sanity-checked against Appendix B

H.2 Material and mechanical

#	Item	Section	What is unverified	How to resolve
12	Nail wire tensile strength 350–450 MPa	2.7.2	Trade guidance from nail-machine builders, not a specification	Manufacturer mill certificate or DoP
13	Hardness of a finished bright common nail	3.5.3	No published value found; F1667 sets no hardness requirement for unhardened nails	Manufacturer testing to ASTM F680 §9
14	Which wire standard EN 10230-1 nominates	2.7.4	Not established	Purchase EN 10230-1:1999
15	ASTM F1667 clause 9.1 workmanship wording	6.1.1	Read in the 2005 edition; currency in F1667/F1667M-21 a not confirmed	Purchase ASTM F1667/F1667M-21 a

H.3 Coatings

#	Item	Section	What is unverified	How to resolve
16	EN ISO 1461 coating tables	2.8.2	Values in circulation are from the 2009 edition; the 2022 edition is stated to have revised thickness requirements	Purchase EN ISO 1461:2022
17	Meaning of the “c” suffix in Fe/Zn 12c	2.8.2	The supplementary conversion treatment designation was	Purchase ISO 2081:2025

#	Item	Section	What is unverified	How to resolve
			not confirmed against ISO 2081	
18	EN 14592 Type 1 / Type 2 / Type 3 coating classification	12.2.3	Annex F of the 2022 edition is normative and concerns Type 3 coatings, but the type definitions are paywalled	Purchase EN 14592:2022
19	Minimum coating masses inside EN 14592	12.2.3	Not read	Purchase EN 14592

H.4 Design values and codes

#	Item	Section	What is unverified	How to resolve
20	The designation string "ANSI/AWC NDS-2024"	E.3	Title and approval date (16 Oct 2023) are verified; the exact ANSI designation format is inferred from the 2005 and 2015 covers	AWC publication cover page
21	Verbatim 2024 NDS text for §12.1.6.x, §12.2.3.5, §12.5.4 and Tables 12N / 12.2C / 12.3.3	3.6	Quotations are verbatim NDS-2015 plus the official 2018 Commentary. Section numbers 12.2.3.1, Eq. 12.2-3, Table L4, Table 11.3.1 and §12.1.6.3 are independently	Purchase the 2024 NDS

#	Item	Section	What is unverified	How to resolve
			confirmed for 2024	
22	The 2018/2024 clause number for the bored-hole rule	7.9.2	Quoted as NDS-2015 §12.1.6.3; probably §12.1.6.2 after the 2018 renumbering	Purchase the 2024 NDS
23	NDS Commentary Table C12.1.6.6 numbering	6.7.1	The printed 2018 Commentary is internally inconsistent; AWC errata renumber it	Check your specific printing plus current errata
24	IRC Table R602.3(1) primary text	Appendix D	The code publisher blocks automated access; rows come from cross-checked reproductions of state-adopted editions	Licensed ICC copy
25	2024 IRC sheathing sub-rows and footnotes a to i	Appendix D	Not verified verbatim; the 2021 values are given	Licensed ICC copy
26	That IRC Chapter 2 contains no definition of toe nail / face nail / end nail	7.5.1	Probable, but Chapter 2 was not exhaustively searched	Licensed ICC copy
27	EN 1995-1-1 edition currency	3.7.6	Clauses quoted from +A1:2008 . Whether +A2:2014 amended Section 8.3, and how BS EN 1995-1-1:2025 restates it, was not	Purchase the edition your National Annex invokes

#	Item	Section	What is unverified	How to resolve
			established	
28	ASTM D1761 current-edition lateral test rate and specimen geometry	3.6.4	Verbatim only from D1761-88(R2000); current pages paywalled	Purchase ASTM D1761-20(2025)
29	Whether APA TT-012 was revised after TT-012B (Dec 2011)	10.3.2	One APA page showed an April 2020 date that could not be reconciled to a document face	APA technical library
30	Absolute corrosion rate for a galvanized nail in ACQ	4.6.2	Only ratio comparisons were obtainable	FPL-GTR-220 directly
31	Whether AWWA U1 contains a normative fastener clause	4.6.2	Only AWWA E12 is confirmed as the corrosion test method	AWWA directly
32	A quantitative fracture-mechanics account of end-of-board splitting	4.5	No authoritative source found; the codes treat it empirically	—

H.5 Safety, tools and regulatory

#	Item	Section	What is unverified	How to resolve
33	ANSI/HTI B173.1 designation	5.3.2	Confirmed only via a manufacturer page that itself contains a typographical error	ANSI catalogue

#	Item	Section	What is unverified	How to resolve
34	Z87 and Z87+ impact test parameters	5.2.1	Available only from PPE manufacturers' literature; the standard is paywalled	Purchase ANSI/ISEA Z87.1-2025
35	Hardness or chip-resistance requirements in ASME B107.400	5.3	Paywalled, no free text. The only published threshold found is one manufacturer's <i>"Do not strike objects harder than 46 HRC"</i>	Purchase ASME B107.400
36	A manufacturer warning against lateral prying with a claw hammer	8.3	No such warning was found. Existing side-related warnings concern striking , not prying	—
37	Storage conditions and shelf life for bright nails	6.2	No standards body, trade institute or major manufacturer publishes any	—
38	Effect of surface rust on drivability; code provisions on corroded fasteners	6.2.1	Neither could be located	—
39	National injury statistics for hammer work	5.1	No CPSC or BLS figure isolating hammers was found. The one NEISS hammer study is craniomaxillofacial	CPSC NEISS query

#	Item	Section	What is unverified	How to resolve
			-only and reports a raw sample of 2 967 over 20 years, not a weighted national estimate	
40	EN 14592 Annex ZA and Table ZA.1	12.2.3	Not read. System 3 is established from Commission Decision 97/176/EC — the legally controlling instrument — plus manufacturers' DoPs	Purchase EN 14592:2008+A1:2012
41	A DoP for a plain smooth round wire nail declaring My,Rk, fax,k and fhead,k	12.2.4	Only screw and bolt DoPs were retrieved	Request from the nail supplier
42	Whether UK(NI) marking is triggered for System 3 products	12.3.2	No explicit official statement found	UK Office for Product Safety and Standards
43	RCRA classification of nails specifically	11.4	No source names nails; the conclusion is an inference from the scrap-metal definition	Local regulator

H.6 Sources actively identified as unreliable

The following were encountered during preparation and should **not** be used.

Source	Problem
The widely copied "Family B" hardware nail size	6d 0.120, 8d 0.134, 16d 0.165, 20d 0.203, 30d

Source	Problem
charts	0.220, 40d 0.238 — the gauge column contradicts ASTM A510 Table 1 in every row. See Section 3.1.1.
One popular online reproduction of EN 1995-1-1 Table 8.2	Three confirmed errors: a_1 for $420 < p_k \leq 500$, a_2 pre-drilled, and cos versus sin throughout the a_4, t rows
A national design guide's reproduction of EN 1995-1-1 Table 8.1	Last row given as $a_1 = 5 d$; the standard reads 4 d
Retail listings for "16d sinker"	Advertise 0.162 in or 0.165 in against the NDS Table L4 value of 0.148 in
A commercial article giving 16d box and sinker head diameters as 0.191–0.230 in	Contradicts NDS Table L4, which gives 0.344 in
GA-214 cited for nail-pop guidance	The topic does not appear in that document. GA-222 is the correct reference.
Older continuing-education material citing " $C_d = p/10D$ " for nails	Based on NDS-2001; superseded. See Section 3.6.3.
29 CFR 1926.301(c) cited as a hammer-face rule	It applies to struck tools, not hammer faces
"Light surface rust is acceptable on fasteners"	RCSC requires cleaning, and retesting for pretensioned joints. The acceptable-rust concept applies to faying surfaces , not fasteners. See Section 6.2.1.
Supplier pieces-per-kg rows that fail the density check	See Section 3.2.2 and Appendix B

End of document. OM-CWN-001 Revision 1.0.