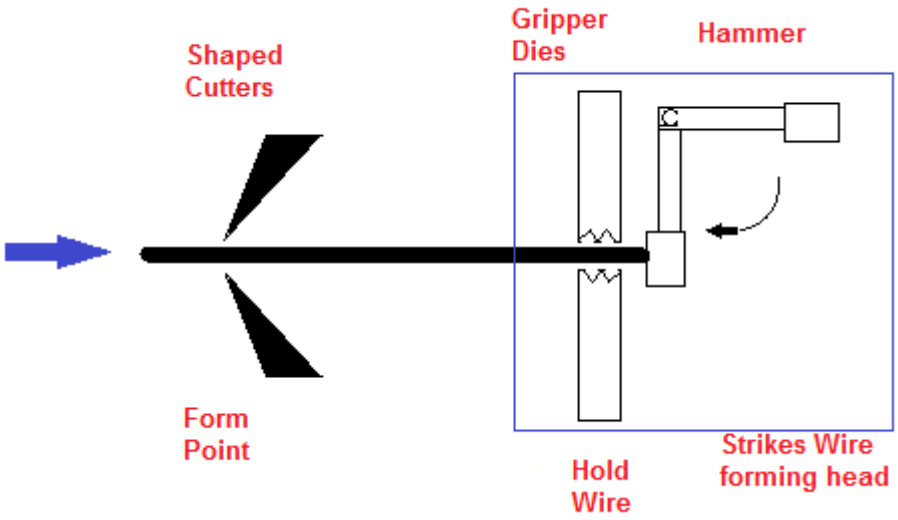
The following presentation was made to RICOWI in 2017 and has been updated in 2023

Part 2

Simplified Representation of Nail Forming



Wire is drawn from a coil – fed into machine – Gripper Dies secure the wire while hammer with shape of head strikes end of wire. Shaped cutters cut the point and free the nail from the wire.

High speed nail making machinery produce hundreds of nails per minute.

Materials

Materials of Construction*

Steel
(mild to medium-high carbon)

Stainless Steel

Aluminum

Copper

Brass

Copper Clad Steel Wire

*Per ASTM F1667

Materials of Construction – Carbon Steel

Steel wire used in the manufacture of nails is low carbon, medium-low carbon steel or medium-high carbon steel (range of 0.05 - 2.5% carbon). As carbon content increases, the steel has the ability to become harder and stronger through heat treating but at a tradeoff in lower ductility (ability to be stretched into wire) and in the case of a nail the ability to withstand cold bending without fracturing. Examples of some of the grades of steel used would be 1018, 1020, 1030.

Nails used for engineered construction (framing, roof and wall sheathing, etc.) are required to meet minimum bending yield requirements. For nails in these applications the requirements range from 100,000 to 80,000 psi. dependent on the nail diameter.

ASTM F1667 standard does not make specific reference to grades of steel. The manufacturer of the nail has the latitude to choose materials that will allow for the production of the nail and still meet the ductility and bending yield requirements.

Materials of Construction – Stainless Steel

ASTM F1667 is more specific when it come to stainless steel for use in nails.

The standard call for 4 grades of stainless 302, 304, 305, and 316. The most commonly used grades are 304 and 316.

Stainless is used when corrosion protection is required such as in outdoor use, contact with preservative-treated wood, contact with fire-retardant wood, and with certain wood species like cedar and redwood.

304 and 316 stainless steel are similar in material properties. There is one notable difference in that 316 has the addition of molybdenum. This provides resistance to chloride (salt) attack on the exposed surfaces of the nail.

Stainless nails are significantly more expensive than carbon steel nails.

Materials of Construction - Aluminum

ASTM F1667 is also specific with regards to the aluminum alloys that can be used in nails. The listed alloys are 2024, 5056, 6061 and 6110.

Aluminum nails are generally used for the attachment of wall sidings and roofing components. They are typically not used for framing and the attachment of sheathing as they do not have the required strength for these types of structural connections.

Materials of Construction – Copper, Brass, Copper Clad Steel Wire

Nails made of these materials are specialty nails engineered for specific requirements.

Copper Nails are required to be 98% pure copper

Brass used in nails shall be good commercial quality suitable for the purpose intended

Copper Clad Steel Wire nails
-must have a minimum 20% copper by weight
-<u>average</u> thickness of the copper must not be less than 10% of the radius of the clad wire
-<u>minimum</u> thickness of 8% of the radius of the clad wire.

Nail Finishes / Coatings

Nails can be made with a variety of finishes or coatings

Bright Finish – term applied to nails with natural bare finish resulting from cleaning of nail which has not undergone treatments

Zinc Coated – term applied to nails in which zinc is applied to the surface of the nail synonymous with ‘galvanized’

Other coatings may be used by manufacturers to aid in corrosion protection, assisting in the driving of nails, aesthetics or other functions.

Polymers	Phosphate	Blued	Tin Plating
Liquor	‘Cement’ coating	Proprietary coatings	

Materials of Construction - Galvanization

When nails are zinc coated or galvanized, they are produced by one of the following methods

Cut and formed from

a.) hot dipped hard-wiped steel wire
b.) electrogalvanized steel wire
c.) zinc flake/chromate dispersion-coated steel wire
d.) uncoated (bright) steel wire which after forming is
    i. hot-dip galvanized
    ii. electrogalvanized coated
    iii. mechanically deposited coated
    iv. thermo-diffusion galvanization

Materials of Construction – Galvanized Wire

Nails made from galvanized steel wire have a coating weight in accordance ASTM A641/A641M Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.

When there are no specific weight requirements, but just a reference to being ‘galvanized’, the requirements of A641/A641M section 9.2 are met.

When requirements call for minimum coating weights there are 3 options. These are referenced in Table S1.1 – Supplementary Requirements in A641/A641M

Class 1 ranging between 0.28 – 0.50 oz/ft² depending on nail diameter
Class 2 ranging between 0.50 – 0.75 oz/ft² depending on nail diameter
Class 3S 1oz/ft² for all referenced diameters.

Materials of Construction - Galvanization

For nails coated to ASTM A641/A641M Class 1, the coating weights can be thought in terms of this example.

Wire dia. (in.)	Weight oz./ft²	
0.092	0.28	
0.148	0.35	
0.192	0.50	

Would be like taking the number of quarters shown, rolling them flat to cover an 8½ x 11 sheet of paper evenly.

Materials of Construction - Galvanization

Nails that are hot-dipped after forming have a coating in accordance to ASTM A153/A153M Class D when a heavier coating is specified. This equates to 1oz/ft².

- 1 oz. / ft² of surface area average

Would be like taking these 3¼ quarters rolling them evenly to cover an 8½ x 11 sheet of paper

Materials of Construction – Code Requirements

The IBC and IRC reference galvanization requirements in two methods

a. “Galvanized” which does not provide specific requirements for coating level.
b. Hot-dip galvanized in accordance with ASTM A153 Class D or ASTM A641 Class 3S*

The codes require galvanization in accordance with A153 Class D or A641 Class 3S for use with preservative treated wood, decks and wood shakes and shingles.

When these specific requirements are not called out, a galvanized nail can be coated with zinc from any of the galvanization process at a coating level to be determined by the manufacturer.
[Hot dip, electro-galvanized, mechanical galvanization, thermo-diffusion galvanization]

City or state codes may have specific galvanization requirements that are not addressed in the IBC or IRC and should be consulted prior to use.

*ASTM A641 Class 3S is being introduced into the 2024 IBC and IRC as an equivalent to ASTM A153 Class D

Properties

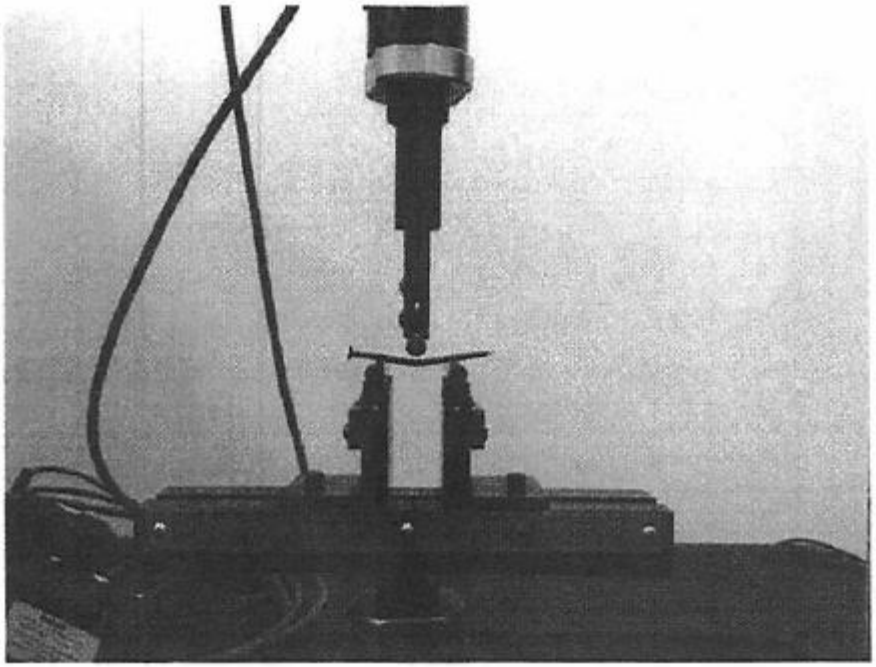
There are three mechanical or physical properties to be met that are called out in ASTM F1667.

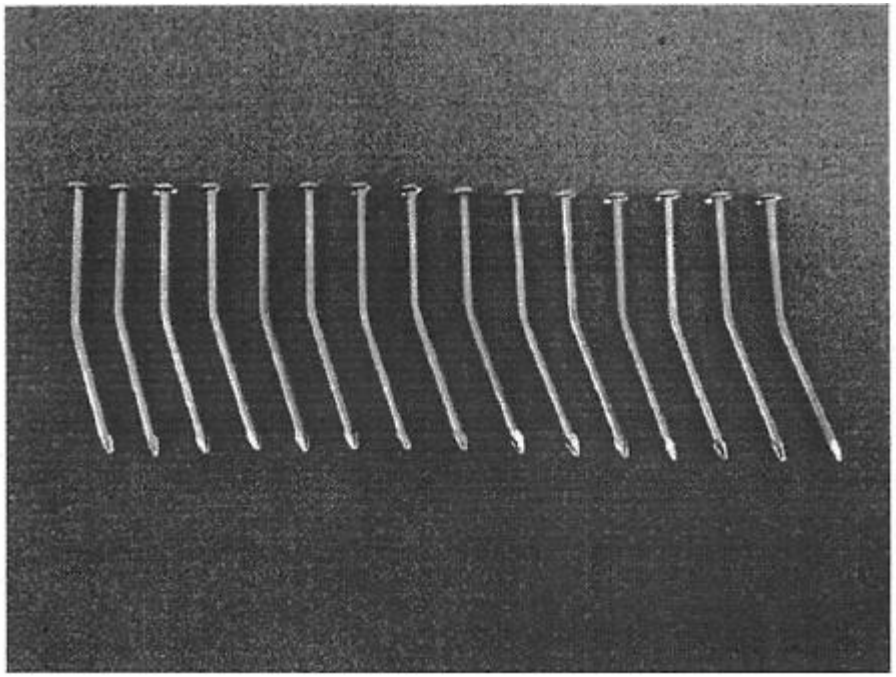
Ductility – is a solid material's ability to deform under tensile stress. This is often characterized by the material's ability to be stretched into a wire. A nail shall be sufficiently ductile to withstand cold bending without fracture. Different materials have different ductility requirements.

Tensile Strength – is the measurement of the force required to pull (wire in this case) to the point where it breaks. Although the nail are not normally subject to tension testing, the wire used to manufacture the fasteners is required to be controlled in the manufacturing process.

Bending Yield Strength (F_{yb})- When a nail is subjected to an excessive lateral or side force or load it will begin to bend. Yield or failure occurs when the fastener bends and cannot return to its original shape when the load is removed. Bending Yield Strength is the resisting strength of the material to yielding. When exceeded, permanent deformation has occurred.

The most common physical test performed on a nail is the bending yield test





Nail Dimensions & Dimensional Tolerances

As mentioned, most of the nails made today are formed from wire. Wire is manufactured and sold by its decimal equivalent or gage. Most manufacturers designate nail sizes by shank diameter in inches and length.

ASTM F1667 provides standards for tolerances related to

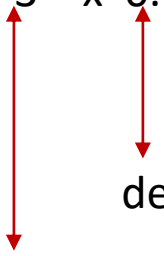
shank lengths
shank diameters
head diameters

Nail Dimensions & Dimensional Tolerances - continued

Because of the gage / decimal equivalency, information on nail dimensions are unique and can be sometimes confusing.

Nails used in building construction will often be listed with a combination of decimal, fractional and whole numbers when dimensioned. Some examples of commonly used nails in framing and the attachment of sheathing.

2½ x 0.131
3 x 0.148



decimal

whole & fractional

where 2½ and 3 are the lengths of the nail from the point to the underside of the head (inches)

where 0.131 and 0.148 are the nominal shank diameter (inches)

Nail Dimensions & Dimensional Tolerances - continued

Some manufactures/distributors list nail shank diameters by gage size.

When referring to “gage” as a size, one must be careful. There are multiple gage tables in use. Presently ASTM F1667 only references steel gage and not gage for aluminum, copper and brass.

The user should always verify the dimensional diameter when only “gage” is referenced as a size. You may not be getting what you think you have!

Nail Dimensions & Dimensional Tolerances - continued

Real example:

Many roofing nails are marketed as 10 gage.

Per ASTM A510/A510M the nominal diameter for 10 gage is 0.135 inches. F1667 shank tolerances for this size nail are ± 0.004 inches which would provide a range of 0.131-0.139 inches.

Some companies list 10 gage as 0.131 inches. If 0.131 is the minimum dimension held in their manufacturing process, this is not an issue. But, if 0.131 is their nominal dimension then the manufacturing range could run 0.127 – 0.135 inches.

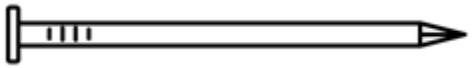
Depending on building design or code requirements, this could be of concern.

Nail Identification and Designations

In engineered construction there are nails that have similar shapes and dimensions.

These nails are used in connecting framing members, sheathing and roofing products, but have important differences.

common nails
cooler nails
box nails



These look similar but there are dimensional differences

Common nails as the name implies are everyday nails for use in typical construction and are often addressed as 6d common, 8d common, etc.

Box nails look like common nails, but have smaller shank diameters. In some cases the nail head may be larger than a common nail of equivalent shank dimeter. These nails are addressed as 8d box, 10d box, etc.

Cooler nail have shank diameters, lengths and head diameters that are smaller than box nails. These nails are commonly addressed as 6d cooler, 8d cooler, etc.

Nail Identification and Designations

	Table 6 Type I, Style 4A – Box Nails	Table 10 Type I, Style 7 – Cooler Nails	Table 15 Type I, Style 10 – Common Nails
	L x D head dia.	L x D head dia.	L x D head dia.
6d	2 x 0.099 0.266	$1^{7}/_{8}$ x 0.092 0.250	2 x 0.113 0.266
8d	2½ x 0.113 0.297	$2^{3}/_{8}$ x 0.113 0.281	2½ x 0.131 .281
10d	3 x 0.128 0.312	$2^{7}/_{8}$ x 0.120 0.297	3 x 0.148 0.312
12d	3¼ x 0.128 0.312	==========	3¼ x 0.148 0.312

What does the d mean after the number in the first column?

Within the industry, one can find references to d with regards to nail descriptions. This designation also often accompanied by the term “penny”.

These terms refer to a measure of sizes of nails. There is conflicting information on the historical basis of where the terms came from.

-d is thought to be an abbreviation of the Latin term denarius

-a symbol for a monetary penny.

-In early English history a penny was the price of 1000 nails

What is important to know that the terms are still used today.

Nail Identification and Designations

	Table 6 Type I, Style 4A – Box Nails	Table 10 Type I, Style 7 – Cooler Nails	Table 15 Type I, Style 10 – Common Nails
	L x D head dia.	L x D head dia.	L x D head dia.
6d	2 x 0.099 0.266	$1^{7}/_{8}$ x 0.092 0.250	2 x 0.113 0.266
8d	2½ x 0.113 0.297	$2^{3}/_{8}$ x 0.113 0.281	2½ x 0.131 .281
10d	3 x 0.128 0.312	$2^{7}/_{8}$ x 0.120 0.297	3 x 0.148 0.312
12d	3¼ x 0.128 0.312	==========	3¼ x 0.148 0.312

Note that

$$6d\ box \neq 6d\ cooler \neq 6d\ common$$

and this applies to other size nails with the *d* designation.

The *d* designation is also used in casing, sinker, corker, double headed, finish, flooring, lath, certain roofing, shingle and siding nails. Unfortunately some of the information in the industry may only indicate nails as 6d, 8d, etc. without specifying the type of nail.

Nail Identification and Designations

Penny - d? What do these mean? - Continued
Examples in various building codes

The International Building Code (IBC) and International Residential Code (IRC) have done a good job of identifying nails by designation and dimensions

as an example: 2021 IBC Table 2304.10.2 where the quantity, d designation and dimension are called out

10d box (3" x 0.128")
8d common (2½" x 0.131") among many examples.

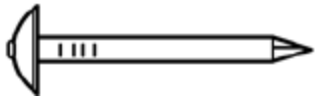
In some of the older codes, such as 2015 IRC Table R602.3(2)] a nail will be prescribed and it is not clear on the exact size

examples: 3d, corrosion-resistant, ring shank nails
6d, ring-grooved underlayment nail
In these cases the shank diameter and length and head diameters are not readily apparent.

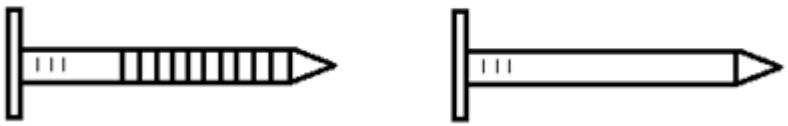
The general rule of thumb should be….look for the length and shank diameter on the package labeling to ensure that the correct nail is being used! ISANTA has made an effort to bring clarity to size requirements in later versions of the codes.

Nail Identification and Designations

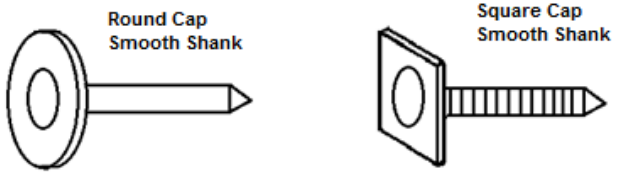
Roofing Nails



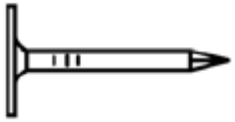
umbrella head
leak resistant



aluminum shingle
steel shingle nail
steel roofing



Cap-head roofing nails
(plastic or metal caps)



aluminum roofing,
steel reinforced head

Elastomer washered roofing nails
(steel and aluminum)