MINIMUM STEEL THICKNESSES FOR NARROWBOATS

A discussion paper

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Acknowledgments

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Introduction

Marine surveyors and boat owners are regularly heard to say there is a minimum 4.0mm of hull thickness required at time of survey of a steel narrowboat. Some brokers even publish videos of such information, with some surveyors enforcing it (Whilton Marina, 2012 and 2016). Boaters are subject to it and repair often follows. In a recent article, Geoff Waddington (2021) explains there is confusion in the industry about wastage limits, and consequently acceptable residual hull plate thicknesses, and opinions among surveyors 'vary wildly', with some quoting 3mm acceptable minimum plate thickness, others using percentage loss.

This short paper explores what a standardised acceptable limit for diminution, and therefore residual plate thickness, could be. It describes a variety of methods of calculating the design plate thicknesses (scantlings) and the minimum acceptable residual plate thickness. In doing so, this paper aims to open discussions across the inland waterways sector.

Design thicknesses

The origin of minimum design thicknesses for narrowboats was considered. Prior to the 1990s, which saw the advent of the well-known 10/6/4 specification (where 10mm is the base plate, 6mm the hull side plate, and 4mm the superstructure), narrowboats were built of varied steel thicknesses. It is not uncommon to find all-steel narrowboats from the 1960s onwards of 6/5/3 (or imperial equivalents), 6/6/4, 8/5/3 8/6/4 etc. Some 80s boats started to have thicker plating such as ½" base plates (e.g., Les Allen). Springer of course successfully built many boats of all-over 3mm. The convention now is 10/6/4, with some builders using 15mm for base plates (e.g., Amber, Hudson).

This increase in design thickness is significant, and the absence of evidence of boats built to the lighter (thinner) specification breaking up through lack of strength suggests narrowboat hulls with this increased design thickness are over-engineered. A thicker base plate might be favoured because these often-unpainted plates have a greater tolerance to corrosion loss. A reduction in ballast requirements is also often mentioned as a reason for

thicker base plates. As the industry grew into the 2000s, 10/6/4 became the minimum standard and 6mm bottomed narrowboats built post 1995 are seldom seen.

There does not seem to be a design reason for thick base plates based on structural necessity. The Canal Boatbuilders Association (CBA) (1999) published the below chart of design steel thicknesses for conventionally shaped narrowboats and so-called widebeam narrowboats.

Taking a 50' all-steel narrowboat as an example, the CBA chart shows design thicknesses as follows:

Length x breadth in metres gives figure to look up on graph to ascertain required section modulus of framing, to be multiplied by 1.3.

Bottom shell plating and side shell plating obtained from graph by looking up length in metres.

L x B = 15.24m x 2.08m =	31.7m^2
Section modulus (from graph) =	24.5cm^3. Multiply by 1.3 = 31.85
Bottom shell plating (from graph) =	**4.7mm**. Round up to 5.0mm
Sideshell and deck plating (from graph) =	**4.15mm**. Round up to 5.0mm
Transverse Frames	60mm x 60mm x 6mm angle bar @ 750mm centres
Longitudinals	60mm x 40mm x 5mm angle bar @ 2 per panel

Figure 1 - CBA scantlings specification, 50' narrowboat, 1999

75.GRAPH OF SHELL PLATING, TRANSVERSE AND LONGITUDINAL FRAME SECTION MODULUS AGAINST BOAT LENGTH AND FORM FACTORS.

WB = wide beam; NB = narrow beam; PW = panel width; Z = section modulus in cm^3;

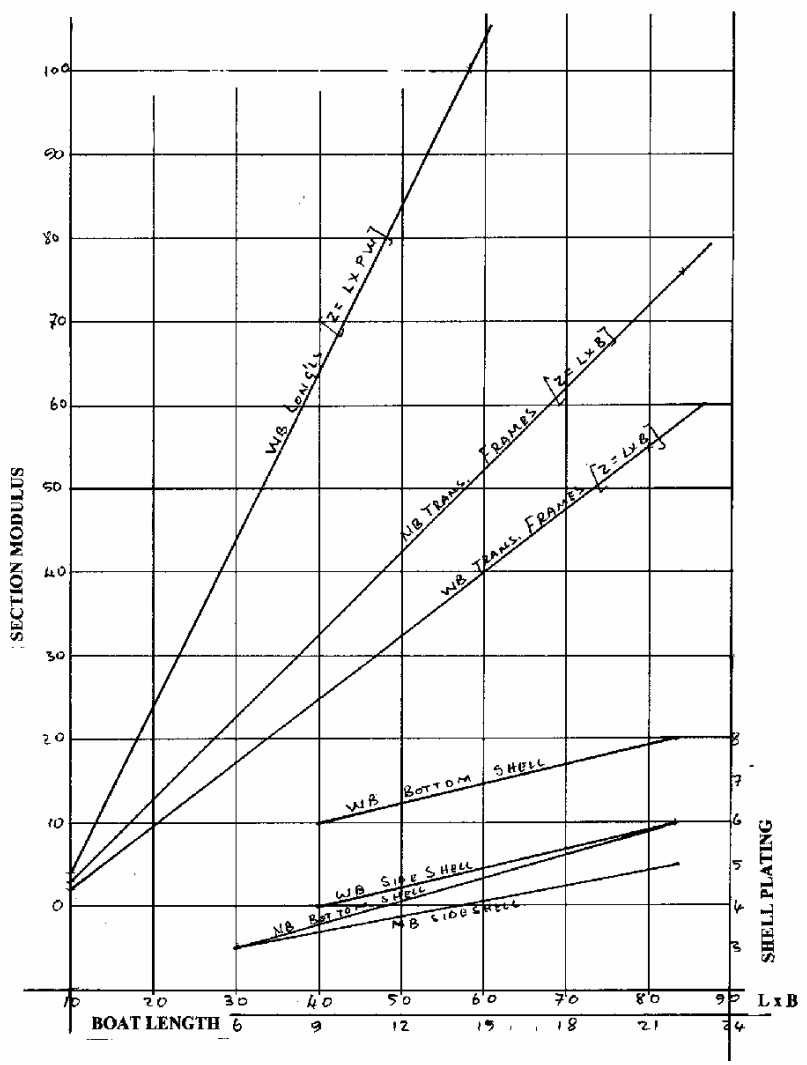

Figure 2 - CBA scantlings specification, 1999

The CBA round up and the 50' narrowboat ends up being 5mm base and 5mm hull sides. For 30', 3mm is adequate; Springer Engineering using this for base and sides to good effect in the 1980s. In fact, the CBA state at clause 67, that 3.0mm is the effective minimum thickness for bottom shell, side shell and deck plating; this appears to be irrespective of length or beam.

These thicknesses for narrowboats have of course been tested over the last 50 years and fortunately we do not see narrowboat structures failing due to a lack of design thickness. There are plenty of plating failures as a result of lack of maintenance and erosion, but it follows that a well-maintained 3mm Springer is an adequately designed vessel (and should therefore also be insurable). The CBA does not reference its data, but it is not arbitrary and somewhere down the line calculations were made to enable them as a trade association to recommend scantlings of a certain size to their members.

Dave Gerr (2000) in his book *The Elements of Boat Strength* provides various formulae aimed at enabling builders, designers, and owners to calculate required scantlings. Taking the 50' narrowboat example, once the scantling number is calculated as Gerr instructs, the below formulae provide design thickness.

Dimensions in m	
Length (L)	15.24 (50')
Beam (B)	2.08 (6' 10")
Hull depth (D)	1.3 (51")
ST = (L x B x D)	41.20896
Divisor	28.32
Scantling No (sn) (ST/28.32)	1.45511864
Multiplier	3.05
Sn	1.45511864
power of 0.25	1.09830915
SHELL PLATE THICKNESS in mm (3.05 x 1.09830915)	**3.35**
(Added thickness if required)	0
BASE PLATE THICKNESS in mm	**3.35**
SUPERSTRUCTURE	
Multiplier	2.79
Sn	1.45511864
power of 0.23	1.09010074
SUPERSTRUCTURE THICKNESS (2.79 x 1.09010074) in mm	**3.04**

Figure 3 - Dave Gerr's scantling formulae

He further specifies that the figures generated are over-specified, directing the designer to use the next available thinner plate. In the case of our 50' narrowboat, the designer would take the 3.35mm figure for the base and chooses 3.0mm plating.

The CBA and Gerr both arrive at thinner plating than the current 10/6/4 convention directs. Both state that 3mm is the minimum effective thickness for the smallest vessels. However, whereas Gerr is focussed on efficiency of design, the CBA are factoring in the inland waterways' environment. Furthermore, Gerr's calculation for the 50' boat, with typical transverse framing as common on narrowboats, relies on frame centres of 275mm, CBA 750mm. It is worth noting that the heavily built narrowboats of the 1990s were often built 10/6/4 and 600mm frame centres, but that recently 1200mm centres have been observed.

Considering contemporary industry-specific guidance, British Marine (2022) in their *Inland Boatbuilding Code of Practice* detail a scantling assessment to be completed as follows:

> The hull and superstructure for each craft, or model of craft, should be demonstrated to be strong enough for the purpose intended. This can be by showing that the scantlings (i.e., combination of framing and hull plating) used either meet a recognised standard or have a proven service history.
>
> To show that the scantlings meet a standard, this may be undertaken in one of three ways:
> a) Manual calculation. The manual calculations are available within the ISO standards referenced.
>
> b) Use of a computer program. Either to the ISO standards or alternatively accepted standards such as Lloyds Special Service Craft
>
> c) Service history on Category D boats – then Post Construction Assessment on:
>
> - Historic boats
> - Existing designs
>
> Using c) must be supported by documented evidence of in-use vessels.

Figure 4 - Extract from British Marine Boatbuilding CoP

Historically narrowboat builders have used customs and practice or followed guidance from trade groups like CBA, using the proven service history route. The ISO standard referred to in the British Marine extract is ISO 12215:2017. Using this, the design thicknesses required for a 50' narrowboat were as follows:

ISO 12215:2017 – 50’ narrowboat calculations

For calculating the side plate thickness of a 50’ long steel narrowboat

$t = b.f_k$. square root$((P.k_2)/ 1000.s_d)$)

t = 600 x 1 x square root ((0.0356 x 0.493)/(1000 x 0.6))

t = **3.245mm**

where :-
t = required plate thickness in mm
b = short dimension of the panel
f_k = correction factor for curvature (1 in this case) from ISO 12215-5 Table 7
P is the design pressure of the panel in kN/m^2
k_2 is the aspect ratio coefficient from ISO 12215-5 Table 6
s_d is the design stress

For the bottom plate of a 50’ long narrowboat with no longitudinal centre stringer

$t = b.f_k$. square root$((P.k_2)/ 1000.s_d)$)

t = 600 x 1 x square root ((0.0712 x 0.5)/(1000 x 0.6))

t = **4.62mm**

Note :- With a longitudinal stringer along the centreline of the bottom plate this calculation gives **4.52mm** for the bottom plate.

Figure 5 - ISO 12215:2017 scantling calculations

The above calculations are based upon the internal transverse and vertical framing placed at 600mm intervals.

NB: When considering dutch barges the calculations become more complicated, and even with the light framing that is generally utilised for a welded steel plate hull we can arrive at a scantling requirement of 3mm thick steel plate. Riveted wrought iron plated dutch barges may well result in a different scantling figure due to the different yield strength of the wrought iron, but it is unlikely to be significantly different.

Summary of 50’ narrowboat plating requirements, transverse framing

Table 1 - Summary of thicknesses

Source	Hull sides (mm)	Base Plate (mm)	Frame centres (mm)
Dave Gerr	3.35	3.35	275
CBA	4.15	4.7	750
ISO 12215	3.3	4.62	600

A limitation that should be noted, and has been well documented, is that for a surveyor looking at a narrowboat, the framing is usually not accessible.

It should be further noted that hot rolled steel plate can have a significant $^{+}/_{-}$ tolerance from the nominal thickness as supplied by the rolling mill. For instance, 6mm steel plate produced to EN 10029 can have one of four tolerance classes, with tolerance class D permitting the thickness to range from nominal 6mm $^{+}/_{-}$ 0.75mm, so it is possible, though unusual, that a hull constructed from nominal 6mm steel may give an ultrasonic thickness reading of 5.25mm. In this case, it should not be presumed that there is 0.75mm of wastage to the hull as the plating thickness may be as originally constructed. Likewise, some plates may have a taper to them. Due to the overdesign plate thickness of narrowboats, it would not be unusual for narrowboat builders to purchase steel plate from the rolling mill that is not “prime” and thus achieve some cost saving.

An extract from EN 10029 is included at Appendix A.

Insurance requirements

Given the general success of all the varied narrowboat structures, it is curious how some insurers and brokers have arrived at the ‘minimum 4mm’ rule. In the last couple of years, some narrowboat owners have been sent renewal documents, subject to survey, where the minimum hull thickness found must be 4mm. Insurers have differing requirements and this lack of harmonisation further complicates the matter.

In private emails, major UK inland waterways insurers were asked for their minimum thicknesses:

Table 2 - Insurer’s minimum thickness comments

Insurer	**Comment**
A	No minimum thicknesses as such but would expect minimum of 4mm for base plates
B	Minimum of 4mm to all hull plating. 3mm Springers required to be overplated to gain insurance
C	No minimum thicknesses, would expect to see minimum 3mm, but relies on expertise and judgement of surveyor. 3mm Springers acceptable, but the report findings are subject to greater scrutiny
D	Stipulates minimum 4mm in renewal documents (but doesn’t clarify why)

Insurers A and C seem on balance to reflect historic understandings, insurer B has taken exception to Springers despite the proven scantlings and presents a problem for 5mm sided vessels with pitting, and D has a simple catch-all strict approach.

The lack of harmonisation seems to penalise boat owners, as it is not obvious to them what their insurer wants. Furthermore, knowing how this compares to what their boat actually

measures – bear in mind it might be 10 years old, CE marked, 5mm with 1.1mm pitting and in breach of insurance requirements – is difficult to ascertain and almost an apparently arbitrary and unknown condition of cover. With the trend in the sector towards a domestic dwelling setting over a leisure one (CRT in 2021 report the proportion of liveaboard boaters has risen from 15% in 2011 to 27% in 2020), industry professionals need to be mindful that they are dealing with people's homes, security, and possibly everything they own in the world.

Considering acceptable diminution

In recent cases, inland waterways marine surveyors have been challenged legally for not mandating repairs where wastage has been found above 20% of original plating thickness, and the origins and sense of this were considered.

Taking the all-steel 50' narrowboat with 6mm sides and 10mm base, 20% wastage allowance would mean any thickness loss or pitting in excess of 1.2mm on the sides and 2mm on the base would have to be repaired immediately. During research for this paper, reports were heard where a surveyor has "failed" a narrowboat base plating due to 30% diminution due to pitting. The plating was 15mm, with 5mm pitting.

Taking this approach across the board - and given that most narrowboats subject to rudimentary blacking maintenance have active pitting - would mean most narrowboats would require welding repairs at every docking. Furthermore, given access to base plating is generally poor at docking facilities, it is virtually impossible to clean, inspect and repair all pitting accurately.

The lack of maintenance is one plausible reason that boatbuilders have over-specified plating thicknesses; as a corrosion buffer or allowance. If it can be proven that a 50' narrowboat needs a design thickness of 3mm, then the 20% wastage allowance seems completely arbitrary without considering it in context.

The 20% wastage allowance figure is quoted in a variety of places concerning commercial shipping.

MSIS 27.2 / R08.22 – MCA Instructions for the Guidance of Surveyors on Construction, Watertight and Weathertight Integrity Chapter 2 has a table at 2.7.5. For vessels of length less than 100m built to one of the MCA recognised classification society rules, the following corrosion limits should be complied with:

Plating – Bottom and Topsides – Within L/2 midships	15%
Plating – Bottom and Topsides – Elsewhere	30%

At 2.7.7 MSIS 27.2 it states:

> In general, hull plate areas below 3mm in thickness should be renewed

Classification Societies concerned with the design and maintenance of commercial shipping also reference wastage of 20% and 25% (DNV, 2020). Lloyd's Register (2022) in their *Rules and Regulations for the Classification of Inland Waterways Ships,* which applies to ships operating in Zone 3 (where the maximum significant wave height based on long-term significant wave height statistics, excluding the highest five per cent of the observed waves, does not exceed 0.5m), refers to allowable limits of corrosion, defining substantial corrosion as

> wastage of individual plates and stiffeners in excess of 75 per cent of allowable margins, but within acceptable limits.

Furthermore, they state:

> Additionally, when a survey results in the identification of structural defects or corrosion, either of which, in the opinion of the Surveyor, will impair the ship's fitness for continued service, remedial measures are to be implemented before the ship continues in service

This last statement reflects the position that the inland waterways marine surveyor finds themselves in daily, except that deteriorating vessel condition and paucity of repair services often make remedial measures difficult to achieve.

Further to that, these Class Society rules quoted are designed to be applied to ships, which are subject to a different environment to narrowboats, and furthermore the rules are designed to be applied to ships from design right through their life. It therefore seems unreasonable to apply them retrospectively to narrowboats.

There might be some validity in applying the 25% wastage rule, but only if this is proportionate and just. Clearly, with our 50', 10mm bottomed narrowboat, mandating repair when a single pit on the base plate reaches 2.1mm seems hasty, given that 7.9mm remains, and the design thickness requirement has been shown to be between 3mm and 4.7mm. It might, therefore, make more sense to agree that 25% wastage can only be a trigger point for mandatory repair when based upon the minimum design requirements.

This suggestion might not be well received by marine surveyors, insurers, and purchasers. In essence, the suggestion is that the 50' narrowboat with the 10mm base plate could see a reduction in plate thickness to 3mm (the design requirement) minus 25% (the wastage permissible). On this basis, the in-service base plating would be acceptable if reduced to 2.25mm. This seems uncomfortably thin, not just because the industry is used to much thicker plating, but because the corrosion allowance is gone, and there is scant resistance to impact through grounding.

The MCA (2022) provide guidance for fishing vessels that might provide helpful comparative data. Their document *Instructions to Surveyors – Construction, Watertight and Weathertight Integrity MSIS27 Rev 08.22* states:

> In general, the maximum allowance for wastage is of 25% of original design thickness (consequently, original scantlings should be available).

And further:

> Isolated areas of pitting, with a depth not exceeding 50% of the plate thickness, may be repaired by welding, subject to the use of qualified welders, and approved procedures and materials, e.g., classification society approved. In general, hull plate areas below 3mm in thickness should be renewed.

Here, we have a guide to permissible wastage, a repair method, and a minimum overall acceptable thickness. This seems to match what inland waterways marine surveyors have been saying is acceptable for years and is at odds with the minimum 4mm ‘requirement’ that has become common in recent years.

The key thing that is missing for the inland waterways marine surveyor is original scantling calculations. As most builders use customs and practice of 10/6/4, scantling drawings or calculations will likely have never been completed. Boatbuilders are content that the long-established success of the narrowboat structure is adequate proof the design is sound. This is true – narrowboats are intrinsically strong – but it does not help the marine surveyor in determining acceptable wastage.

Dave Gerr’s calculations result in a design thickness less than those in ISO 12215:2017, with CBA guidelines close to ISO 12215:2017. ISO 12215 is a complicated document, the interpretation of which is beyond many without specialist training and knowledge; in short, narrowboat boatbuilders do not use it. Other methods are far more effective; Dave Gerr’s formulae can be added to a spreadsheet where numerous computations are made simple, or for rule of thumb, CBA’s chart is adequate. These can be used and are easy to interpret.

A note on impact / collision

Conversations with inland waterways marine surveyors about their accepted minimum thicknesses reflected the variance discussed. All were nervous of the lack of industry guidance available, and all would happily work to an agreed figure. Some, when asked, said 4mm minimum without hesitation to mitigate collision or impact. When asked to expand and citing the 5mm sided boat with 1.1mm pitting, the feeling changed; seemingly a degree of pitting to most is not an issue, beyond insurance requirements or not. Clearly this is an uncomfortable situation the marine surveyor finds themselves in.

Deciding on a minimum thickness that can defend against impact on the spot is entirely arbitrary and subjective. What is the object that will be struck? At what speed? At what angle? None of the design documents mention this, yet surveyors do. 4mm is not enough to defend the vessel against every conceivable obstruction impact on the inland navigation

system; 6mm bow plating has been seen holed, so specifying 4mm on this basis would have been pointless. Damage from impact is of course one of the things insurance is for. Whatever the thickness of the plating, there may be unexpected consequences in a collision that could result in perforation or penetration of the plating.

Of course, much of the wastage and diminution surveyors of narrowboats find, and owners repair, could be easily avoided. If boatbuilders grit-blasted and epoxy coated all underwater plating as a matter of course from new, vessels would be protected against pitting corrosion and have a much longer life. Widespread blanket over plating would be eliminated. Returning to Dave Gerr again, in Chapter 14 of his book he deals extensively with corrosion and prevention; it's within the section called *Design Considerations*. He advocates grit-blasting and epoxy coating inside and out of steel hulls, as well as discussing the various advantages of materials including CorTen steel. It is astounding then, that the contemporary British Marine narrowboat design code of practice makes absolutely no consideration to hull protection whatsoever. It does not even get a mention. The owner, vessel and surveyor are battling corrosion from the start.

Summary

A lack of harmonisation and clear guidelines of minimum hull thicknesses is penalising owners, causing fragmentation within the industry and leaving marine surveyors who apply other criteria and/or who use their professional expertise to determine reasonable wastage exposed unfairly to defending liability claims.

The authors have shown that there are a variety of ways of calculating what the design minimum should be and if necessary, a marine surveyor could use them on site to aid assessment. The MCA provide a minimum thickness of 3mm, which matches the CBA and Dave Gerr's minimum design thickness for steel vessels. The MCA also give us a wastage maximum of 25% from the scantling design, but it has been established that narrowboats are over-specified, and the thicker base plating includes a generous buffer for corrosion.

It therefore seems that where no specific guidance exists from a vessel designer, architect or boatbuilder, the following can be considered as acceptable outcomes:

1. Insurers, surveyors, and repairers could agree that 3mm is the minimum required hull thickness for steel narrowboats. However, this must be considered against other factors, and this is where the discretion and expertise of the surveyor is paramount. The area must be subject to satisfactory hammer sounding. The cause of any internal thinning e.g., pooled water lying in rebates or bilges must be identified and eliminated. Continued abrasion / erosion of the area when returned to service should be considered. Any other contra-indicators should be taken into account.

   Setting 3mm plate thickness as a minimum does not preclude the need to carry out repairs to hulls sooner, and residual plate thicknesses of 3mm should be considered as a minimum, not a target.

2. Where hull plating has reduced to 3mm, the vessel is deemed to be at its absolute minimum and preventative intervention is required. The plating should be grit-blasted, inspected, repaired where necessary and a proprietary hard-wearing paint system applied such as 2 pack epoxy. The point here is that this is known to halt pitting and correctly done should prevent corrosion worsening and help prevent

future large-scale repairs from becoming necessary. This will in most cases require a further timely docking at an appropriate location, but taken as a whole, the result will be better for the owner.

3. Where hull plating of steel narrowboats has reduced to less than 3mm, immediate repair is required because the design minimum thickness has been subceeded, and as such (subject to point 1 being agreed) insurers may discontinue cover.

4. With respect to the 3mm original hull plates of some Springers, minus 25% ought to be a maximum accepted wastage where the minimum residual plate thickness is 2.25mm or better. However, to enable a better margin for future wastage or corrosion a surveyor should indicate that remedial works should be carried out when the measured residual plate thickness approaches 2.5mm.

5. In the case of pitting, this can be repaired using industry guidance provided by the MCA and Class Societies, e.g., clean and dry the area, start the weld outside the pitting and reverse the welding direction for each layer

6. In the case of erosion wear or where pitting is too widespread, various repair methods are common across the inland waterways and the surveyor is presently at liberty to select which one to follow. This last point is certainly worthy of a separate discussion paper.

Further Work

1. **An industry-wide agreement should be reached** that clarifies hull insurance requirements for steel narrowboats. To achieve this some degree of harmonisation is required and a consultation with underwriters should be completed.

2. The repair methods for steel narrowboats should be researched and an agreed process drafted into a reference document available to surveyors, insurers, repairers, and owners alike.

3. Tackling the issue at source; prevention of corrosion through hull coatings is well documented across the sector but is conspicuous by its absence in CBA and British Marine guidance. Trade bodies should be encouraged to convey to their members the value and importance for the life of the vessel in a thorough coating system for all underwater plating, including base plating. Boatbuilders should be encouraged to grit-blast and epoxy coat from the start.

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Appendix A

TOLERANCES TO EN 10029 FOR HOT ROLLED PLATE 3MM AND ABOVE

General

This standard covers non-alloy and alloy steels including stainless steels with:

1. Nominal thickness ≥ 3mm ≤ 250mm
2. Nominal width ≥ 600mm
3. Specified minimum yield strength < 700 N/mm^2

Tolerances on plate less than 600 mm wide shall be agreed at time of enquiry/order

Thickness tolerance

At the enquiry/order stage it is necessary to define which of 4 classes A-D is required.

Nominal thickness	Tolerances on nominal thickness [1)]							
	Class A		Class B		Class C		Class D	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
≥ 3 < 5	-0.4	+0.8	-0.3	+0.9	-0	+1.2	-0.6	+0.6
≥ 5 < 8	-0.4	+1.1	-0.3	+1.2	-0	+1.5	-0.75	+0.75
≥ 8 < 15	-0.5	+1.2	-0.3	+1.4	-0	+1.7	-0.85	+0.85
≥ 15 < 25	-0.6	+1.3	-0.3	+1.6	-0	+1.9	-0.95	+0.95
≥ 25 < 40	-0.8	+1.4	-0.3	+1.9	-0	+2.2	-1.1	+1.1
≥ 40 < 80	-1.0	+1.8	-0.3	+2.5	-0	+2.8	-1.4	+1.4
≥ 80 < 150	-1.0	+2.2	-0.3	+2.9	-0	+3.2	-1.6	+1.6
≥ 150 < 250	-1.2	+2.4	-0.3	+3.3	-0	+3.6	-1.8	+1.8

Notes to Editors

Tom Keeling and Peter Brookes are inland waterways-based marine surveyors. Both have run independent consultancy businesses in this sector for many years, specialising in the survey of steel hull boats.

This paper is available at

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and

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