



Precision Enterprise Foundry & Machine

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Engineering Guide to Casting Design



Casting Design 101.

Draft, Wall Thickness, Typical Radius, Design Considerations



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Appendix A

Selected Aluminum Association Engineering Standards

excerpted from

Standards for Aluminum Sand and Permanent Mold Castings
12th Edition

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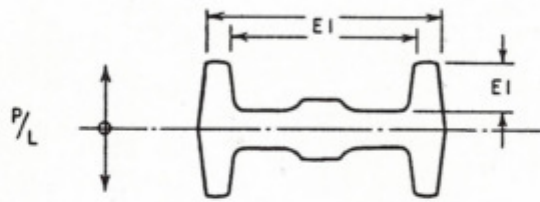
Standards For Aluminum Sand and Permanent Mold Castings



ENGINEERING SERIES (E)

AA-CS-E1-85
LINEAR TOLERANCES—One Side of
Parting Line

NOTE: The values shown herein represent normal production practice at the most economic level. Greater accuracy involving extra close work or care in production should be specified only when and where necessary since additional costs may be involved. Conversely, more liberal values should be indicated, when acceptable, as these tend to keep costs to a minimum. Any variations in these values shall not be binding on the foundry unless accepted in writing.



TOLERANCE, IN.

Sand Casting*		Permanent Mold		
			Fully machined mold cavities	Cast to size molds
Basic Tolerance up thru 6 in.	± .030	Basic Tolerance up thru 1 in.	± .015	± .030
Additional Tolerance for each additional inch over 6 in.	± .003	Additional Tolerance for each additional in.	± .002	± 0.003

*Calculated for castings produced from mounted wood or metal matchplate pattern equipment.

NOTE: The tolerances shown above must be modified when dimensions are affected by a parting line, cores and/or moving mold parts. See E2 and E3.

DRAFT: A dimension pertaining to a surface requiring draft is measured at one point on that surface only. Draft will increase or decrease such dimensions as indicated in E4.

STARTING DIMENSIONS: The points or planes from which inspection and/or machining layouts are started, should be indicated on the drawing by symbol or other means. Such designation tends to control the accumulation of tolerances, in addition to the prime purpose of establishing a common location from which to work. The points on which the casting rests for inspection should be located close to its extremities to minimize variations in alignment. See E20 for details.



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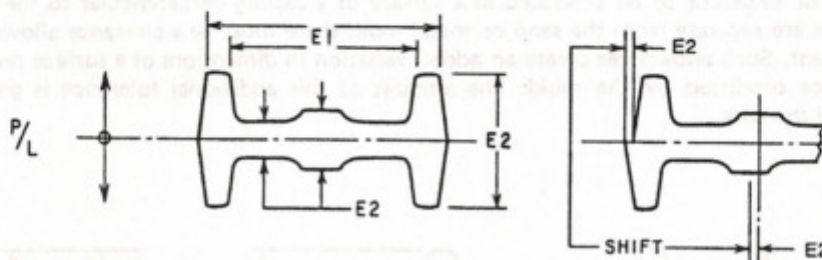
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ENGINEERING SERIES (E)

AA-CS-E2-85
LINEAR TOLERANCES—
Across Parting Line

NOTE: The values shown herein represent normal production practice at the most economic level. Greater accuracy involving extra close work or care in production should be specified only when and where necessary since additional costs may be involved. Conversely, more liberal values should be indicated, when acceptable, as these tend to keep costs to a minimum. Any variations in these values shall not be binding on the foundry unless accepted in writing.



Parting line tolerances must be added to the linear tolerances, indicated in E1, on all dimensions which cross the parting line of the casting. The tolerances in E1 reflect only the variations caused by expansion and contraction of the mold itself, the metal during solidification, patternmaking tolerances and vibration of the pattern during its removal from the mold. Dimensions *crossing* a parting line are affected by all of these, plus the hydrostatic pressure of the fluid metal, which acts as a hydraulic fluid in a cylinder, attempting to force the mold halves apart and, in sand, the tendency of the top half of the mold to 'sag' from its own weight. The amount of additional variation across the parting line therefore, is related to the 'projected area' of the casting at the parting line and the values shown below must be added to the tolerances listed in E1 on dimensions crossing the parting line. For multiple cavity molds the projected area will be the area of the mold occupied by the cavities including the area between the cavities.

E2 dimensions parallel to the parting plane, as well as those which are perpendicular, are affected if the surfaces are on opposite sides of the parting line.

(E2) ADDITIONAL TOLERANCES, IN.

Projected Area—Sq. In.	Sand Casting	Permanent Mold
Up thru 10	± .020	± .010
Over 10 thru 50	± .035	± .015
Over 50 thru 100	± .045	± .020
Over 100 thru 250	± .060	± .025
Over 250 thru 500	± .090	± .030

For over
500 square inches
of projected area
consult foundry.

Additional tolerances, in the case of cores or moving mold parts, are shown in Standard E3.



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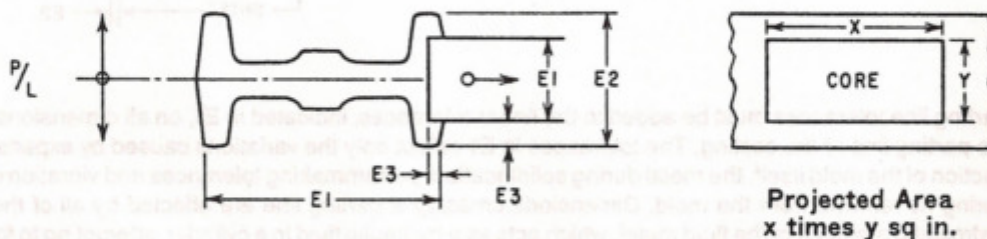
ENGINEERING SERIES (E)

AA-CS-E3-88

LINEAR TOLERANCES — Cored Areas;
Sand and Moving Parts

NOTE: The values shown herein represent normal production practice at the most economic level. Greater accuracy involving extra close work or care in production should be specified only when and where necessary since additional costs may be involved. Conversely, more liberal values should be indicated, when acceptable, as these tend to keep costs to a minimum. Any variations in these values shall not be binding on the foundry unless accepted in writing.

The use of sand and/or metal cores broaden the design flexibility of sand and permanent mold castings by allowing a hole or undercut to be produced in a surface of a casting perpendicular to the parting plane. Since these cores are separate from the sand or metal mold there must be a clearance allowance for placement or movement. Such allowances create an added variation in dimensions of a surface produced by the core to a surface produced by the mold. The amount of this additional tolerance is governed by the projected area of the core.



ADDITIONAL TOLERANCES, IN.

Projected Area—Sq In.	Sand Mold Sand Core	PM to Sand Core	PM to Metal Core
Up thru 10	± .020	± .015	± .010
Over 10 thru 50	± .035	± .025	± .015
Over 50 thru 100	± .045	± .030	± .015
Over 100 thru 250	± .060	± .040	± .022
Over 250 thru 1,000	± .090	± .060	± .032

Over 1,000 square inches, consult foundry

NOTE: The above tolerances are to be added to those determined for a dimension as provided in Standards E1 and E2. Dimensions wholly within the area of a single core need not have this tolerance added; linear tolerance, only, would apply.



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Standards For Aluminum Sand and Permanent Mold Castings



ENGINEERING SERIES (E)

AA-CS-E4-85
DRAFT REQUIREMENTS
Page 1 of 2

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All walls on castings that are perpendicular to the parting plane require draft or taper. This draft is not constant. It will vary with the length of draw (L). See sketches below and graph on Page 2 which applies to all surfaces except cored holes and pockets.

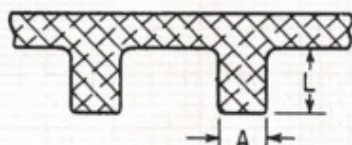


Fig. 1

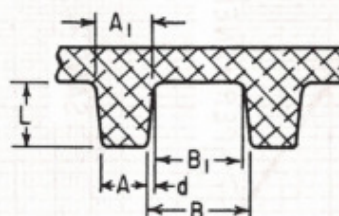


Fig. 2

Normally the drawing does not show draft (Figure 1). Standard foundry practice is to 'add' draft to the part. To avoid misunderstanding, this is synonymous with saying it will add metal to the casting, thereby increasing its size and weight.

Draft " d " will be 'added' to " A ", increasing its size to " A_1 ". Note that 'added' draft affects dimension " B " by decreasing its size to " B_1 ". This is shown in Figure 2.

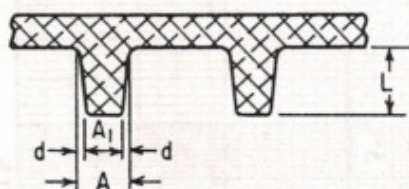


Fig. 3

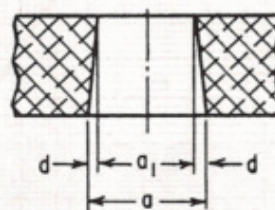


Fig. 4

Draft may be 'removed' if desired but must be specified on drawing, as shown in Figure 3.

In holes, draft will be 'added' to " a " decreasing its size to " a_1 "; see Figure 4. When the designer desires a hole dimension to become larger for reasons such as clearance, he should so indicate.

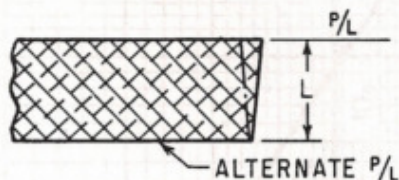


Fig. 5

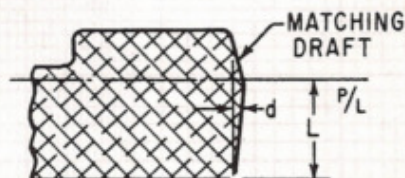


Fig. 6

The 'direction' in which draft is applied is governed by the location of the parting line and will be at the foundry's option unless otherwise specified; see Figure 5.

When a parting line interrupts a surface to which draft is applied, the amount of draft to be added will be determined by the longer portion of surface to be drawn. Drafts will be applied to the remainder of the surface to provide a match at the parting line; see Figure 6.



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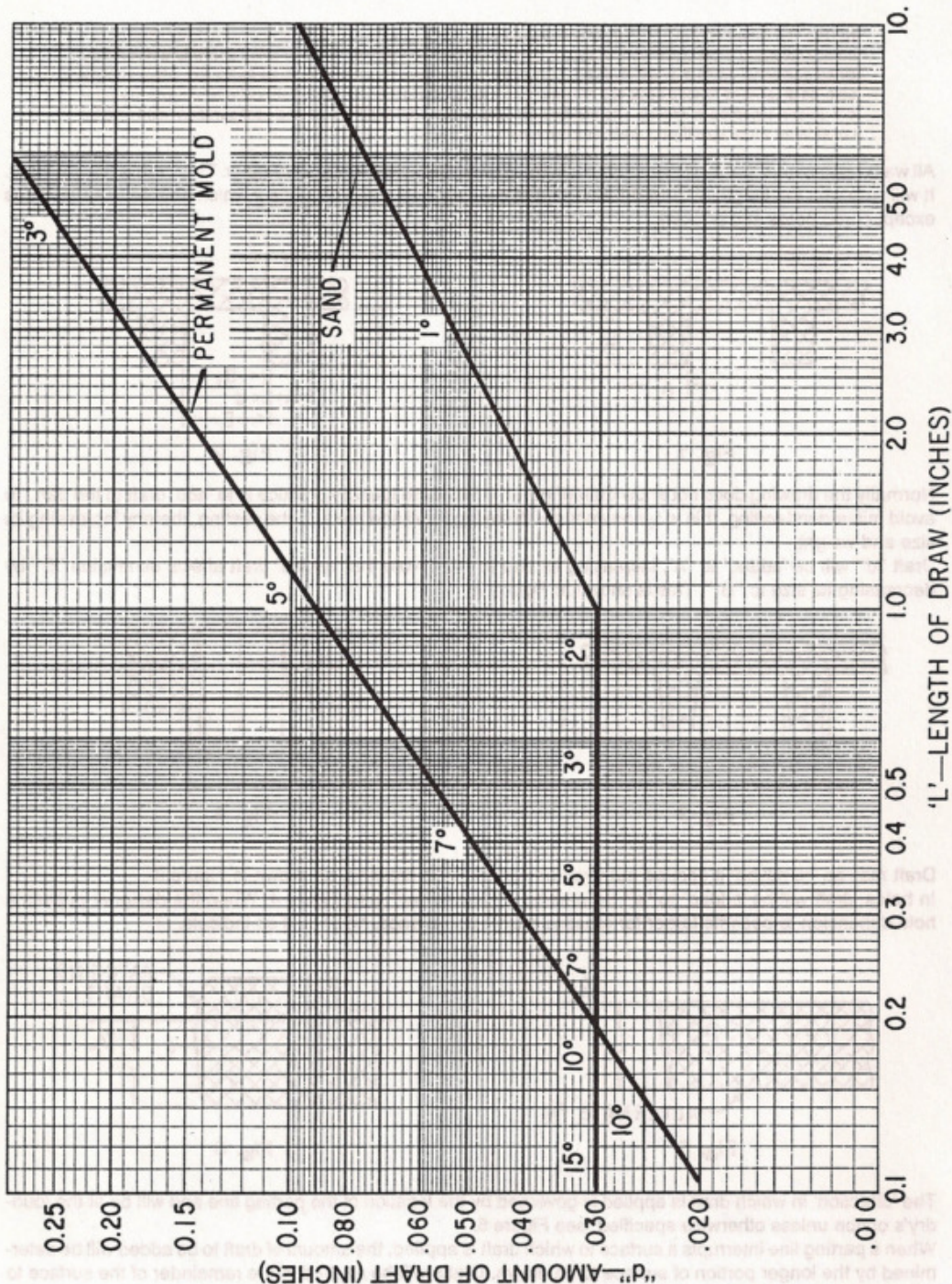
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ENGINEERING SERIES (E)

AA-CS-E4-85
DRAFT REQUIREMENTS
Page 2 of 2



NOTE: Figures shown in degrees are recommended angular draft for a given length of draw.



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ENGINEERING SERIES (E)

AA-CS-E5-85

FLATNESS-



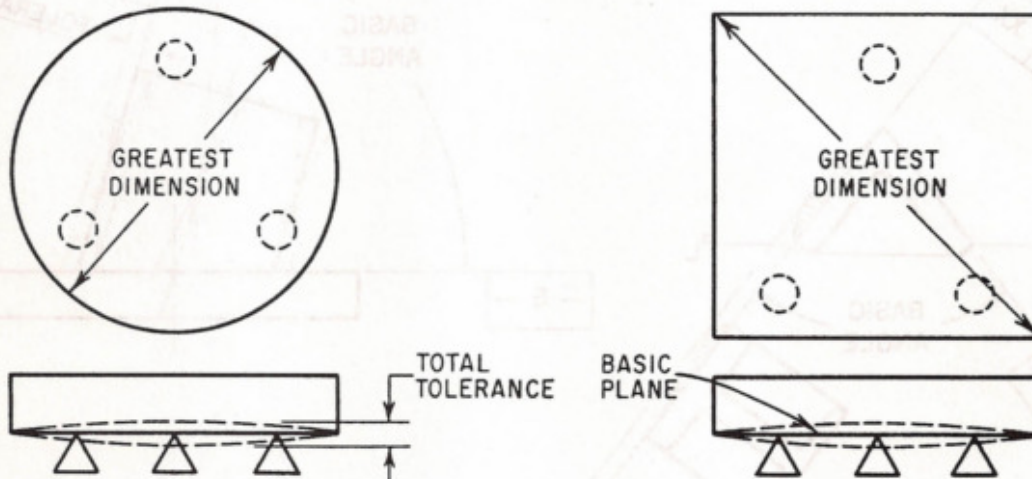
STRAIGHTNESS-



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FLATNESS: Flatness is that condition which exists when all points on a surface lie in the same plane. The surfaces of castings can be measured for flatness by supporting the surface in question on three widely separated points to establish the basic plane. The flatness variation is the deviation from that plane as measured by mutually accepted methods.

FLATNESS TOLERANCE: A flatness tolerance is that total deviation permitted from a plane and consists of the distance between two parallel planes within which the entire surface so tolerated must lie.



Greatest Dimension	Permanent Mold Tolerance	Sand Tolerance
0 thru 6 in.	within 0.020 in.	within 0.030 in.
each add'l. inch thru 24 in.	0.003 in. per inch	0.003 in. per inch

For castings over 24 inches consult foundry.

Checking for flatness will be performed only on those surfaces specified.

On castings of such configuration and/or alloy where it becomes impossible or impractical to straighten, exceptions to the above tolerances are required. In such cases the foundry should be consulted.

Tolerances closer than the above can at times be obtained. Special gauges and fixtures requiring extra costs may be needed.

STRAIGHTNESS: Straightness is that condition which, when matched with a true straight edge of a true flat surface, will permit full line contact along the full length. Tolerance should be discussed with foundry.



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Standards For Aluminum Sand and Permanent Mold Castings



ENGINEERING SERIES (E)

AA-CS-E11-85

ANGULARITY—

$\angle$ B .XX

PERPENDICULARITY—

$\perp$ A .XX

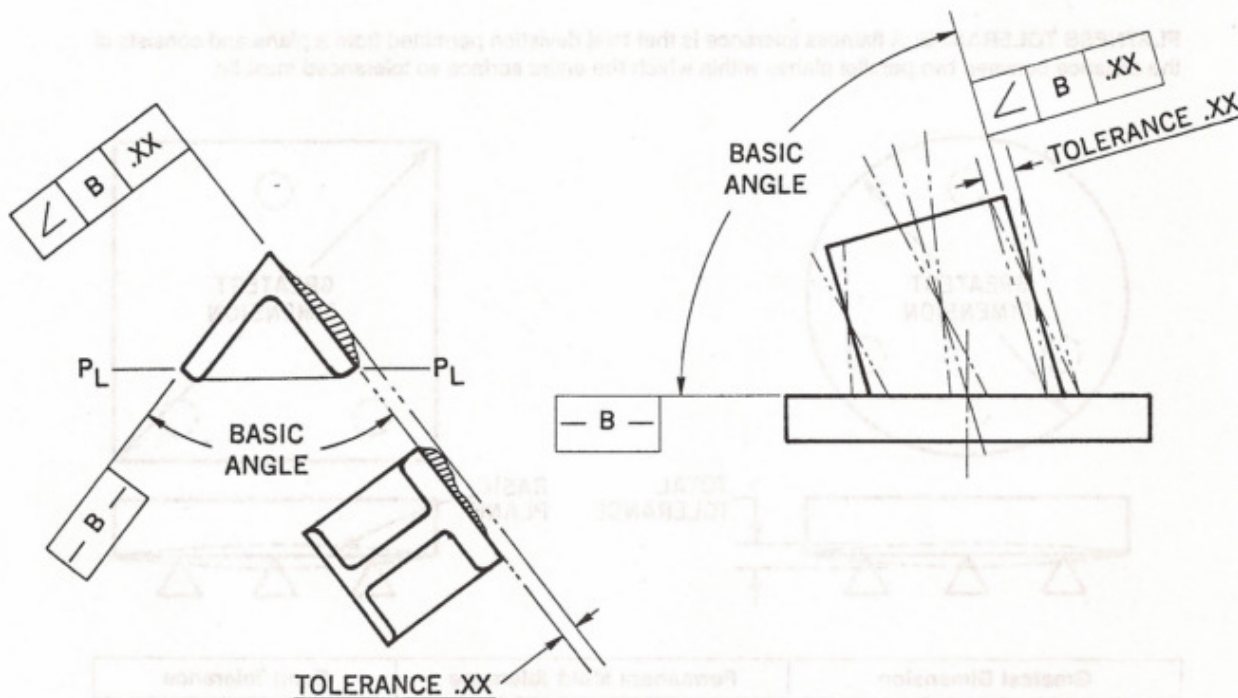
PARALLELISM—

// A .XX

PAGE 1 OF 4

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The angularity (including perpendicularity & parallelism) tolerance is the total deviation between two planes within which the entire surface, so tolerated, must lie. The planes of deviation (tolerance zone) forms the basic angle to the datum plane which is expressed by the symbol $\angle$ B .XX



The tolerances indicated (Page 2 & Page 3) are for those surfaces or planes that are normally considered to be free of any draft requirements.

Engineering Standard E-5, Flatness and Straightness, tolerances must be considered in establishing planes, and must be added to the above.

ANGULARITY: Angularity refers to the angular departure from the designed relationship between the elements of a casting. The angular accuracy is affected by numerous factors including the size of the casting, the strength and rigidity of the mold and mold parts under conditions of high temperature, positioning of mold members, distortion during handling, and heat treating the casting. The angularity of cored holes may vary as a result of distortion and wear of metal cores and wear of core boxes.

This standard may be applied to plane surfaces of, or cored holes in, permanent mold or sand castings.



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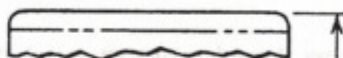


ENGINEERING SERIES (E)

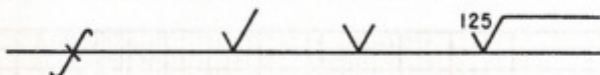
AA-CS-E13-66
MACHINE FINISH ALLOWANCE

Drawings furnished for the manufacture of castings usually picture the finished part after machining or the casting prior to machining.

CASTING DRAWINGS: Drawings showing the casting prior to machining should have the finish allowance indicated in table included in the dimensions shown and no finish symbols added. It is recommended that an undimensioned phantom line be used to represent surfaces after machining, thus enabling the foundry to recognize them for processing reference.



FINISHED PART DRAWINGS: The symbols which follow represent those most commonly used on finished part drawings to indicate those surfaces requiring allowance for subsequent machine operations. Generally, only surfaces so marked will have such allowance added.



CAUTION: Confusion arises with drawings on which some 3-place decimal dimensions appear to surfaces showing *no* finish symbol, while the majority of the dimensions are fractional or 2-place decimals. The normal title box tolerance of $\pm .005$ or $.010$ on such 3-place decimal dimensions cannot be held without machining. It is, therefore, imperative that the designer's intention be clearly indicated to avoid costly misunderstandings.

Following is a table showing the amount of metal normally added for machining. The amount of material to be added is related to the overall size of the casting rather than varying with individual dimensions. The designer should select that line on the table below showing the range within which the casting's greatest dimension falls. The finish allowance shown next to this range is then used on *all* surfaces requiring machining.

MACHINE FINISH ALLOWANCE, IN.

Greatest Dimension, In.	Sand	Cores in PM's		Perm. Mold
		Sand	Shell	
Up thru 6	.060	.060	.060	.045
Over 6 thru 12	.090	.090	.060	.060
Over 12 thru 18	.120	.120	.090	.075
Over 18 thru 24	.150	.180	.120	.090
Over 24	CONSULT FOUNDRY			

The values given in above table are based on a maximum "build-up" or a "safety factor" for average casting variations of flatness, squareness, concentricity, etc., as well as linear tolerance. The values are minimum recommended and foundry draft when required must be added to above values.



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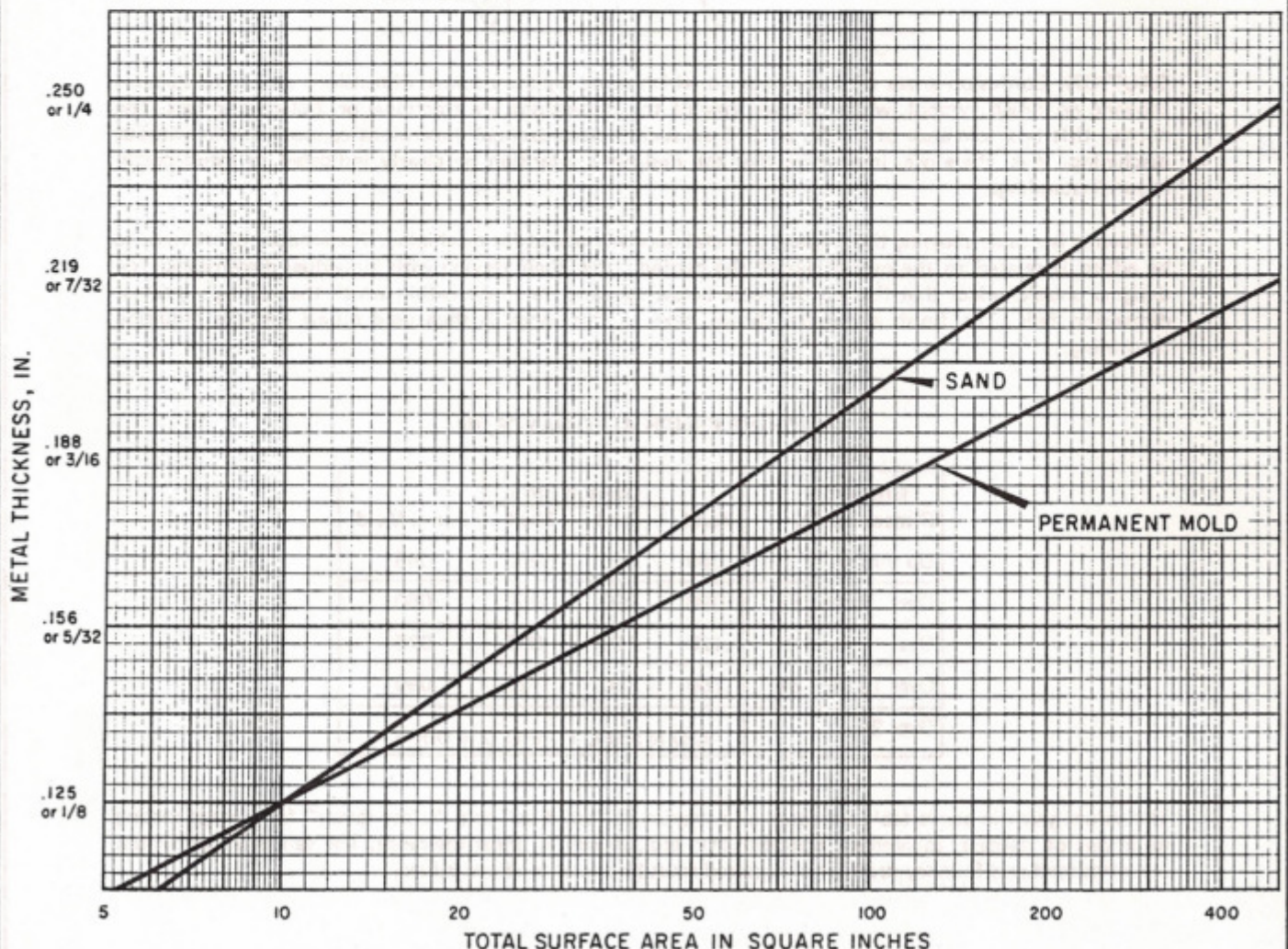
ENGINEERING SERIES (E)

AA-CS-E19-66
METAL THICKNESS

Many conditions and specifications affect the ability of foundries to cast to a desired metal wall thickness i.e.

- (1) fluidity of alloy
- (2) metallurgical quality
- (3) design
- (4) surface finish
- (5) pattern or mold equipment

The figures in the graph below show desired minimum metal thickness that should be specified for aluminum castings of minimum complexity. When metal flow is restricted, or other factors become more important, an increase in values shown may be required.





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Table 5-4. Relative Comparison of Characteristics of Aluminum Sand Casting Alloys

Alloy	Hot Crack Resistance	Pressure Integrity	Castability (Fluidity)	Shrinkage Tendency	Corrosion Resistance	Machinability	Weldability
201.0	4	3	3	4	4	1	2
208.0	2	2	2	2	4	3	3
213.0	3	3	2	3	4	2	2
222.0	4	4	3	4	4	1	3
240.0	4	4	3	4	4	3	4
242.0	4	3	4	4	4	2	3
A242.0	4	4	3	4	4	2	3
295.0	4	4	4	3	3	2	2
319.0	2	2	2	2	3	3	2
354.0	1	1	1	1	3	3	2
355.0	1	1	1	1	3	3	2
A356.0	1	1	1	1	2	3	2
357.0	1	1	1	1	2	3	2
359.0	1	1	1	1	2	3	1
A390.0	3	3	3	3	2	4	2
A443.0	1	1	1	1	2	4	4
444.0	1	1	1	1	2	4	1
511.0	4	5	4	5	1	1	4
512.0	3	4	4	4	1	2	4
514.0	4	5	4	5	1	1	4
520.0	2	5	4	5	1	1	5
535.0	4	5	4	5	1	1	3
A535.0	4	5	4	4	1	1	4
B535.0	4	5	4	4	1	1	4
705.0	5	4	4	4	2	1	4
707.0	5	4	4	4	2	1	4
710.0	5	3	4	4	2	1	4
711.0	5	4	5	4	3	1	3
712.0	4	4	3	3	3	1	4
713.0	4	4	3	4	2	1	3
771.0	4	4	3	3	2	1	...
772.0	4	4	3	3	2	1	...
850.0	4	4	4	4	3	1	4
851.0	4	4	4	4	3	1	4
852.0	4	4	4	4	3	1	4

Note: 1 = best; 5 = worst. From *Metals Handbook, Ninth Edition, Volume 15: Casting*. © 1988, ASM International.