آلیاژهای مس
Cu alloys casting

درجه سانتیگراد	ترکیب شیمیائی	
نقطه ذوب تقریبی	درصد عناصر آلیاژی	در صد مس
۸۶۰	۲۷ Mn	۷۳
۹۰۰	۱۵–۷ Be	۸۵ – ۹۳
۱۴۵۰	۱۰–۵ Fe	۹۰ – ۹۵
۹۰۰ – ۱۰۰۰	۱۰–۷ P	۹۰ – ۹۳
۸۰۰	۱۶ Si	۸۴
۱۰۰۰	۲۵ Si	۷۵
۶۸۰	۵۰ Sb	۵۰
۷۸۰	۵۰ Sn	۵۰
۵۸۰	۵۰ Al	۵۰
۱۰۵۰ – ۱۲۵۰	۳۳–۱۵ Ni	۶۷ – ۸۵
۶۷۰	۵۰ Al ۱۰ Ni	۴۰
۸۳۰	۷۰ Al ۱۰ Fe	۲۰

جدول ۵ – ۸ هاردنرهای مورد استفاده در ریخته گری آلیاژهای مس

مشخصات	فسفر	نیکل	سرب	روی	قلع	مس	نام آلیاژ
بعد از افزایش روی بهم زده شود	—	—	—	۲	—	۱	برنج
"	—	—	—	۳	۲	۱	برنج قلع
قبل از ریختن خوب مخلوط شود	—	—	—	۳	۲	۱	آلیاژ توپ ۲–۱۰–۸۸
"	—	—	۳	۴	۲	۱	آلیاژ توپ ۵–۵–۵–۸۸
"	۲و۴			۳	—	۱	فسفر برنز
"	—	۱و۲	۴	۵	۳	۱و۲	ورشو
"	—	۱و۲	—	—	—	۱و۲	نیکل برنز

جدول ۶ — ۸ ترتیب و تقدم ذوب و شارژ عناصر اصلی آلیاژهای مس

نوع آلیاژ	درجه‌حرارت فوق ذوب t_s °C	درجه‌حرارت ریختن t_p °C	فلاکس‌پوششی	اکسیژن‌زدا
برنج قرمز سرخ	۱۱۲۰ — ۱۲۶۰	۱۰۷۰ — ۱۲۱۰	a , b	فسفرکوئیورو ۱/۵درصد
برنج‌زردسرخ	۱۱۲۰ — ۱۲۶۰	۱۱۲۰ ماکزیمم	a , b	فسفریاآلومنیوم
برنج زرد مقاوم،منگنز برنز	۹۲۰ — ۹۷۰	۹۴۰ ماکزیمم	a , b , c	فسفر کوئیورو ۰/۵درصد
برنز قلع، برنز قلع و سرب	۱۱۲۰ — ۱۳۰۰	۱۰۷۰ — ۱۲۱۰	a, b , d	فسفر کوئیورو ۱/۵درصد
برنزقلع پر سرب	۱۲۰۰ — ۱۳۰۰	۹۲۰ — ۱۲۰۰	a,b,c,d	"
برنز نیکل، برنزنیکل‌سرب	۱۱۷۰ — ۱۴۰۰	(t_s — ۵۰)		منیزیم یافسفریا منگنز
برنج‌وبرنز‌ـ های‌سیلیسیم	۱۰۷۰ — ۱۲۱۰	(t_s — ۵۰)	a , b	a
آلومینیم‌برنز	۱۰۷۰ — ۱۲۱۰	(t_s — ۵۰)	a	a

جدول ۴ — ۹ ذوب و ریخته گری بعضی از آلیاژهای مس

توضیح : a= احتیاج نیست . b شیشه و براکس ذغال چوب c سنگ آهک d و فلدسپات

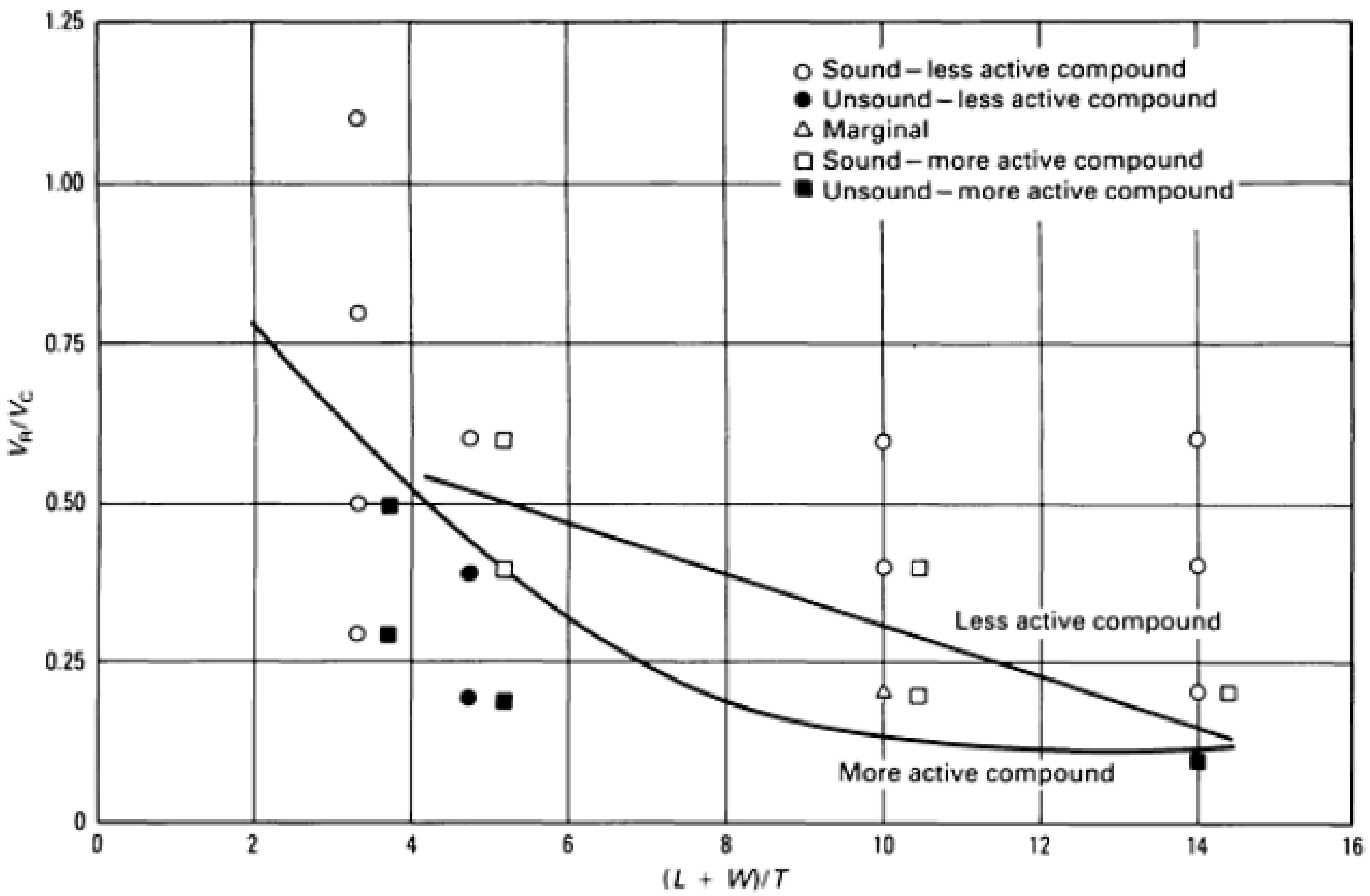
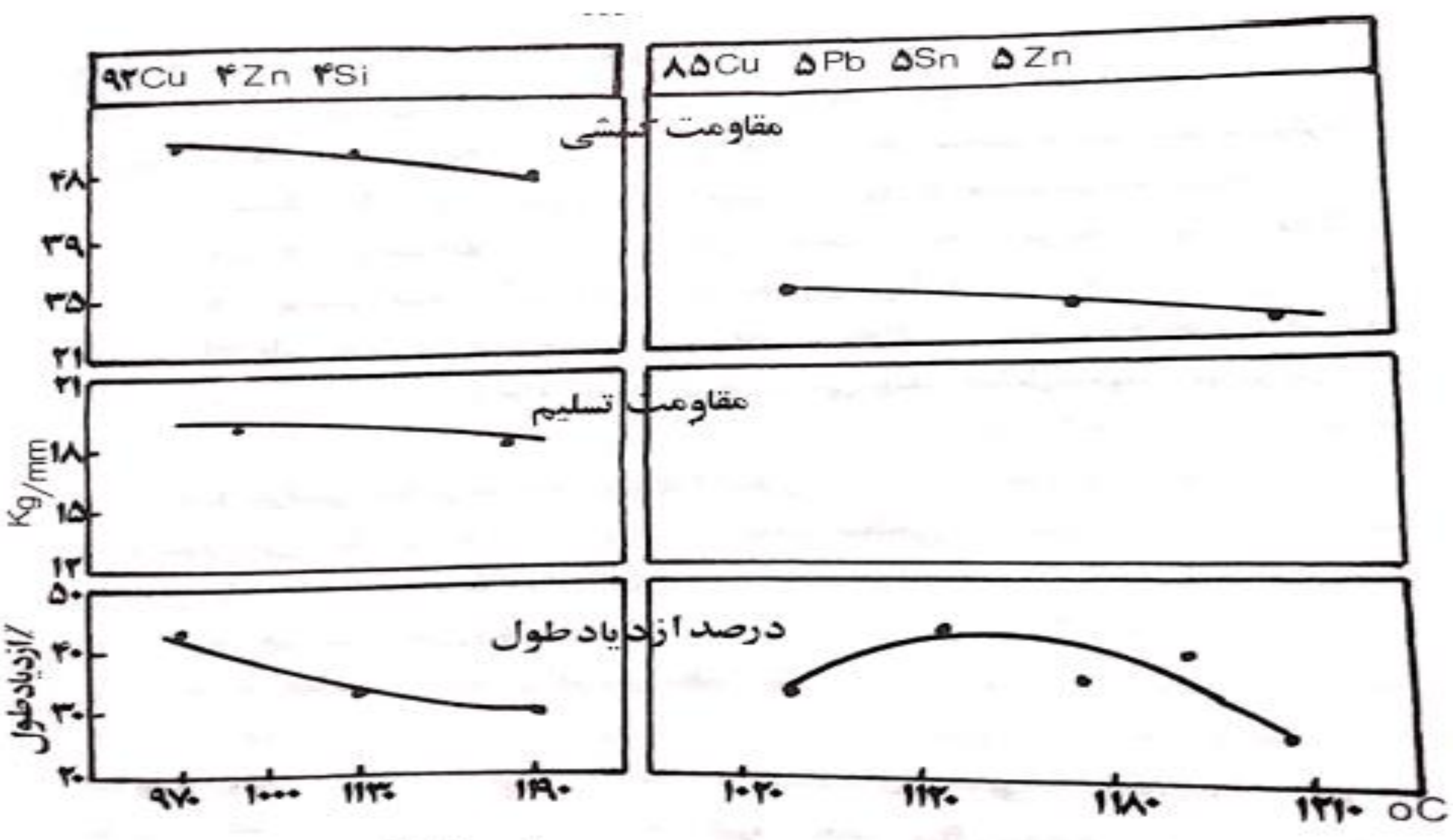


Fig. 20 NRL-type riser curve for aluminum bronze (alloy C95300) using different types of exothermic hot topping and top risers. Source: Ref 5.



۱۲۰. ۹ — ۹ تاءثیر درجه حرارت ریختن در خواص مکانیکی دو نوع آلیاژ مس

$$G_a = \frac{X\sqrt{W}}{\sqrt{H_e}}$$

که در آن

X ضریب بار ریزی و حدوداً برابر $\frac{T}{10}$ می‌باشد که T ضخامت قطعه ریختگی است (اینچ)

H_e ارتفاع مؤثر راهگاه (اینچ)

W وزن قطعه ریختگی بر حسب پوند می‌باشد

از طرف دیگر ارتفاع مؤثر تحت تأثیر پارامترهای مستقل براساس فرمول زیر محاسبه می‌گردد

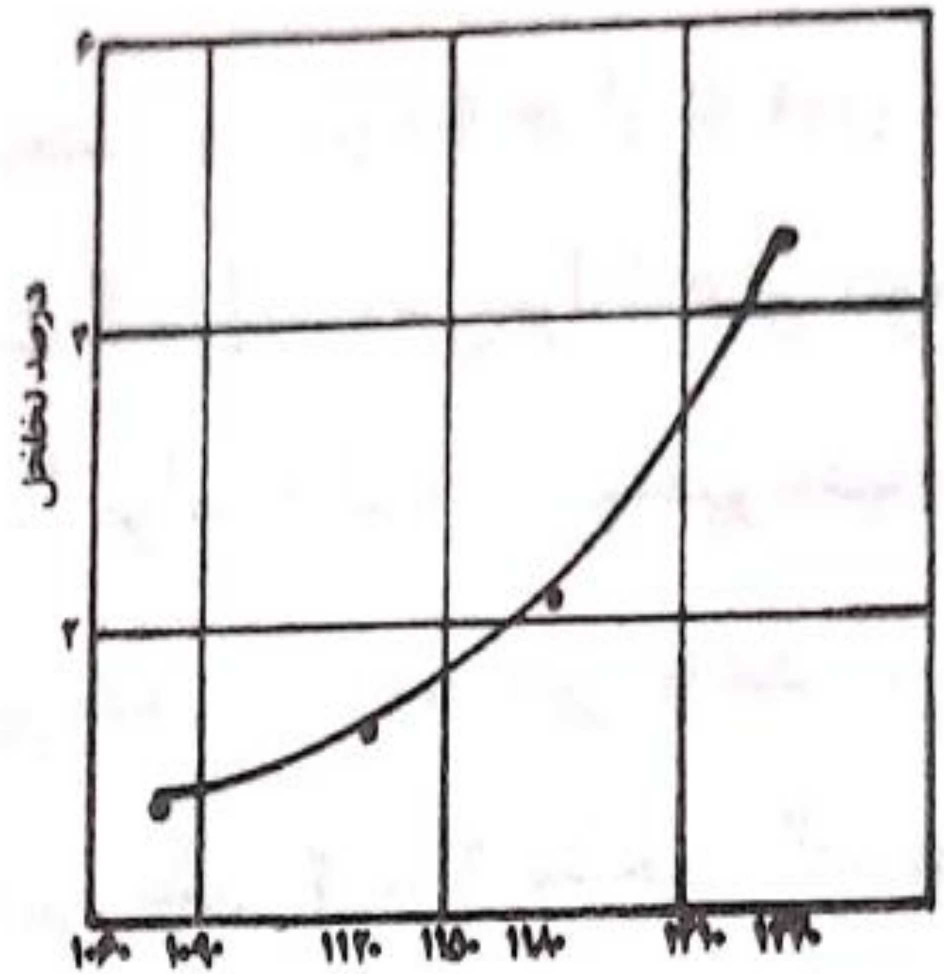
$$H_e = \frac{2Hc - C_q^2}{2C}$$

که :

H اختلاف ارتفاع سطح کانال از بالاترین نقطه سطح مذاب (حوضچه)

C ارتفاع کلی قطعه و

C_q ارتفاع قطعه از سطح کانال فرعی می‌باشد



تاءثیر درجه حرارت ریختن در میزان تخلخل برنج قرمز

Group I alloys are alloys that have a narrow freezing range, that is, a range of 50 °C (90 °F) between the liquidus and solidus.

Group II alloys are those that have an intermediate freezing range, that is, a freezing range of 50 to 110 °C (90 to 200 °F) between the liquidus and the solidus.

Group III alloys have a wide freezing range. These alloys have a freezing range of well over 110 °C (200 °F), even up to 170 °C (300 °F).

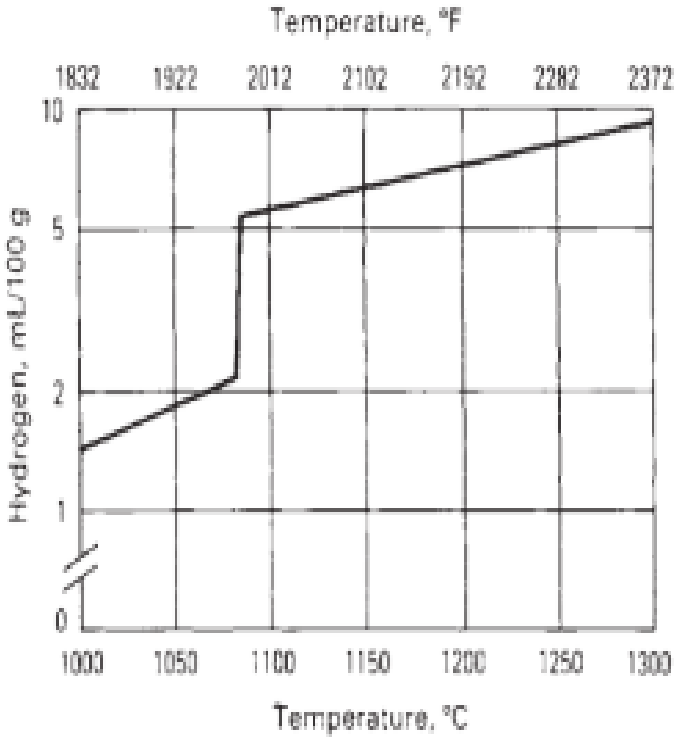


Fig. 13 Solubility of hydrogen in copper. Source: Ref 7

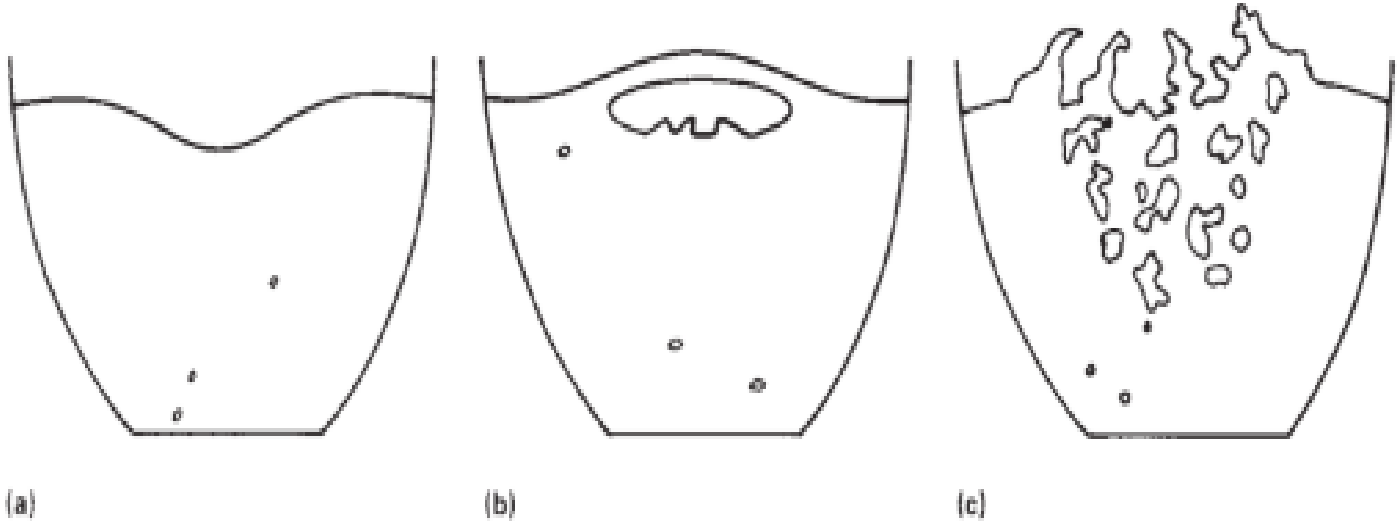


Fig. 16 Effect of pressure on the appearance of copper alloy reduced-pressure test samples containing the same amount of gas. (a) Pressure of 7 kPa (55 torr) results in surface shrinkage. (b) At 6.5 kPa (50 torr), a single bubble forms. (c) Boiling and porosity occur at 6 kPa (45 torr).

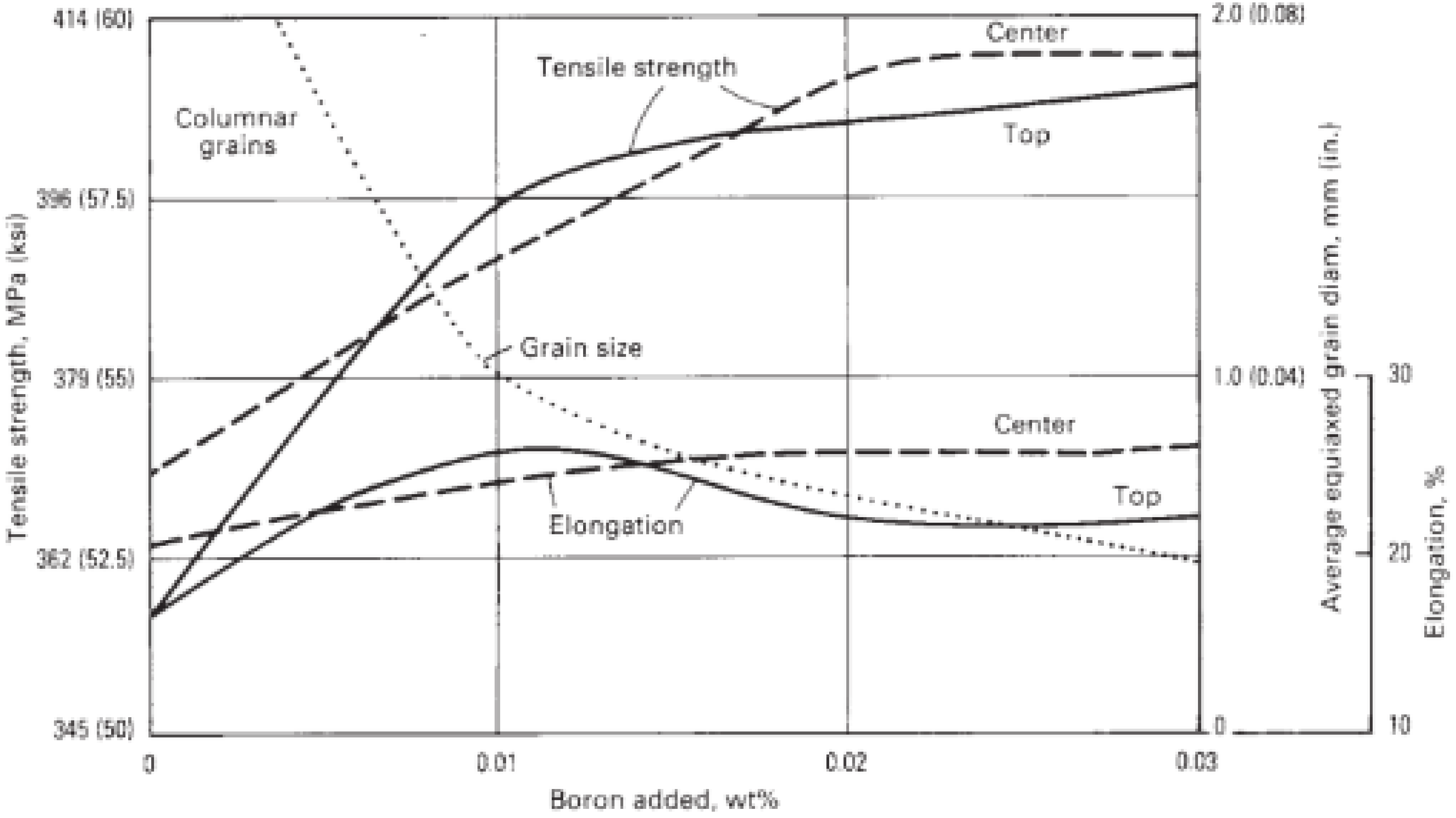


Fig. 25 Effect of boron-refined grain size on the mechanical properties of Cu-10Al alloy. Test specimens were removed from the center or the top of the ingot as indicated. Source: Ref 27

Table 8 Technical factors in the choice of casting method for copper alloys

Casting method	Copper alloys	Size range	General tolerances	Surface finish	Minimum section thickness	Ordering quantities	Relative cost, (1 low, 5 high)
Sand	All	All sizes, depends on foundry capability	± 1/32 in up to 3 in.; ± 3/64 in.; 3-6 in.; add ± 0.003 in./in. above 6 in.; add ± 0.020 to ± 0.060 in. across parting line	150-500 μin. rms	1/8 – 1/4 in.	All	1–3
No-bake	All	All sizes, but usually > 10 lb	Same as sand casting	Same as sand casting	Same as sand casting	All	1–3
Shell	All	Typical maximum mold area = 550 in.^{2}, typical maximum thickness = 6 in.	± 0.005–0.010 in. up to 3 in.; add ± 0.002 in./in. above 3 in.; add ± 0.005 – 0.010 in. across parting line.	125–200 μin. rms	3/32 in.	≥100	2–3
Permanent mold	Coppers, high-copper alloys, yellow brasses, high-strength brasses, silicon bronze, high-zinc silicon brass, most tin bronzes, aluminum bronzes, some nickel silvers	Depends on foundry capability; best, ~ 50 lb Best max thickness, ~ 2 in.	Usually ±0.010 in.; optimum ± 0.005 in., ±0.002 in. part-to-part	150–200 μin. rms. best ~ 70 μin. rms	1/8 – 1/4 in.	100–1,000, depending on size.	2–3
Die	Limited to C85800, C86200, C86500, C87800, C87900, C99700, C99750, and some proprietary alloys	Best for small, thin parts; max area ≤3 ft^2	±0.002 in./in.; no less than 0.002 in. on any one dimension; add ±0.010 in. on dimensions affected by parting line	32–90 μin. rms	0.05–0.125 in.	>1,000	1
Plaster	Coppers, high-copper alloys, silicon bronze, manganese bronze, aluminum bronze, yellow brass	Up to 800 in.^{2}, but can be larger	One side of parting line, ±0.015 in. up to 3 in.; add ±0.002 in./in. above 3 in.; add 0.010 in. across parting line, and allow for parting line shift of 0.015 in.	63–125 μin. rms, best ~ 32 μin. rms	0.060 in.	All	4
Investment	Almost all	Fraction of an ounce to 150 lb, up to 48 in.	±0.003 in. less than 1/4 ; ±0.004 in. between 1/4 to 1/2 in.; ±0.005 in./in. between 1/2 –3 in.; add ±0.003 in./in. above 3 in.	63–125 μin. rms	0.030 in.	>100	5
Centrifugal	Almost all	Ounce to 25,000 lb. Depends on foundry capacity	Castings are usually rough machined by foundry.	Not applicable	1/4 in.	All	1–3

Source: Ref 29

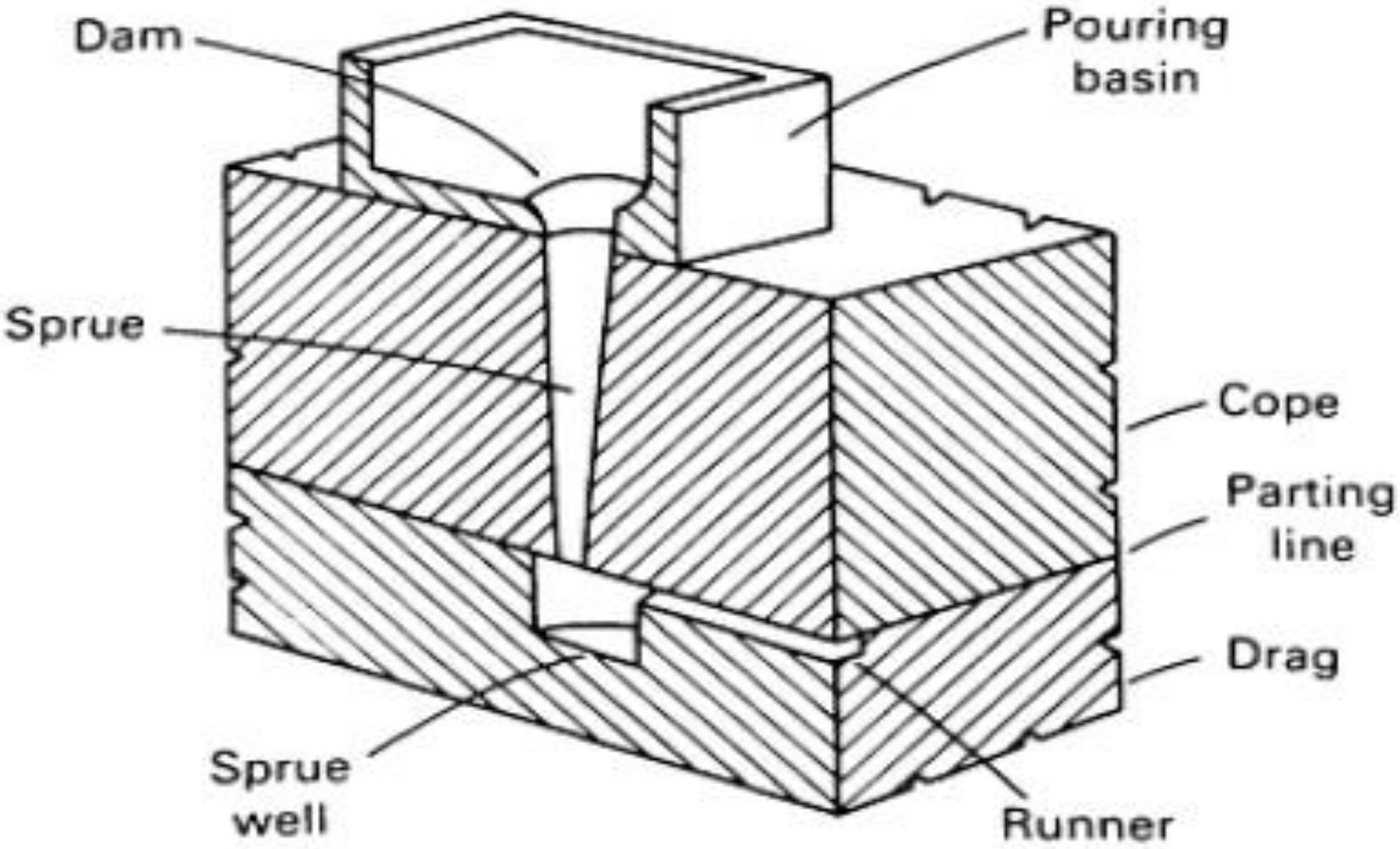


Fig. 7 Section of a typical sand mold with pouring basin.

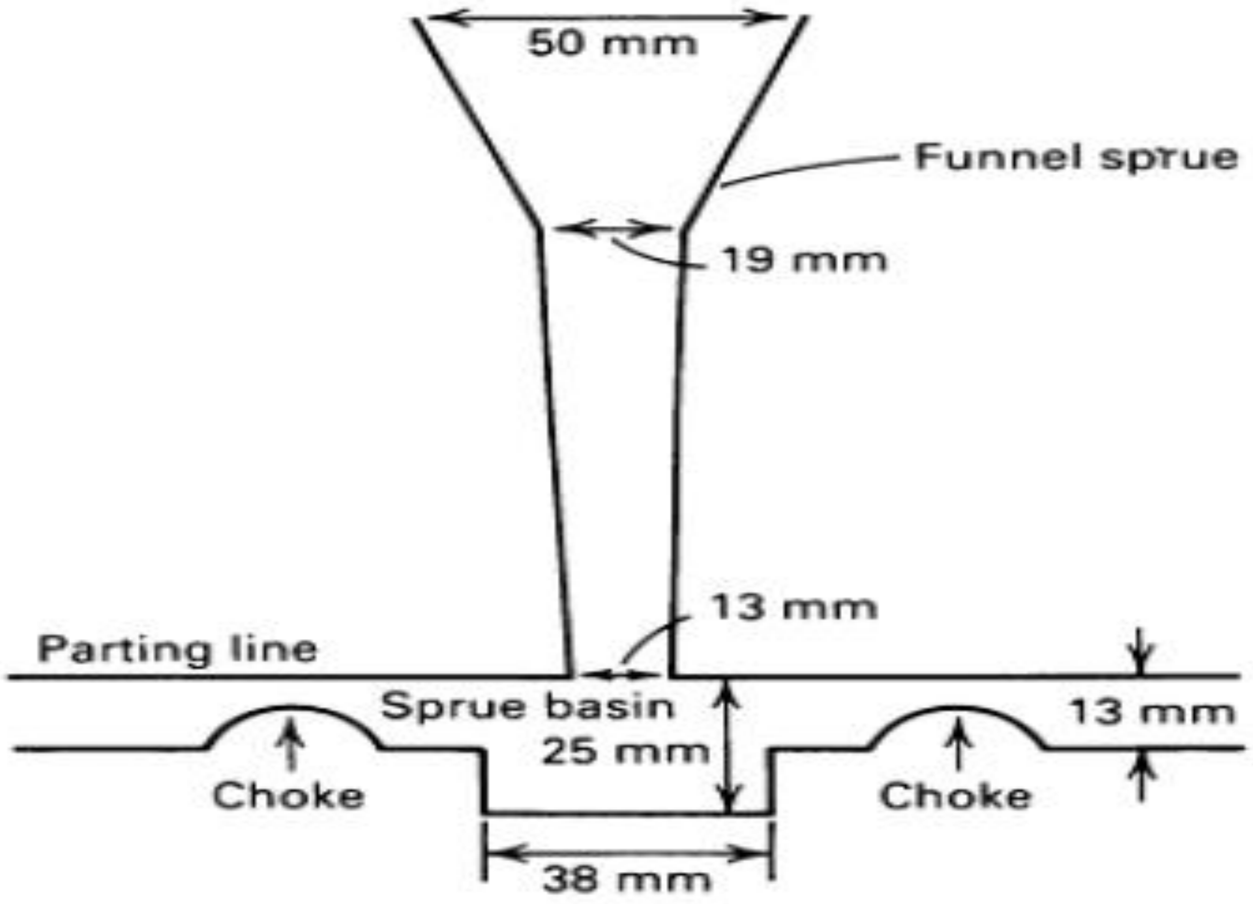


Fig. 8 Funnel sprue, sprue basin, and chokes for reducing turbulence.

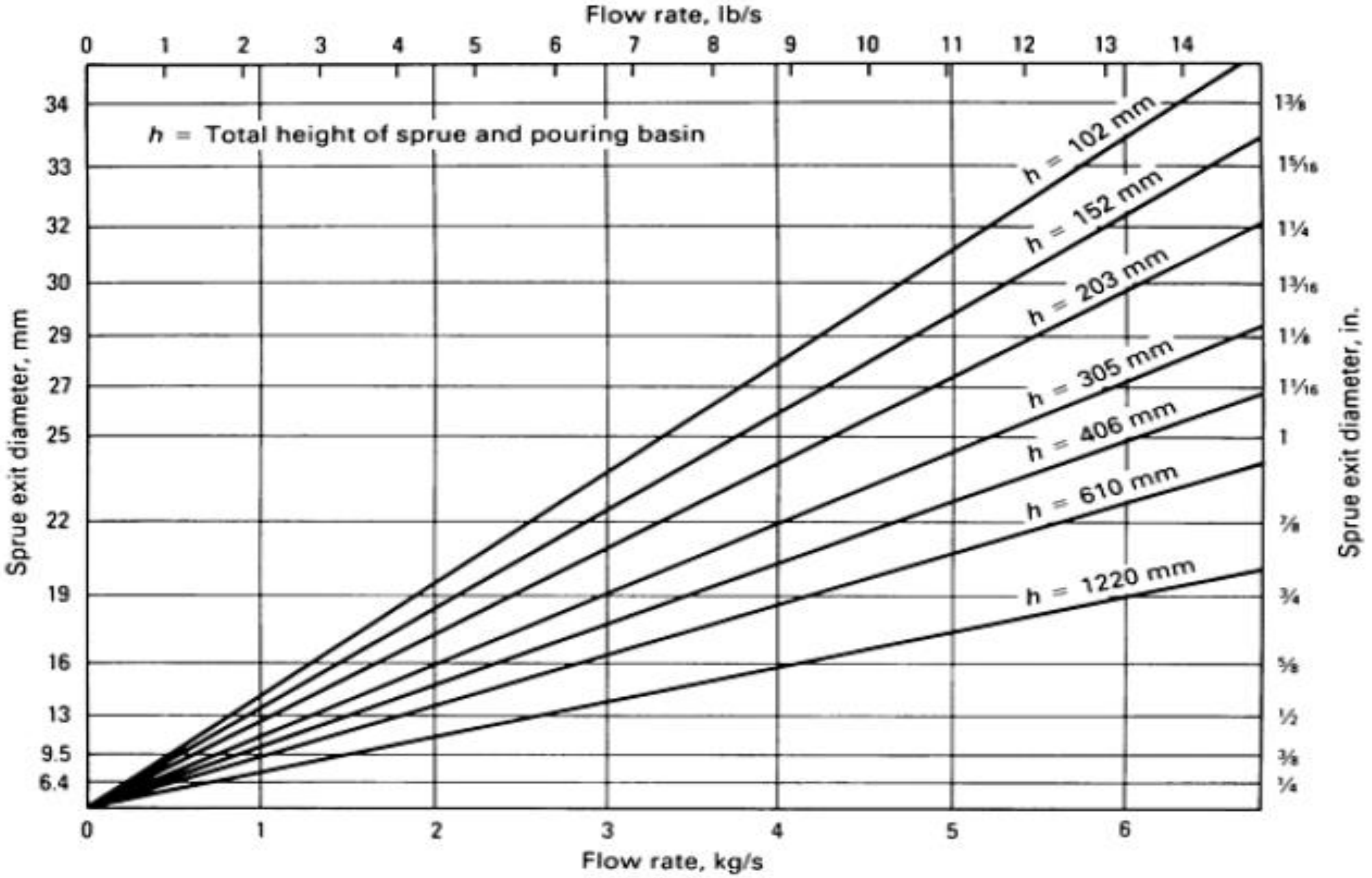


Fig. 9 Flow rates of copper-base alloys through tapered sprues of varying diameter and height.

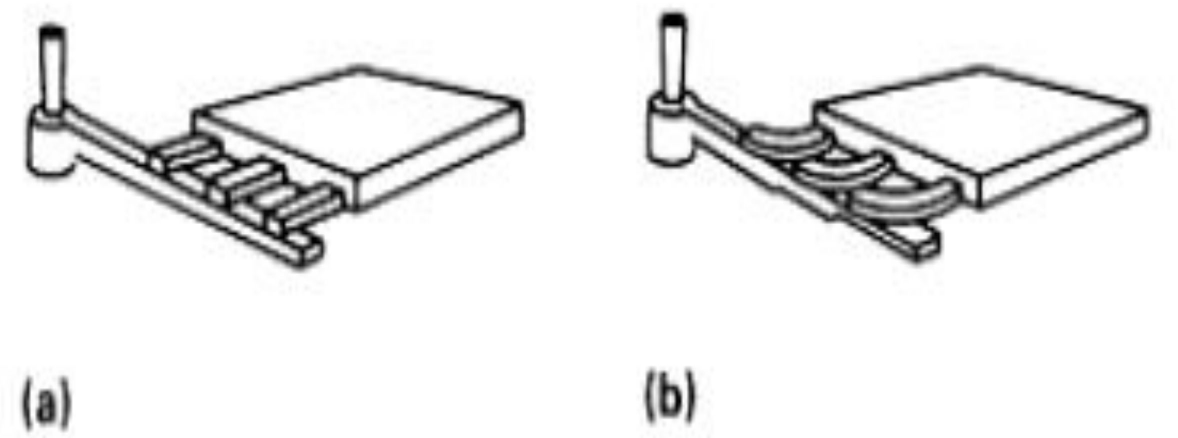


Fig. 10 Typical single-cavity gating systems. (a) Tapered runner. (b) Stepped runner.

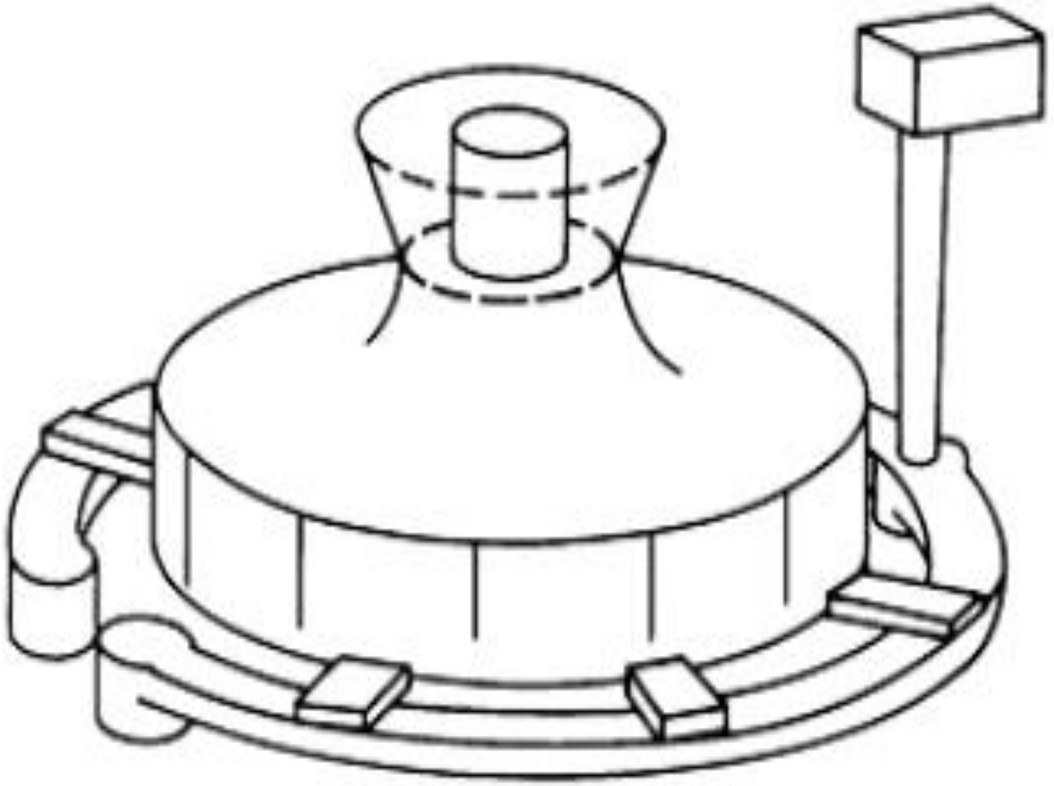


Fig. 11 Method of running a pump impeller with a well at the end of the runner.

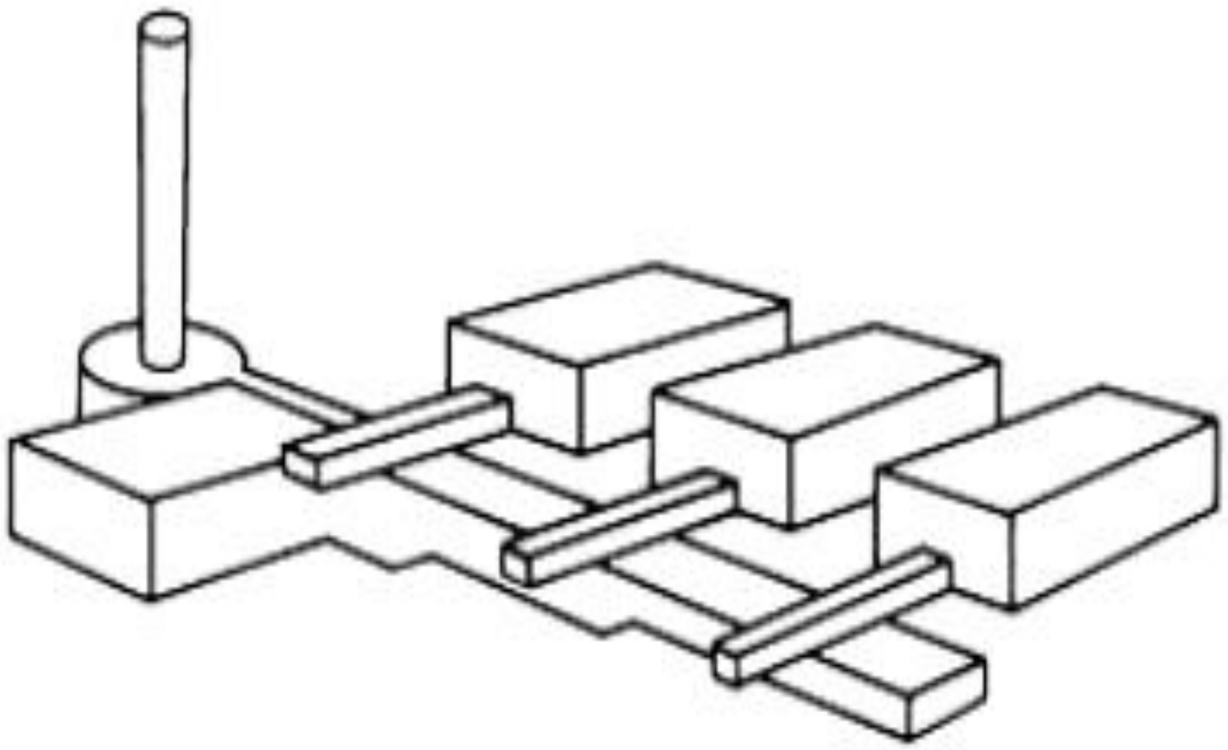


Fig. 12 Recommended multiple-cavity gating system with stepped runner.

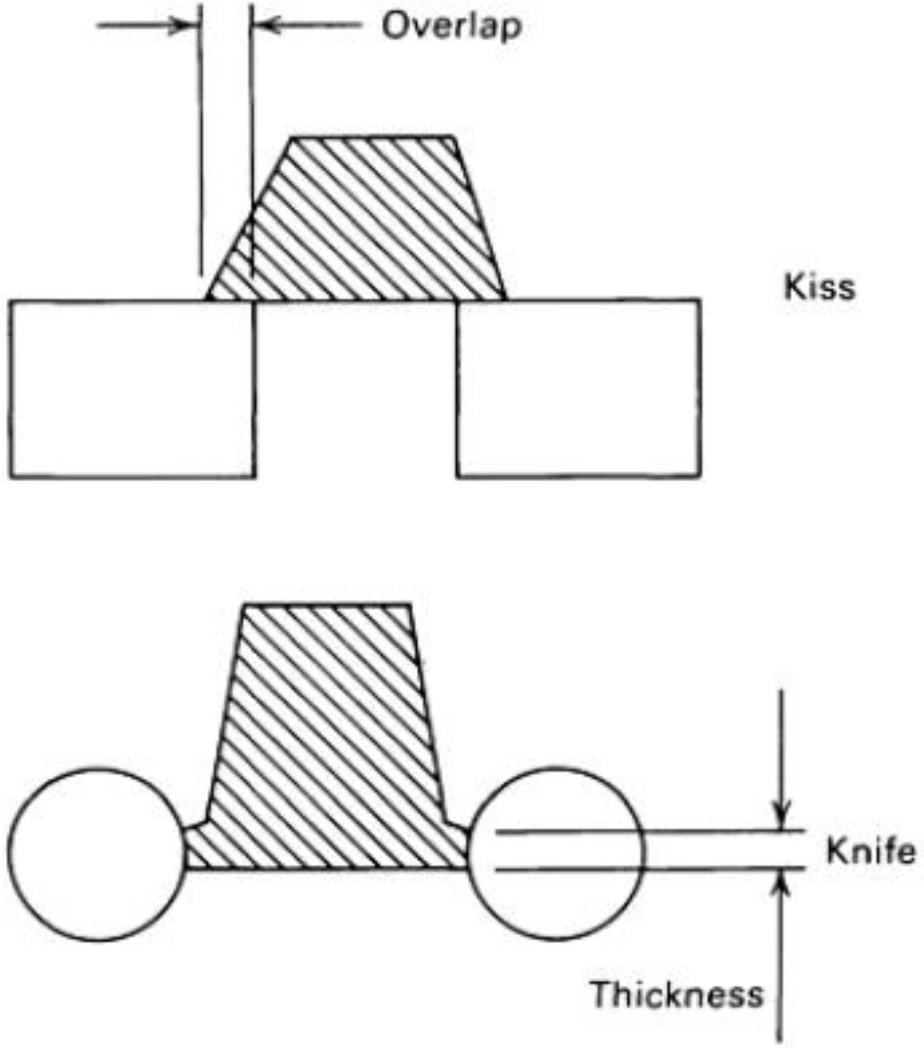


Fig. 13 Basic kiss and knife gates.

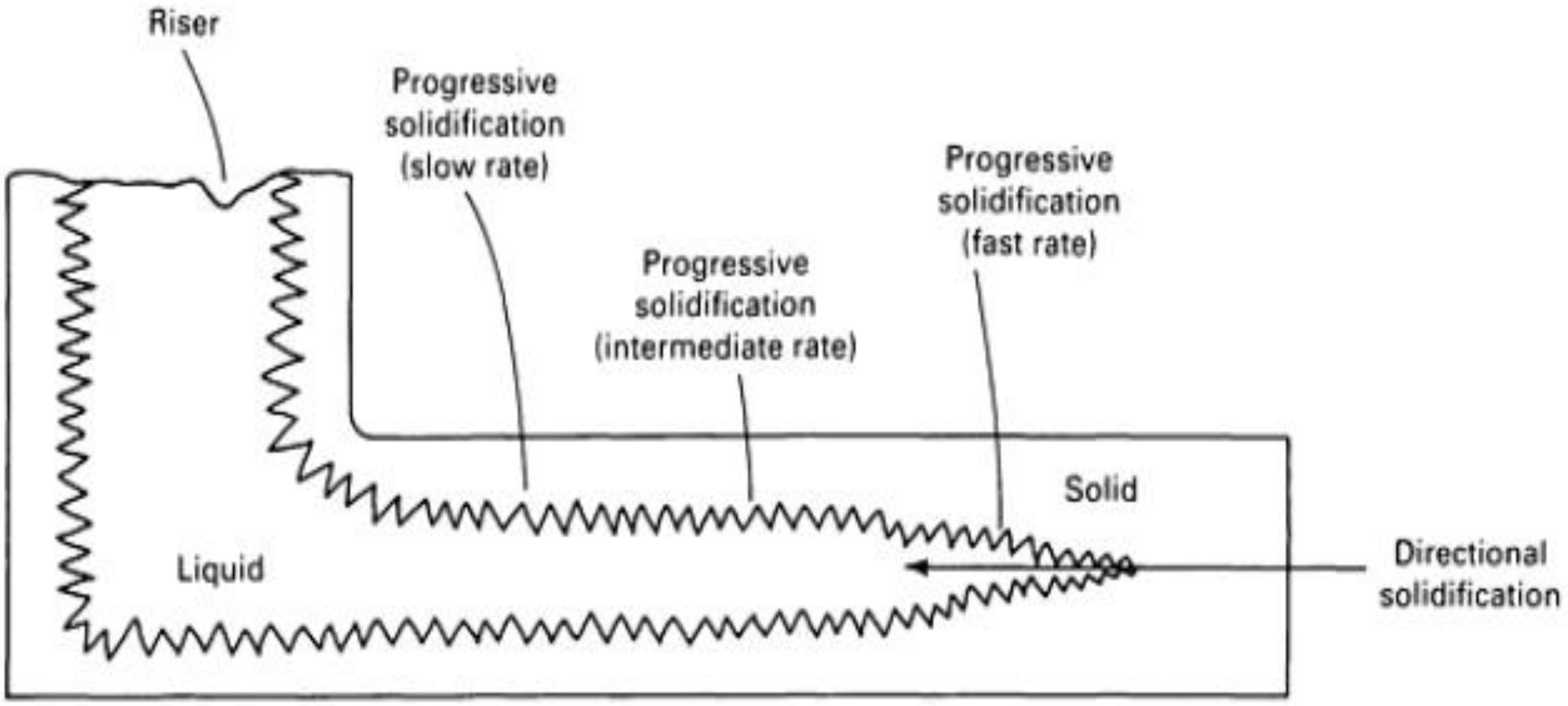


Fig. 14 Features of progressive and directional solidification. Source: Ref 2.

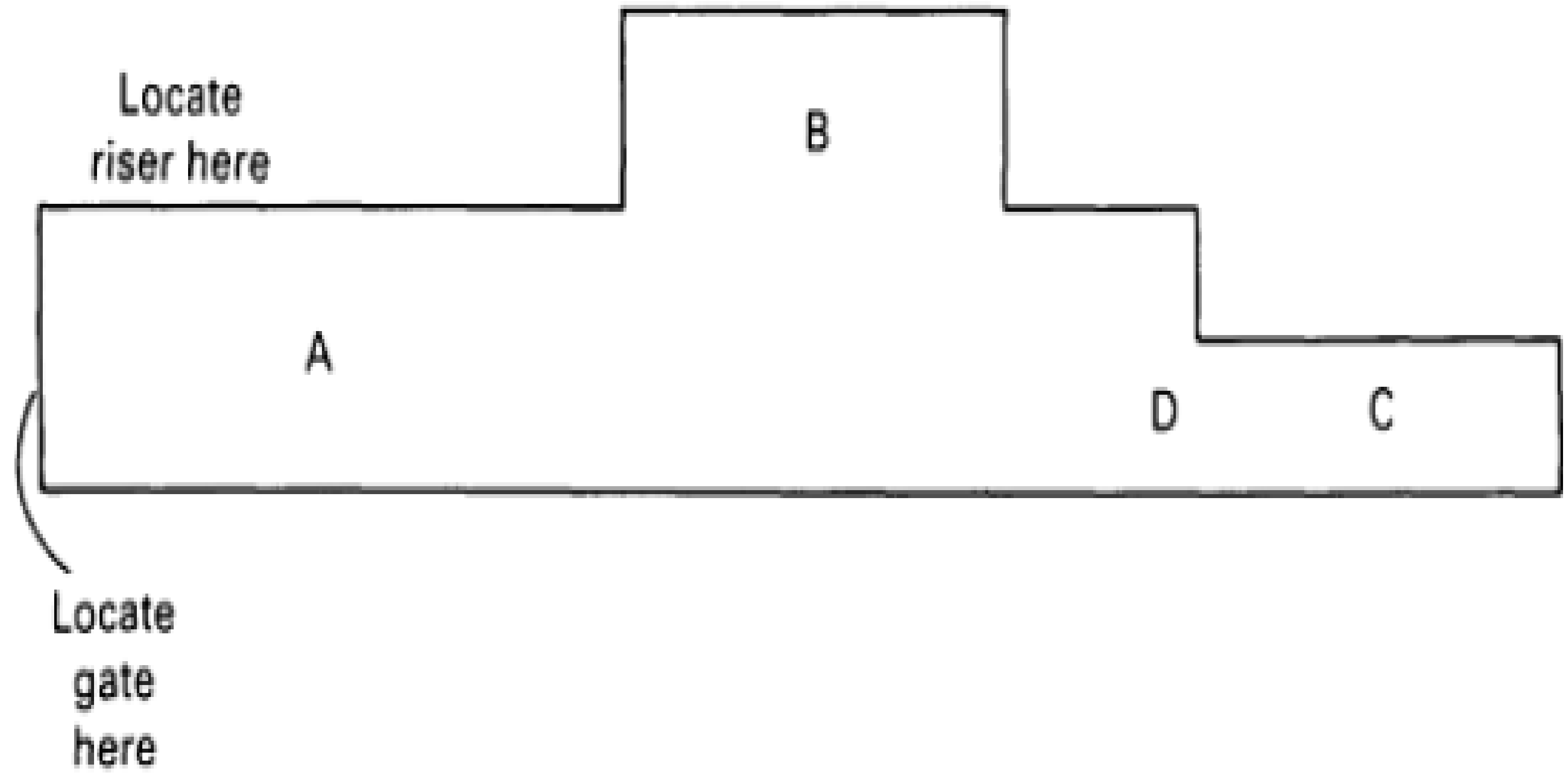


Fig. 15 Hypothetical casting used to illustrate the principles of feeding technique. Source: Ref 3.

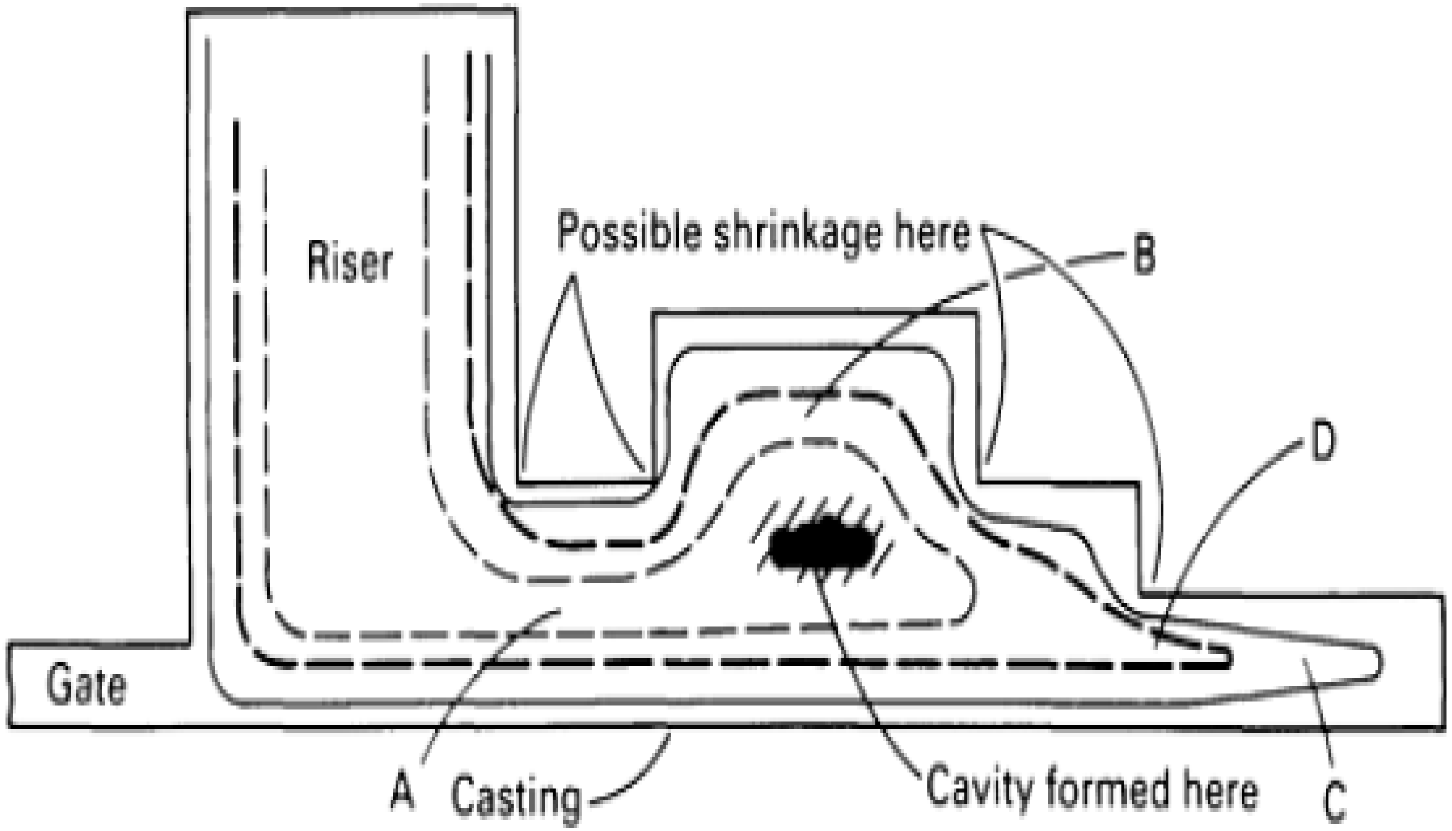


Fig. 16 Mode of freezing the casting in Fig. 15 without special precaution to avoid shrinkage. Source: Ref 3.

Alloy	Shape	Feeding distance, T
Manganese bronze	Square bars	4 T to 10 $\sqrt{T}$, depending on thickness
	Plates	5.5 T to 8 T, depending on thickness
Aluminum bronze	Square bars	8 $\sqrt{T}$

Nickel-aluminum bronze	Square bars	$<8 \sqrt{T}$
Copper-nickel	Square bars	5.5 $\sqrt{T}$

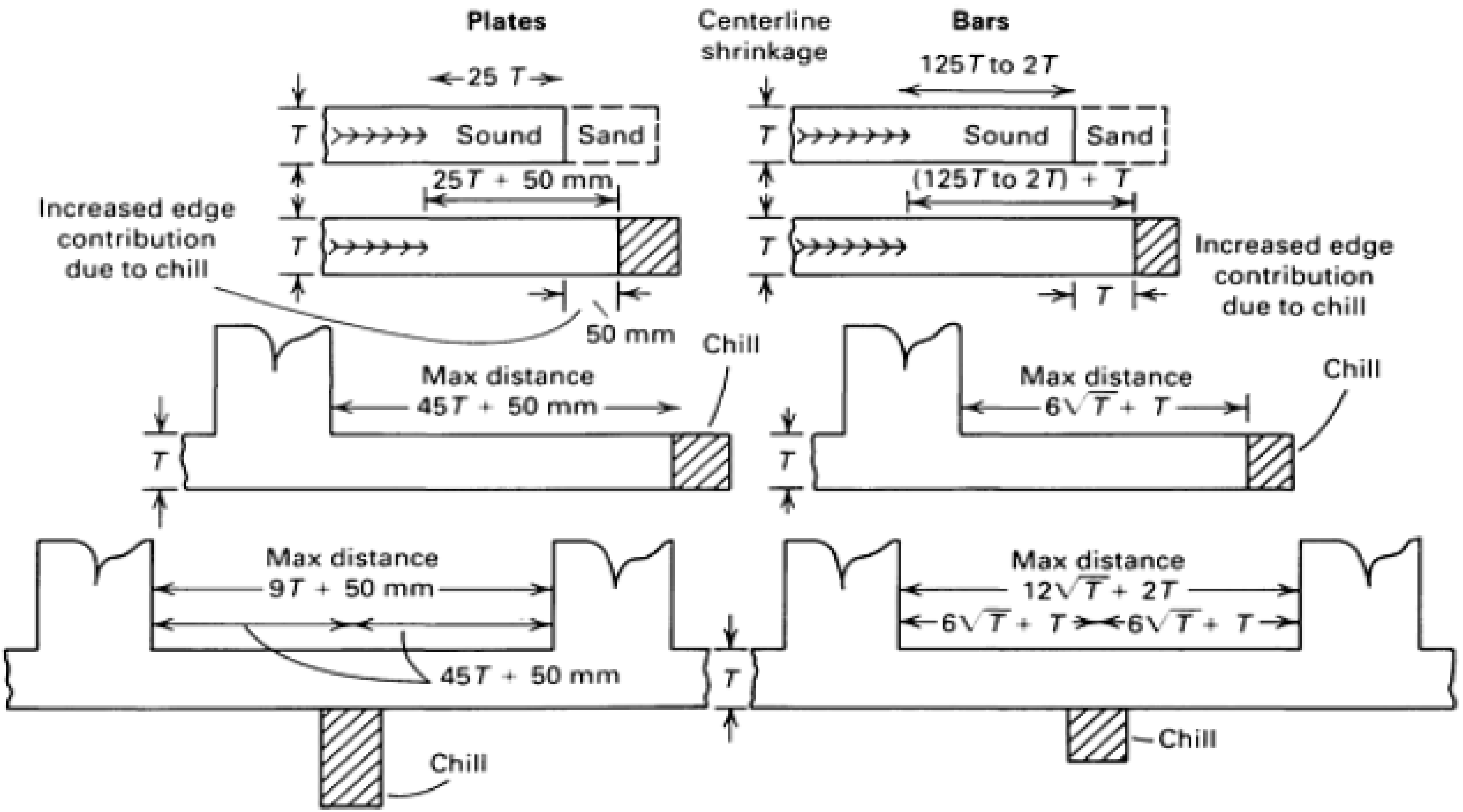


Fig. 17 Effect of chills in increasing feeding range of risers. Source: Ref 2.

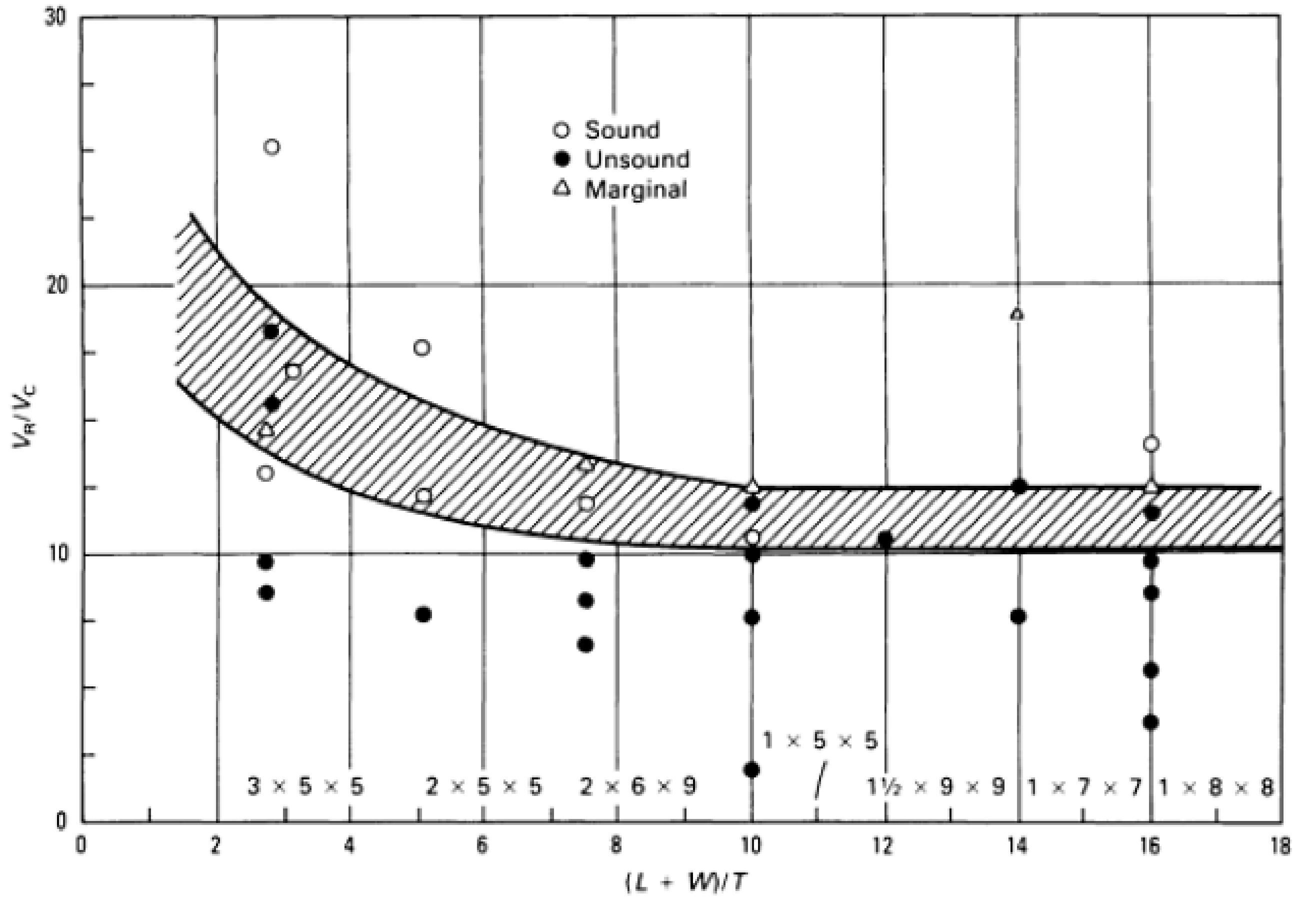


Fig. 18 Naval Research Laboratories (NRL)-type riser size curve for manganese bronze (alloy C86500). Source: Ref 4.

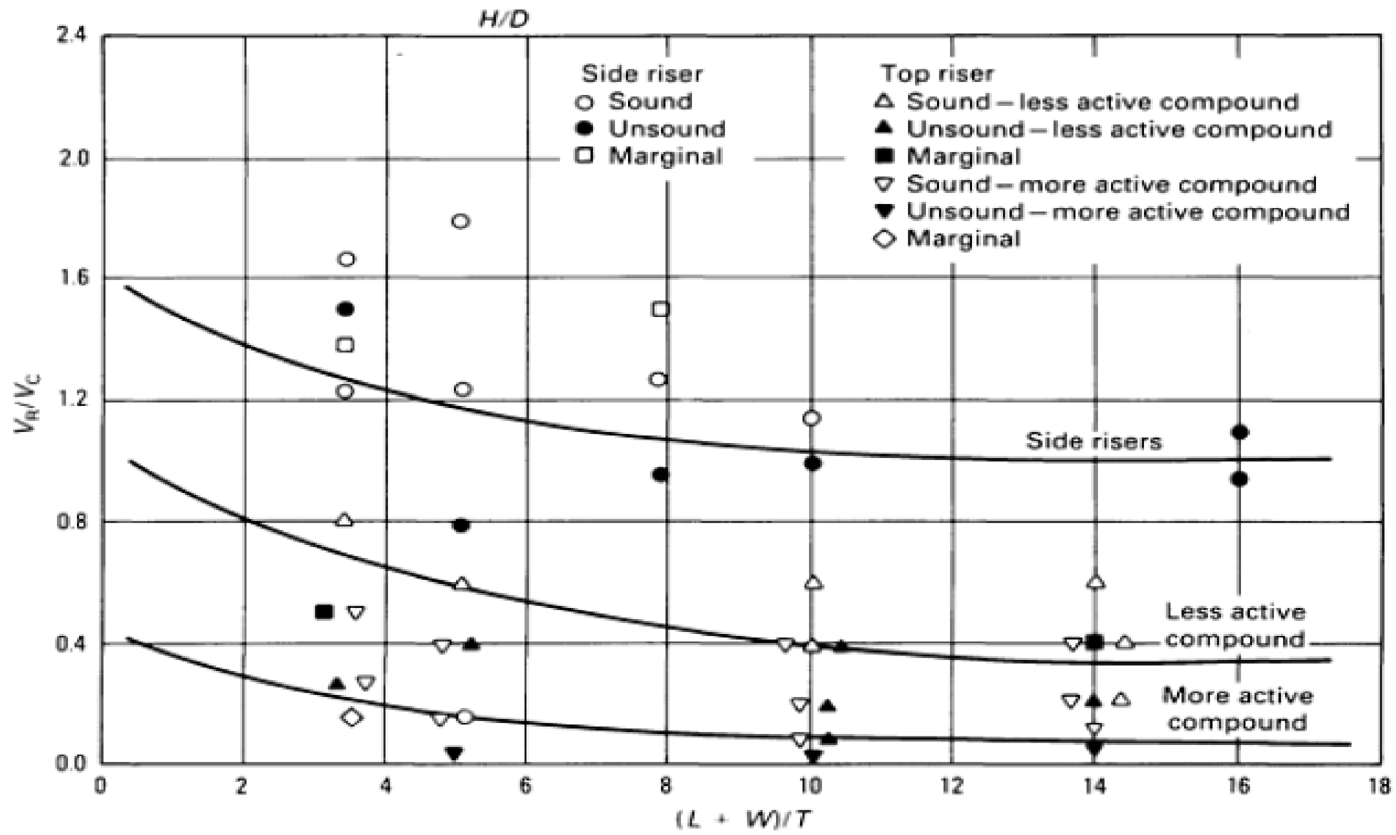


Fig. 19 NRL-type riser curve for manganese bronze (alloy C86500) using different types of exothermic hot topping and top risers. Source: Ref 5.

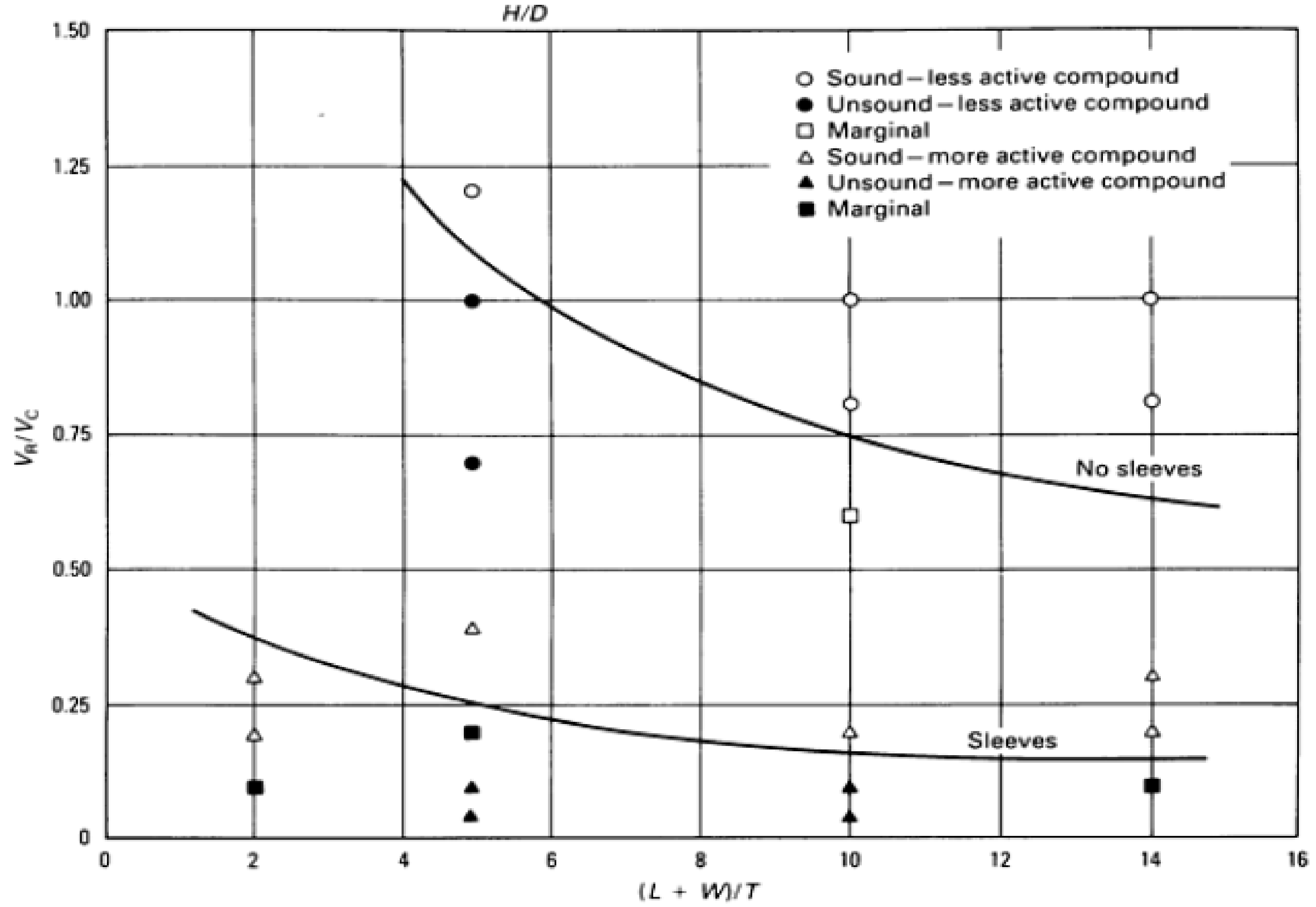


Fig. 21 NRL-type riser curve for Cu-30Ni (alloy C96400) using exothermic sleeves and hot topping versus hot topping alone. Source: Ref 5.

Chvorinov's rule states that the freezing time, *t*, of a cast shape is given by the relationship:

$$t = k \cdot (V/A)^2 \quad \textbf{(Eq 1)}$$

where *V* and *A* are the volume and surface area, respectively, of the cast shape, and *k* is a constant proportionality whose value is dependent on the thermal properties of the metal and the mold. For additional information on the thermal properties of copper, see the article "Aluminum-Base and Copper-Base Alloys" in this Volume.

For convenience, the term (*V*/*A*) in Chvorinov's equation is generally replaced by the symbol *M*, a value referred to as the modulus of the shape. Equation 1, above, can be rewritten more simply to read:

$$t = k \cdot M^2 \quad \textbf{(Eq 2)}$$

Because Chvorinov's equation can be applied to any cast shape, it applies equally to that which is intended to be the casting itself and to the attached riser. With connected shapes, such as a riser and a casting, the surface area of each shape to be considered includes only those portions that contribute to the loss of heat during freezing.

For the riser to be effective in feeding, its solidification time, t_R, must be greater than the solidification time, t_C, for the casting. This can be written:

$$\frac{t_R}{t_C} = \frac{k.M_R^2}{k.M_C^2} = F^2 \text{ or } M_R^2 = F^2 M_C^2 \quad \textbf{(Eq 3)}$$

Further simplified, this becomes:

$$M_R = F \cdot M_C \quad \textbf{(Eq 4)}$$

Table 6 Minimum volume requirements of risers

Type of casting	Minimum V_R/V_C, %			
	Insulated risers		Sand risers	
	$H/D = 1:1$	$H/D = 2:1$	$H/D = 1.1$	$H/D = 2.1$
Very chunky; cubes, and so on; dimensions in ratio 1:1.33:2[a]	32	40	140	198
Chunky; dimensions in ratio 1:2:4[a]	26	32	106	140
Average; dimensions in ratio 1:3:9[a]	19	22	58	75
Fairly rangy; dimensions in ratio 1:10:10[a]	13	15	30	38
Rangy; dimensions in ratio 1:15:30 or larger[a]	8	9	12	14

Feeder Shape. One of the requirements of the riser is to remain liquid longer than the casting; that is, from Chvorinov's rule:

$$(V/A)_R > (V/A)_C \qquad \textbf{(Eq 6)}$$

The shape with the highest possible *V/A* ratio is the sphere. However, spherical risers are rarely used in industry because of molding considerations.

The next best shape for a riser is the cylinder. The *H/D* for cylindrical risers is in the range of 0.5 to 1.0.

Riser Neck Dimensions. The ideal riser neck should be dimensioned such that it solidifies after the casting but slightly before the riser. With this arrangement, the shrinkage cavity is entirely within the riser, this being the last part of the casting-riser combination to solidify.

Specific recommendations for the dimensions of riser necks are contained in the literature for ferrous alloys. These should apply to short freezing range copper alloys and are given in Table 7.

Table 7 Riser neck dimensions

Type of riser	Length, L_N	Cross section
General side	Short as feasible, not over $D/2$	Round, $D_N = 1.2\,L_N + 0.1D$
Plate side	Short as feasible, not over $D/3$	Rectangular, $H_N = 0.6$ to $0.8T$ as neck length increases. $W_N = 2.5\,L_N + 0.18D$
Top	Short as feasible, not over $D/2$	Round, $D_N = L_N + 0.2D$

Source: Ref 6

(a) L_N, D_N, H_N, W_N: length, diameter, height, and width of riser neck, respectively. *D*, diameter of riser. *T*, thickness of plate casting.

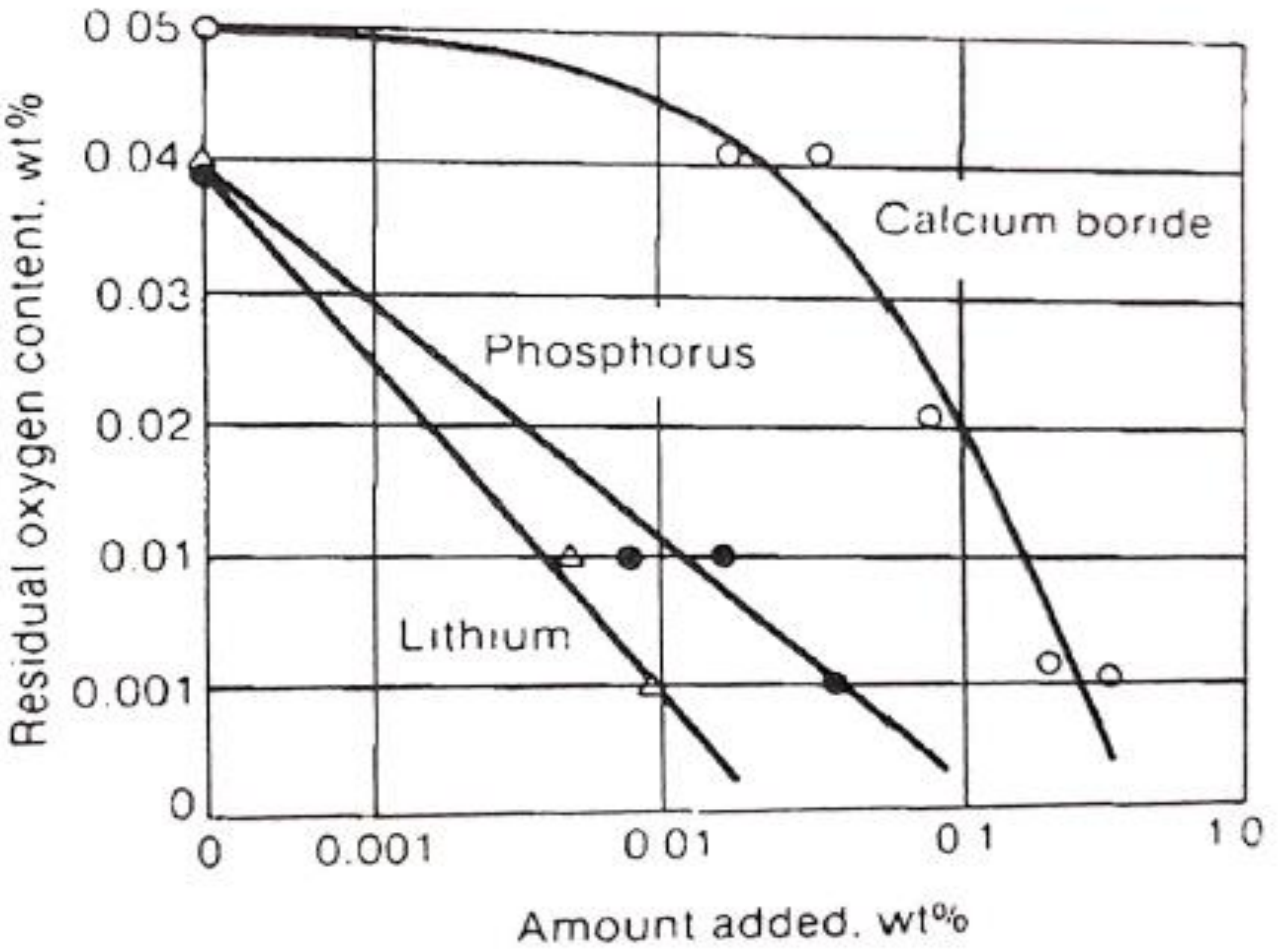


Fig. 24 Deoxidant efficiency in copper alloy melts.
Source: Ref 18