Section two

Risering System Design

Please note:
Risering must be done before gating system can be calculated. Bottle shaped (Heine) risers are now the riser of choice in the majority of systems.
2.0 RISERING SYSTEM DESIGN

2.1 Objectives:
• castings without shrinkage defects
• economic production – maximize casting yield

2.2 Essential Components
• Riser – always “blind” (closed top).
  Riser contact – generally as short as possible. Designed dimensions always measured at the notch.
• Gate – thin and wide for fast freezing (see p. 28).
• Vents – to assist fast mould filling.

2.3 The Following are Suggested by Research and Supported by Industrial Experience
• Volume change patterns of cooling and solidifying graphitic irons result in net volume increase of iron in the mould.
• The net volume increase can produce liquid pressure in the mould of several hundred p.s.i. (2 MPa).
• This pressure always exceeds the elastic limit of the mould, except for very rigid moulds, leading to mould enlargement and swollen castings, often containing shrinkage defects.
• Green sand moulds are not considered to be rigid in this context.
• Riser function is very sensitive to pouring temperature and pouring time.
• Volume change pattern is not constant but varies according to cooling rate and liquid iron processing route (superheat, charge composition, melting method, inoculation, etc).
• Due to the high pressures experienced by the mould during pouring and solidification, mould halves should be clamped together. Weighting alone is not sufficient.
2.4 Typical Volume Change Patterns

- General volume change pattern for steel, white iron, brass, etc.
- Volume change patterns for graphitic irons.
- Shape of volume change pattern influenced by cooling rate and by changes in liquid iron processing. This directly affects the extent of contraction and expansion.

2.5 Planning

The detailed design principles will be presented in the following order:

- Determine significant modulus of the castings ($M_S$).
- Evaluate mould and iron quality, then select appropriate risering method.
- Determine corresponding liquid transfer modulus ($M_N$) and number of risers required for each casting.
- Select riser type and compute dimensions ($M_R$).
- Select riser contact (neck) type and compute dimensions.
- Check that available feed volume in riser(s) is sufficient for casting’s requirements.
- Select pouring temperature based on selected risering method.

Cooling liquid initially contracts then expands. Towards the end of solidification, last remaining liquid solidifies with contraction.
2.6 Cooling Rate

- Casting weight or wall thickness not sufficiently accurate to describe cooling rate.
- Simple shapes: cube, plate, bar etc, all 1 inch (25 mm) thick but all cool at different rates.
- Use modulus (M) to describe cooling.
- Modulus = $\frac{\text{volume}}{\text{effective cooling surface area}}$

- More complicated shapes should be broken down into simple shapes and the moduli of the individual simple shapes, determined.

- Note in the example that the connecting surfaces between adjacent segments are not considered to contribute to cooling (variable “c” below).

Where:

\[ V = \text{total casting volume.} \]
\[ \text{CSA} = \text{total cooling surface area of the casting} \]

**Example for the calculation of Modulus**

- a = any side
- b = any side
- c = non-cooled side

2. Modulus = $\frac{V}{\text{CSA}}$

\[ M = \frac{a \cdot b}{2 (a + b) - c} \]

- all dimensions in cm

\[ M_1 = \frac{5 \cdot 2.5}{12.5} = 1.0 \text{ cm} \]
\[ M_2 = \frac{5 \cdot 3}{10} = 1.5 \text{ cm} \]
\[ M_3 = \frac{5 \cdot 4}{11} = 1.8 \text{ cm} \]

Significant Modulus = $M_3 = 1.8 \text{ cm}$

Note: See example on page 36.
When hollow sections are involved, the cooling effect of cores may be approximated as shown.

**ADJUSTMENTS TO THE COOLING SURFACE AREA**

- If \( d < \frac{1}{3} D \), ASSUME 0% COOLING FROM CORE
- If \( d > \frac{1}{3} D \) and \( d < \frac{2}{3} D \), ASSUME 50% COOLING FROM CORE
- If \( d > \frac{2}{3} D \), ASSUME 100% COOLING FROM CORE

### 2.7 Mould Quality

- Objective is to avoid enlargement of the mould from high liquid pressures exerted by the cooling and solidifying graphitic iron.
- Green sand and shell moulds will not withstand the solidification pressure.
- Chemically bonded sand moulds will resist solidification pressure if they are properly prepared. This requires mechanical compaction of sand during mould preparation and adequate curing.
- Cement sand and dry sand moulds will normally withstand the iron solidification pressure.

### 2.8 Liquid Iron Processing

- All aspects of iron processing have some influence on the magnitude of volume change during cooling and solidification, hence the shrinkage characteristics of the iron.
- Some of the factors which increase shrinkage tendency:
  - high melt superheat temperatures
  - long holding times in the furnace
  - high proportion of foundry return scrap or steel scrap in the charge
  - presence of carbide stabilizing elements in melt chemistry (including high Mg)
  - variable carbon equivalent of the iron
  - inadequate inoculation.
- Combined effect of these (and other) process variables can be assessed, very approximately, by measuring nodule count of standard test piece (Nodule count increases with faster cooling).
- Irons which show low tendency to shrinkage always seem to show low tendency to form as-cast carbides i.e. they graphitise well. Such irons are said to possess good “metallurgical quality”.
- The presence of any type of carbides in the as-cast structure should be considered as an indication that the iron has poor metallurgical quality. Consequently problems with shrinkage defects should be expected.
• Plot shows range of expected nodule counts for good metallurgical quality ductile irons in dependence of modulus (cooling rate).

• For example, a 1 in (25 mm) ‘Y’ block has a modulus of 0.33 in (8 mm). For good metallurgical quality iron, range of nodule counts is 140-280/mm.

• See also 2.16 and 2.17.

2.9 Selection of Risering Method

• CONVENTIONAL RISERING – The test bar blank or ‘Y’ block is one example. Use of a large (open) riser encourages directional solidification ensuring defects appear in the riser not the test bar blank (parallel sided portion).

• Problem with conventional risering is low yield. In this example, about 23%. Not economical.

• APPLIED RISERING –

Use this “family tree” to select risering method for your production conditions.
• Selection based on mould strength and casting modulus.

• Methods take advantage of the fact that graphitic irons expand during cooling, unlike steel, white iron, malleable iron etc.

• WEAK MOULD: Green sand, shell, non-compacted chemically bonded sand.

• STRONG MOULD: Well compacted chemically bonded sand, cement sand, dry sand, permanent mould.

• There are three basic applied risering methods:
  • pressure control risering (PCR) or bottle riser
  • directly applied risering (DAR)
  • riserless

• Application of each method:
  • when mould is weak and casting modulus is greater than 0.16 in. (4 mm) use PCR.
  • when mould is strong and casting modulus is less than 1.0 in. (25 mm) or when mould is weak and casting modulus is less than 0.16 in. (4 mm) use DAR.
  • when mould is strong and casting modulus is greater than 1.0 in. (25 mm) use RISERLESS.

2.10 Pressure Control Risering

• Most green sand and shell moulded castings should be risered by this method.

• Objective is to control the pressure generated during cooling and solidification, between a minimum pressure level, which will prevent the occurrence of secondary contraction defects and a maximum level, at which the mould will enlarge.

- Principles of PCR (necks not used to simplify):
  A. after pouring completed, liquid contracts.
  B. riser compensates for liquid contraction.
  C. when expansion starts, mould deformation avoided by pressurized liquid from casting, “bleeding back” to refill the (blind) riser.
• ideally riser should refill just before expansion ceases.
• this puts all remaining liquid under slight positive pressure and prevents secondary shrinkage defect.

• **Design Sequence:**
  • determine casting significant (largest) modulus ($M_S$) (Section 2.6).
  • determine Modulus – Riserneck ($M_N$)
  • determine Modulus – Riser ($M_R$)
  • see Card #3 metric or english.

**Card #3**

**PRESSURE CONTROL RISERING METHOD**

Relationship between significant modulus ($M_S$), riser-head neck modulus ($M_N$) and riser-head modulus ($M_R$) in pressure-control riser-system design. Includes factor ($f$). See page 28.

• select blind riser type and compute dimensions.

Also see section “bottle riser design”.
• main riser dimensions expressed in terms of diameter, $D$; height = $1.5 \times D$ or with neck located in drag riserheight = $1.5 \times D$ + neck height.
• Find riser neck dimension on Card #4 english or metric.
• Round or square necks = $4 \times M_N$
• Rectangular necks = $3 \times M_N + 6 \times M_N$. 
• Riser neck dimensions are measured at the bottom of the radius between riser and casting.

• Additional notching of the contact may be introduced providing the additional notch depth is not more than one fifth contact thickness.

• Determine volume (weight) of riser(s) for yield and gating system design calculations.

• Only that portion of the riser which is higher than the highest point of the casting to which it is attached, will compensate for liquid contraction in the casting. See Card #5.

• Feeding distance should be assumed to be a maximum of 10 x M_h,j.

Card #5
• Determine effective feed volume of riser(s) and check against casting requirements. “X” is the effective riser height. (See Card #5)

• If the effective volume of riser(s) is less than the volume required by the casting(s), larger or multiple risers should be used.

• In order for the PCR system to function correctly, the gating system must be isolated from the casting and riser very soon after mould pouring is complete. This can be achieved by ensuring the gate has a low modulus $M_G$, (fast freezing) compared to the liquid transfer modulus ($M_N$).

• For design purposes, $M_G \leq 0.2 M_N$. If $M_G$ does not satisfy this condition, increase the number of gates but maintain the same total gate cross sectional area. Individual gate dimensions and modulus will be reduced but mould filling time will be unchanged.

2.11 Bottle Riser Design

It is very important that a primary shrinkage hole (pipe) is created quickly in a riser, so that the riser can feed metal into the casting. If the liquid metal in the riser is not open to the atmosphere (skins over), the riser will not function. Atmospheric pressure is necessary to push metal into the casting.

The classical riser shape with a rounded or flat top, even with a “v” or a dimple on the top, may not always guarantee that the riser will pipe. Temperature control is also very important with this design, since these risers work well at higher pouring temperatures, but not at low ones.

Ductile Iron tends to form a thin stable skin quite quickly and especially at lower temperatures due to the magnesium content contributing to an oxidized surface layer. Once this skin forms the liquid metal is not open to the atmosphere and a vacuum can be created inside the riser. At this point the riser will not feed at all unless it begins to collapse.

A bottle riser (also known as a “Heine Riser”) has such a small area at the top diameter that it will begin to pipe very quickly. So in order to have sufficient feed metal volume these risers must be taller than classical designs, which were normally 1.5:1 height:diameter. The height to diameter ratio for a bottle riser will vary according to the amount of feed metal required. This is usually taken to be about 4%, which includes a safety factor. This type of riser is also not as dependent upon pouring temperature for it to function. Since this riser is so efficient it can improve the overall yield by as much as 2% or more.
The determination of the riser size for the bottle type riser is very simple. The size is calculated from the significant modulus of the casting and the weight of the casting, which determines the amount of feed metal required. Classical methods use the metal quality and the significant modulus to find the transfer (riser) modulus and then calculating the riser diameter and the feed metal required so that it can be compared to the riser feed metal volume. The riser neck calculations are done the same way for both risering methods. All risers should be blind.

**BOTTLE RISER FORMULAS**

Riser diameter \( = 4 \times (M_S) + \) Riser top diameter

Casting feed metal required \( = 4\% \) of pouring weight

Riser feed volume – determined by riser top diameter and height to diameter ratio. See table. Use tallest riser possible for flask size.

Riser height \( = \) H.D ratio \( \times \) riser top diameter

**EXAMPLE:**

Casting weight \( = 187 \) lbs \( (85 \) kg)  
Cope height \( = 13 \) inches \( (330 \) mm)  
Significant modulus of the casting \( (M_S) = .6 \) in \( (15 \) mm)

* Feed metal required \( = .04 \times (187 \) lbs) \( = 7.5 \) lbs \( (3400 \) g)

* Choose from table a riser with a 2 in \( (50 \) mm) top diameter and 5:1 ratio to give 7.6 lbs \( (3434 \) g) of feed metal.

* Riser diameter \( = 4 \times .6 \) in \( + 2 \) in \( = 4.4 \) in \( (110 \) mm)

* Riser height \( = 5 \times 2 \) in \( = 10 \) in \( (250 \) mm)

---

**FEED METAL TABLE**

<table>
<thead>
<tr>
<th>Ratio (Height: Diameter at top)</th>
<th>8:1</th>
<th>6:1</th>
<th>5:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Dia. in (mm)</td>
<td>Feed Wt. lbs (g)</td>
<td>Top Dia. in (mm)</td>
<td>Feed Wt. lbs (g)</td>
</tr>
<tr>
<td>.4 (10)</td>
<td>.10 (44)</td>
<td>.4 (10)</td>
<td>.07 (32)</td>
</tr>
<tr>
<td>.8 (20)</td>
<td>.78 (352)</td>
<td>.8 (20)</td>
<td>.58 (264)</td>
</tr>
<tr>
<td>1.2 (30)</td>
<td>2.6 (1186)</td>
<td>1.2 (30)</td>
<td>2.0 (890)</td>
</tr>
<tr>
<td>1.6 (40)</td>
<td>6.2 (2813)</td>
<td>1.6 (40)</td>
<td>4.6 (2110)</td>
</tr>
<tr>
<td>2.0 (50)</td>
<td>12.1 (5495)</td>
<td>2.0 (50)</td>
<td>9.1 (4121)</td>
</tr>
</tbody>
</table>

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**ILLUSTRATION OF A BOTTLE RISER**
2.12 Riserless Design

Principles of Riserless Design:

• Pour at relatively low iron temperature to avoid (primary) liquid contraction.
• Allow the (rigid) mould to contain all the expansion pressure during iron cooling and solidification.

Production conditions necessary for successful riserless design:

• High metallurgical quality of the liquid iron.
• Very rigid moulds. Green sand and shell moulds not strong enough. Chemically bonded sand moulds may be used providing the sand is mechanically compacted before curing. Mould halves must be clamped or bolted together.
• Minimum casting significant modulus of 1.0 in. (25 mm).
• Pouring temperature range 2,320 – 2,460°F (1,270 – 1,350°C).
• Fast pouring. See Card #2.
• Casting cavity should be well vented.
• Casting cope surface depression will occur if pouring temperature not carefully controlled. Remedy may be effected by using a small blind riser on casting cope surface. Riser volume should be about 2% of casting volume.
• Gating system design should follow the rules described in section 1. Providing fast filling is achieved, gate thickness may be as low as 0.4 in. (10 mm) for the minimum pouring temperature of 2,370°F (1,300°C).

2.13 Directly Applied Risering Design (DAR)

Principles of DAR:

• Use a riser, or the gating system, to compensate for liquid contraction.
• Allow the mould to contain all the expansion pressure during iron cooling and solidification.
• Since the design allows compensation for liquid contraction, thinner sections, poured at higher temperatures, can be produced than is possible with riserless design.

Production conditions necessary for successful DAR design:

• Very rigid moulds if casting significant modulus \( M_S \) is greater than 0.16 in (4 mm).
• Excellent control of iron pouring temperature which should not vary by more than ± 25°F (± 14°C).
• DAR can be used with weak moulds if \( M_S \leq 0.16 \) in. (4 mm).

Design Sequence for DAR:

• Determine casting significant modulus \( M_S \). In contrast to PCR design, \( M_S \) in DAR design may well be the modulus of the smallest segment of the casting, where solidification and expansion begins.
• Select suitable pouring temperature bearing in mind the value of $M_S$.

- Where $M_S \leq 0.16$ in. ($\leq 4$ mm) and the mould is weak, the sprue can be used to compensate for liquid contraction in casting cavity. To achieve this, gate dimensions should be $4(M_N) \times 4(M_N)$ for rectangular section. When $M_S \geq 0.16$ in. (>4 mm) and the mould is strong, a similar arrangement can be used.

- Gate length should be at least 5 times the gate thickness.

- Alternatively, a riser can be used to compensate for liquid contraction in strong moulds when $M_S >0.16$ in. (>4 mm) (when $M_S$ exceeds 1.0 in. (25 mm) consider using RISERLESS technique). Riser contact (neck) should be constructed according to the $M_S/M_N$ plots on the following page. Riser volume should (obviously) be large enough to satisfy the volume contraction requirements of the casting.

Porosity resulting from secondary shrinkage.

• Select contact modulus value, $M_N$, dependant upon $M_S$ and desired pouring temperature.

• For round or square contact, contact diameter $= 4(M_N)$ contact side length $= 4(M_N)$.

• For rectangular contact, short side $= 3(M_N)$ long side $= 6(M_N)$. 
2.14 Selection of Pouring Temperature Based on Risering Method

- **PCR:** 2,500 – 2,600°F (1,380 – 1,425°C) to “guarantee” formation of a shrinkage void in the riser during initial liquid cooling.
- **RISERLESS:** 2,320 – 2,460°F (1,270 – 1,350°C) to avoid liquid contraction in the mould.
- **DAR:** Dependent on casting modulus. (see p. 31)
2.15 Pressure Control Risering
Case Histories

ROTOR: Material GGG 40.3; casting weight 26.0 kg; pouring weight 45.6 kg; yield 58%; moulding material, greensand; $M_S$ 1.90 cm; modulus $A/A = 1.30$; modulus $B/B = 1.25$; $f = 0.60$; $M_N$ 1.14; feeder neck = 45/45 mm; $M_R = 1.37$ cm; feeder = 70 mm dia; pouring temperature 1,400°C min; pouring time 11 sec; gate cross-section 6.5 sq cm; photograph by courtesy of Emmenbrücke foundry, Switzerland.

PULLEY WHEEL: Material GGG 40; casting weight 40 kg; pouring weight 65 kg; yield 62%; moulding material, greensand; $M_S$ 1.0 cm; modulus $A/A = 0.70$; $f = 0.80$; $M_N$ 0.80 cm; feeder neck = 32/32 mm; $M_R = 0.96$ cm; feeder = 70 mm dia; pouring time 12 sec; pouring temp. 1,400°C min; gate cross-section 6.0 sq cm; photograph by courtesy of Emmenbrücke foundry, Switzerland.
FRONT WHEEL HUB: Material GGG 40; casting weight: $5.8 + 5.8 = 11.6$ kg; pouring weight: 19 kg; yield: 61%; $M_S = 1.0$ cm; $M_R = 0.8$ cm; feeder = 50 mm dia; $x = 4.6$ cm; $M_N = 0.66$ cm; feeder neck 40 by 20 mm; pouring temperature 1,370/1,420°C; gate area 2.64 sq cm; sprue area 4.5 sq cm; produced on a Disamatic moulding machine by BFL-Karachi/Pakistan.
Bottle risering case histories

HUB PLATE: Ductile Iron grade 420/12; casting weight 2.85 kg; riser weight 2.85 kg; total poured weight 25.3 kg; yield 67.6%.

Green sand mould; \( M_s = 0.61 \) cm; feed metal required 4\% \( \times \) 2.85 kg \( \times \) 3 = 342 g; riser 14 cm high, 2 cm top diameter. Base 10 cm diameter (increased because of 3 castings per riser); riser ratio 7:1; riser neck \( M = 0.55 \) cm. Riser neck 4.5 cm \( \times \) 1.5 cm; ingates (2) 3.5 cm \( \times \) 0.5 cm \( \times \) 12 cm long; runner 3 cm high \( \times \) 1.5 cm wide; downsprue 2.5 cm diameter \( \times \) 25 cm high; pouring temperature 1400°C; pouring time 9 sec; photo and data courtesy Bolan Engineering Foundry, Pakistan.
**CASE HISTORY [ENGLISH SYSTEM (INCH: LB)]**
- Heavy truck wheel hub casting. Weight 150 lb. (68 kg).
- Very high scrap due to shrinkage defect located at ‘A’. (Segment M₃)
- Green sand mould (weak).
- Significant modulus, $M_S = 0.77$ in.
- PCR method applies.

---

**GATE / RISER SYSTEM**

**Part No:** 770  
**Company:** ABC  
**Estimated Casting Weight:** 150 lb

1. **Layout:**

2. **Modulus**  
   
   \[ M_1 = \frac{2\frac{1}{2} \times 1\frac{1}{4}}{6\frac{1}{4}} = 0.50 \text{ in} \]
   
   \[ M_2 = \frac{2\frac{1}{2} \times 1\frac{1}{4}}{5} = 0.87 \text{ in} \]
   
   \[ M_3 = \frac{1\frac{1}{4} \times 2}{3\frac{1}{4}} = 0.77 \text{ in} \]

3. **$M_N$** see Card #3  
   
   $M_S = 0.77$ in  
   
   $M_N = 0.40$ in

4. **Riser modulus ($M_R$)**  

   \[ M_R = M_1 = 0.50 \text{ in} \]

5. **Blind Riser Type**  

   **Type 2**  

   \[ D_1 = 4.91 \times M_R (2.46) = 3.0 \text{ in}^* \]

---

**NOTE:** Max. $M_T = M_1 = 0.50$ in  
Assumes good metallurgical quality of the liquid iron.

* Use a 3.0 in diameter riser to obtain adequate feed volume.
6. Riser Contact modulus \((M_n) = 0.40\) in
   See Card #4.

6b. Contact Shape
   - Square: Side Length = 4 \((M_n) = 1.6\) in
   - Round: Diameter = 4 \((M_n) = 1.6\) in
   - Rectangular:
     - Short Side = 3 \((M_n) = 1.2\) in
     - Long Side = 6 \((M_n) = 2.4\) in

7. Check Feed Volume
   - Estimated Casting weight (each) = 150 lb
   - Estimated Casting volume =
     \[\frac{150}{0.25} = 600\text{ in}^3\]
   - Required feed volume =
     \[3\% \text{ of } 600 = 18\text{ in}^3\]
   - Available feed volume “X” dimension = 4-1/2 in
   - Available feed volume = 25 in³
   - Number of risers required/casting = 1

8. Total choke cross sectional area (section 1.8) per casting. \(A_c = 0.65\) in² (from chart)
   - Number of gates. \(n_1 = 1\) (per casting)
   - Gate dimensions (4/1):
     \[n\,(4a^2) = A_c\quad 4a^2 = 0.65\quad a = 0.4\text{ in}\]
     \[4a = 1.6\text{ in}\]

9. Runner Bar:
   - Cross sectional area, \(A_R = 2\) to 4 \((A_c)\)
     \[= 3\,(2)(0.65) = 3.9\text{ in}^2\ (2\text{ chokes})\]
   - Height = 2 x width, \(2a^2 = A_R = 2\) to 4 \((A_c)\) (2)
     \[a = \sqrt{3}(0.65)\]
     \[a = 1.4\text{ in}\]
     \[2a = 2.8\text{ in}\]

10. \(A_s \geq A_c\sqrt{\frac{H}{h}}\) or \(A_c \leq A_s\sqrt{\frac{h}{H}}\)
    \[A_s \geq 2(0.65)\sqrt{\frac{10}{3}}\quad D_s^2 = 4\,(2)(0.65)\sqrt{10/3}\]
    Sprue diam. = 1.74 in
    or, total choke \(\leq 0.43\) in²

11. Pattern Yield:
    - Volume of castings = 2 x 600 = 1200 in³
      - risers & contacts = 100
      - sprue & basin = 62
      - runner = 50
      - gates = 1
      - sprue well = 10
      - Total volume poured = 1423 in³

    \[
    \frac{\text{Pattern Yield}}{\text{Total volume poured}} = \frac{1200}{1423} = 84\%
    \]
2.16 Metallurgical Quality Control and the importance of the nucleation condition

One of the most important factors involved in the risering of a casting is to understand and exercise some control over the way in which the solidification process takes place. The schematic representation of the volume changes which accompany the cooling and solidification of ductile iron are shown above. As can be seen from the plots A, B, and C the volume changes are not constant, even for ductile irons of identical chemical composition, there can be differences in the degree of nucleation which will affect the volume change pattern. It is the "metallurgical quality" of the iron which is important and is directly related to the self-feeding characteristics (small volume changes) of the ductile iron.

There is no universally accepted measure of metallurgical quality at the present time. Nevertheless we do have knowledge about the important features of raw materials selection, melting practice, magnesium treatment and inoculation – all of which influence metallurgical quality. From a practical view point also it is important to maintain all conditions as constant as possible in order to ensure consistent volume change behaviour with consistent and predictable feed metal requirements.

2.17 Methods to measure the Metallurgical Quality

- Base Iron:
  chemistry and wedge test (check undercooling)
- After treatment and inoculation:
  chemistry (including Mg content), cooling curve analysis, and nodule count/modulus. (See page 24).
2.18 Other Risering Aids

The reasons for using exothermic or insulating risers is that you can sometimes use smaller risers where the application dictates that the riser be cold (not gated into – such as a top riser and isolated risers). Normal risers use only a small portion (around 14%) of their volume for feed metal. Exothermic and insulating risers can give up to 80% and more as feed metal to the casting. These risers are also designed in relation to the significant modulus of the casting to be fed. In this case you can normally use relatively small risers to feed the castings even in heavy castings. The normal exothermic and insulating risers have, by their nature; an increased effective modulus of about 1.4 to 1.5 times in relation to sand molded riser. Another type of special riser system is called a “Mini-Riser” which is a small exothermic riser. This type will have an increased modulus of approximately 2.3 times.

To calculate the size of the risers, normally you should measure or calculate the significant modulus and casting weight. The actual feed metal required is about 3 – 5% of metal by weight. This is depending on the mould-hardness, metallurgical quality of the iron and pouring temperature. One should also consult the manufacturer’s recommendations on the use of these special types of risers. Maximum utilization of this “mini-riser” should be no more than 70% of its volume.

Example:
If we have a casting with a significant modulus of 2.5 cm and a weight of 20 kg you get the following riser: Weight of the riser = 3% minimum x 20 kg = 0.60 kg or 600 gr. ÷ 70% = 857 gr. of feed metal would be supplied. The riser modulus should be 1.1 x 2.5 cm = 2.75 cm.

The neck is also very important when using these risers. A breaker core is necessary between the casting and the riser. The diameter of the hole in the breaker core should be maximum 1/3 of the diameter of the riser. This has the advantage to avoid shrinkage holes in the riser neck and also it reduces finishing costs.

One further advantage of the “Mini-Riser” is that the pressure, which is created during the growth and expansion of the graphite, is not going on the mould, it is relieved by the riser because there is still liquid metal and a void in the riser. This type of riser was invented in a foundry where they produce hydraulic castings. This foundry has had great problems with penetration and cracking of the cores. After using the “Mini-Risers” the problem nearly disappeared, because now the feeding system was a pressure control system. During solidification the riser was feeding the castings with liquid iron and during the formation of graphite iron was forced back into the open riser and the pressure was released.

All exothermic risers contain aluminum and other elements to provide the reaction. These elements can often cause graphite degeneration. To avoid this problem you have to increase the height or length of the riser neck. There are also other elements that can cause casting defects if they get into the sand system especially in the unburned condition. Defects such as “Fish eyes” can be produced.
2.19 The use of chills

Since there are more methods of non-destructive testing performed on castings, foundries are forced to find economical ways to make completely sound castings. Ductile Iron has an expansion phase during solidification. If you have a slow solidification and a strong mould you can make sound castings riserless and most often with some chills. However the majority of castings are smaller and made in relatively soft green sand moulds. During the expansion of graphite the mould walls will yield and so it is not possible to use the expansion of the iron for the feeding of the castings. Ductile Iron is also a eutectic alloy. All eutectic alloys are liquid very long during solidification. They don’t form a skin during solidification. When using chills we quickly form a solid skin in the area where we have placed the chill. We also increase the density in the matrix producing fine structure in this area. This can help improve wear resistance and pressure tightness.

Most foundries are using chills made from Grey iron. The thickness of the chill should be at least the same size as the thickness of the section to be chilled. Adding chills to one side of a section can reduce the modulus by up to 50%. Grey iron chills can be used until they get cracks. Using chills with cracks may produce blow-holes in the area were you placed the chills. To avoid this problem foundries are using more SiC-bricks or graphite blocks as chills. They do not have as strong a chilling tendency as Grey iron chills, but they have no tendency to absorb moisture. Applying chills can reduce the number of risers and normally also the scrap rate. These things can increase yield and reduce finishing costs.
More bottle riser examples

Cross section through links and riser.

Link castings connected by a bottle riser.

LINK CASTING: GGG80; casting weight 5 kg; green sand mould; $M_s = 1.5$ cm; modulus riser neck = 1.05 cm; riser diameter at parting $4 \times 1.5$ cm + 3 cm = 9 cm; riser height 15 cm (5:1 ratio); feedmetal 741 g (needed 5 kg $\times$ 4% $\times$ 2 = 400 g); riser neck dimensions 2.5 cm $\times$ 6.4 cm.
HUB CASTING: GGG40; one riser for 4 castings; \( M_s = 1.0 \, \text{cm} \); casting weight each = 2.5 kg; green sand mould; \( M_{\text{neck}} = 0.7 \, \text{cm} \); neck dimensions 1.8 cm \( \times \) 6.0 cm; riser modulus 0.8 cm; riser dimensions (5:1 ratio) 3.0 cm top diameter; 15.0 cm high, diameter at parting 14 cm; feedmetal required 400 g; feedmetal supplied 741 g.
Use of bottle risers.
BIBLIOGRAPHY

1. Chvorinov, N.
Giesserei vol. 27 1940 page 177

2. Wlodawer, R.
Directional Solidification of Steel Castings
– Pergamon Press 1966

3. Karsay, S.I.
Ductile Iron vol. 1 – Production published by
QIT – Fer et Titane Inc. 1976

4. Karsay, S.I.
Ductile Iron vol. 3 – Gating and Risering published
by QIT – Fer et Titane Inc. 1981

5. Corlett, G.A. & Anderson, J.V.
Experience with an Applied Risering Technique for
the Production of Ductile Iron Castings
AFS Transactions 90, 1983, 173-182

6. Gerhardt Jr., P.C.
Computer applications in Gating & Risering System
Design for Ductile Iron Castings
AFS Transactions 1983, 73, 475-486

7. Karsay, S.I.
International Foundry Congress, Budapest 1978
paper 28

8. Karsay, S.I.
“The practical foundryman’s guide to feeding and
running Grey, CG and SG iron castings”
Published by Ferrous Casting Centre
Available form AFS Headquarters
Des Plaines, U.S.A.

Pouring rate, pouring time and choke design for S.G.
Iron Castings”.
British Foundryman, December 1985

10. Rödter, H.
“An alternative method of pressure control risering
for Ductile Iron castings.
QIT – Fer et Titane Inc., June 1984

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CANADA

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CARD #1 ENGLISH

Total Poured Weight (Incl. Risers)  Per Choke. lbs.

Casting in Cope
Casting in Drag

Choke Cross Sectional Area in²

Total Poured Weight (Incl. Risers)  Per Choke. lbs.
CARD #1 METRIC

Casting in Cope

Casting in Drag

Total Poured Weight (Incl. Risers)  Per Choke. Kg.

Choke Cross Sectional Area cm²
PRESSURE CONTROL RISERING METHOD

Significant Modulus ($M_S$) in

Riser Neck Modulus ($M_N$) in

Riser Modulus ($M_R$) in  ($M_R = M_N \times 1.2$)

Poor Quality

Good Quality

I  II  III
CARD #3 METRIC

PRESSURE CONTROL RISER CONTROL METHOD

Significant Modulus ($M_S$) cm

Riser Neck Modulus ($M_N$) cm

Riser Modulus ($M_R$) cm  ($M_R = M_N \times 1.2$)

I

II

III

Poor Quality

Good Quality

0.5  1.0  1.5  2.0  2.5  3.0  3.5  4.0  4.5  5.0  5.5  6.0

0.5  1.0  1.5  2.0  2.5  3.0  3.5  4.0  4.5  5.0  5.5  6.0  6.5  7.0  7.5  8.0  8.5  9.0  9.5  10.0
USE OF CARD
Curved lines represent riser neck modulus ($M_N$). To find neck dimensions, follow diagonal line to $M_N$ (curved line). Where these lines meet read dimensions on a and b scales for neck size.
USE OF CARD
Curved lines represent riser neck modulus \( (M_N) \). To find neck dimensions, follow diagonal line to \( M_N \) (curved line). Where these lines meet read dimensions on a and b scales for neck size.