NRL REPORT NO. M-3360

INSULATION OF RISERS FOR FERROUS CASTINGS

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September 24, 1948

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ABSTRACT

This report describes experiments conducted with an inexpensive method of insulating risers on iron and steel castings in order to obtain a higher yield. The insulating material, a mixture of 40 percent by weight of sawdust with 26 percent dextrine and 34 percent water, is pressed into the desired shapes, dried, coated with a refractory wash, and molded in position upon a pattern to form a riser cavity. A series of steel and cast-iron cubes of various sizes were cast with insulated and uninsulated risers to compare feeding efficiencies. When insulated risers are employed, the risers can be reduced in volume by at least 50 percent. This riser insulating method has these disadvantages: (1) it produces a segregated area of high carbon content in the casting, (2) it causes boiling or spattering of the metal in the riser unless precautions are taken to keep the insulation dry and (3) the amount of gases discharged to the foundry atmosphere is excessive.

PROBLEM STATUS

This report concludes the work on this problem and unless otherwise advised by the Bureau of Ships, the problem will be closed one month from the mailing date of this report.

AUTHORIZATION

NRL Problem No. M02-10D

INSULATION OF RISERS FOR FERROUS CASTINGS

STATEMENT OF THE PROBLEM

In current steel foundry practice, only about 50 percent of the poured metal produces usable castings. The remainder consists of gates and risers and must be removed and remelted as scrap. Risers, to function properly, should remain molten until after the casting becomes solid and therefore, in normal sand-molding practice, must be larger in diameter than the section which they feed. The purpose of this study was to develop an insulating material and method of application which would decrease the speed of cooling of the riser in respect to that of the casting, thereby permitting the use of smaller risers and increasing casting yields.

KNOWN FACTS AND THEORETICAL CONSIDERATIONS

Taylor and Wick[1] have shown that the efficiency of nonferrous risers can be greatly improved by surrounding them with gypsum which is a good insulator. They demonstrated that when gypsum riser sleeves are used, risers can often be reduced to 25 percent of the weight which would be necessary in normal practice. Furthermore when gypsum insulation is used, cleaning costs can be reduced by decreasing the riser-contact area. Gypsum cannot be used with ferrous metals because reaction between the sulphur in the gypsum and the iron impairs the properties of the latter.

A British paper[2] described experimental work with riser insulators which contained various combinations of sawdust, fireclay, coal dust, aluminum powder, straw and sand. Only slight increases in casting yields were obtained and the prepared insulation was too weak to be rammed in place in sand molds.

While powdered materials are now commonly added to prevent premature freezing of riser tops, this insulating effect is limited by the relatively small area affected. The only other compound known to the writer, which has been developed to insulate the lateral surface of risers, is a proprietary exothermic mixture which can be molded into desired shapes. While this material will permit increase in yields, its high cost often makes it uneconomical to use.

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[1] Taylor, H. F., and Wick, W. C., The Foundry, 73, 88-93, Oct. 1945.

[2] Report of the Steel Castings Research Committee, First Report of the Foundry Practice Sub-Comm., Iron-Steel Inst. (Br.) Paper No. 12/1945, Feb. 1945.

EXPERIMENTAL WORK

Preparation of Insulating Riser Sleeves

A number of commercial insulating and refractory materials were given preliminary tests as riser insulators by forming them into cylindrical shapes and using them on gray-iron block castings. None of the materials proved completely satisfactory. A sleeve made of pea-size pieces of diatomaceous earth, bonded with bentonite and water, was fragile and had only slight insulative properties. Asbestos mixed with various binders such as bentonite, cement, and molasses water was also tried, but when it was packed sufficiently hard to be handled without breaking, it did not act as an insulator. A gypsum sleeve, separated from the molten metal by a 3/8-in. sand core was unsatisfactory, because the gypsum became hot enough to decompose. A sleeve containing expanded mica fused at the temperatures of the molten metal. Ground firebrick and bentonite had only mild insulative qualities. Sawdust, mixed with various binders showed the best insulating qualities, but burned and permitted metal penetration.

Although it is probable that several of these materials could have been perfected as a suitable riser insulator with sufficient experimentation, sawdust was chosen as the base material for further work because it showed the most promise as an insulator and because it is cheap and plentiful. Foundries which have pattern shops have access to a supply of sawdust at no cost. The most satisfactory mixture contained three pounds of sawdust, two pounds of dextrine and 2.6 pounds (1.25 quarts) of water. It was mulled, formed into a sleeve, and dried in a core oven. This weight of mixture will make a sleeve of 6-in. outside and 3-in. inside diameter about $7\frac{1}{2}$-in. high. Figure 1 is a photograph of the equipment used to make the sleeves shown in Figure 2. Two methods of fabricating these insulating sleeves are as follows:

Method No. 1: the mulled material is packed between a metal tube and a split tube of larger diameter; a ram in the form of an annular ring is set on top of the mixture; the unit is then placed in the small hydraulic press shown in Figure 1 and a pressure to 200 psi is applied through the ram.

Method No. 2: a layer of the mulled material, several inches in thickness, is placed between the inner and outer metal tubes and hand rammed; this cycle is repeated until a sleeve of desired height is obtained. Although steel tubing was used for work in this report, wood or cement forms may be employed.

Immediately after forming, the sleeve has sufficient green strength to be removed from the tubes. It is then dried in an oven at 250 to 325^{0} F for four hours and while it is still hot, coated on the inside with a silica wash. The bottom must also be coated with this wash, or preferably, a thin oil-sand core is pasted on this end. The opening in this core may be reduced as shown in Figure 3 to make a "knock-off" riser.

The sleeve is placed in the desired position on the pattern, and molding sand is then rammed around it. The sand adjacent to the sleeve may be rammed either pneumatically or by hand to any reasonable hardness without danger of cracking or crushing the sleeve. When the casting is poured, and the sleeve becomes heated, the volatile matter generated burns with a nearly smokeless flame. The sawdust chars and sinters leaving a weak residue of charcoal and ash. The residue of the insulating sleeve does not contaminate the sand to a detrimental degree. (Steel castings having satisfactory surfaces were obtained from molds faced with a mixture of equal volumes of sand and insulating sleeve residue.) The sleeves are sufficiently permeable to allow the large volume of gases generated to escape to the foundry atmosphere. However, moisture can be absorbed by the sleeves from

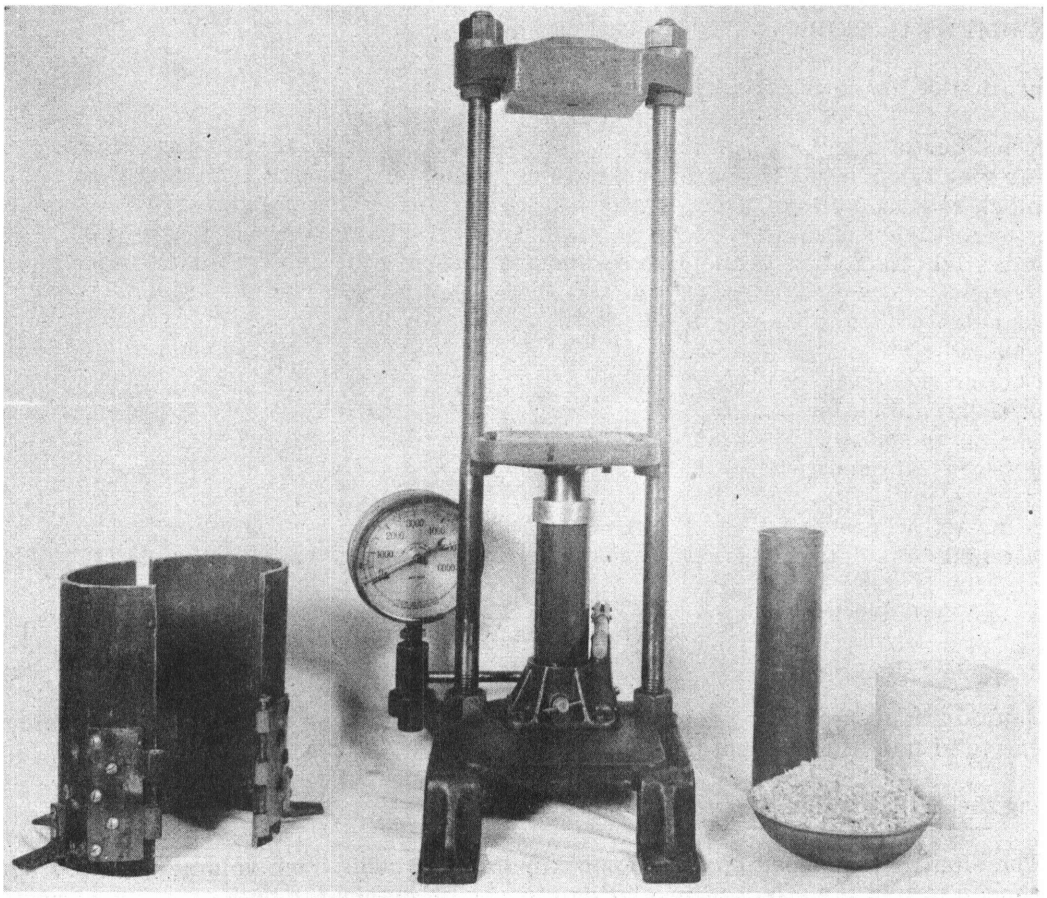

Fig. 1 - Apparatus Used in Making Riser Sleeves

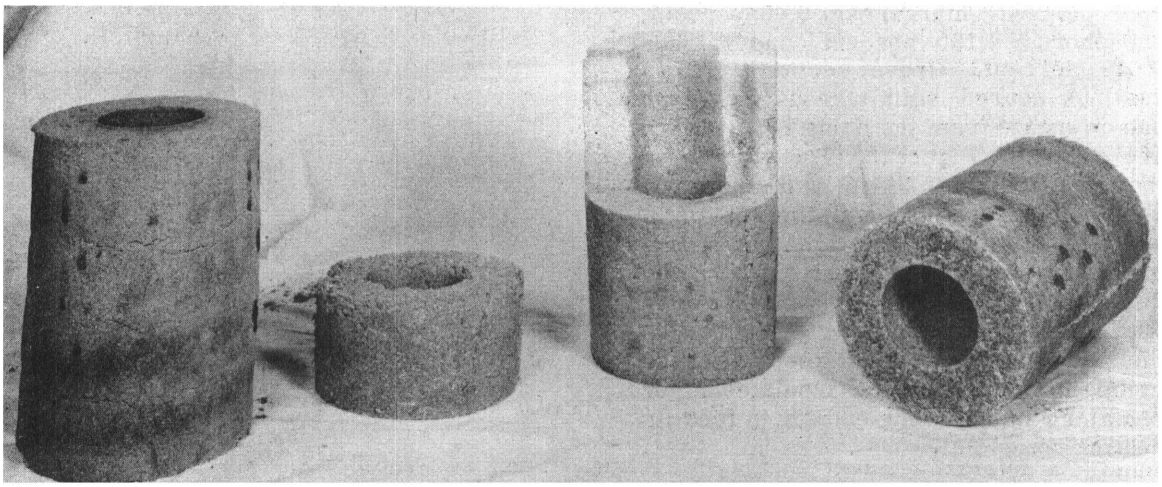

Fig. 2 - Completed Riser Sleeves

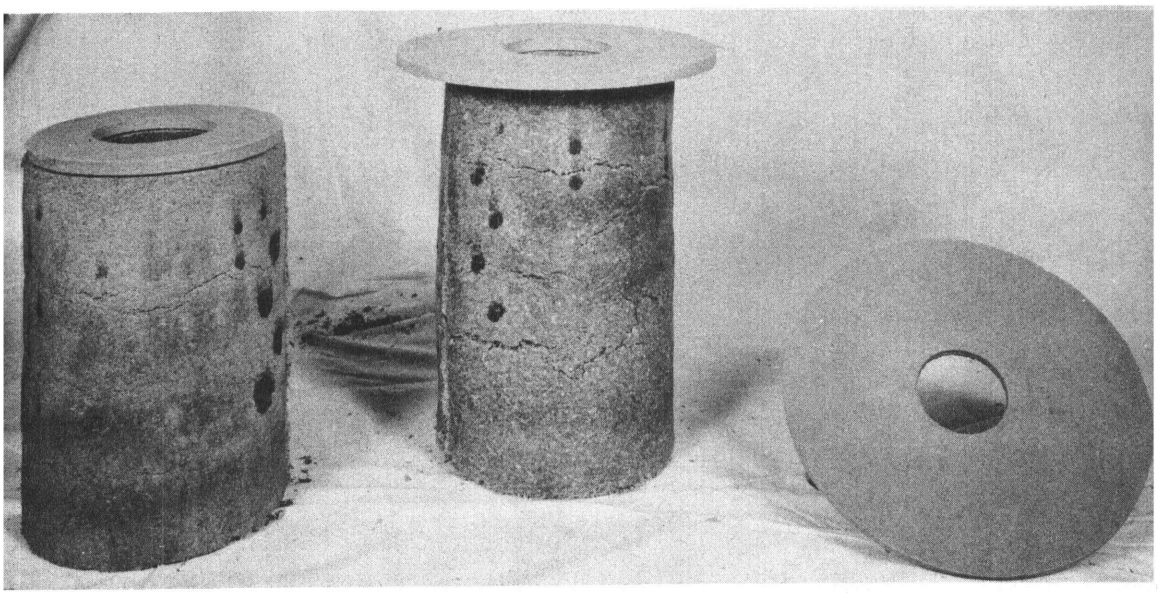

Fig. 3 - Riser Sleeves With Bottom Cores

very humid atmospheres or prolonged contact with green sand molds thereby causing the molten metal to boil and erupt from the riser cavity.

Testing the Efficiency of Sleeves

The small Tee-shaped block of approximately 65-cubic-inch volume shown in Figure 4 was chosen to test the effect of insulating sleeves on risers for both gray-iron and steel castings.

The first test castings were made of high-shrinkage gray cast iron of the following analysis: Carbon 2.40 percent, silicon 1.60 percent, manganese 0.45 percent, phosphorus 0.150 percent, and sulphur 0.019 percent. Cross sections of two castings poured simultaneously through one downgate from the same ladle of iron are shown in Figure 5. The casting on the left had a riser $2\frac{1}{2}$-in. in diameter by 4-in. high encased in insulating material, while the casting on the right had a normal sand-surrounded riser of the same dimension. Both risers were treated with a graphitic anti-pipe compound in the same manner to help keep the riser metal molten. Only the insulated riser remained molten long enough to feed its casting completely.

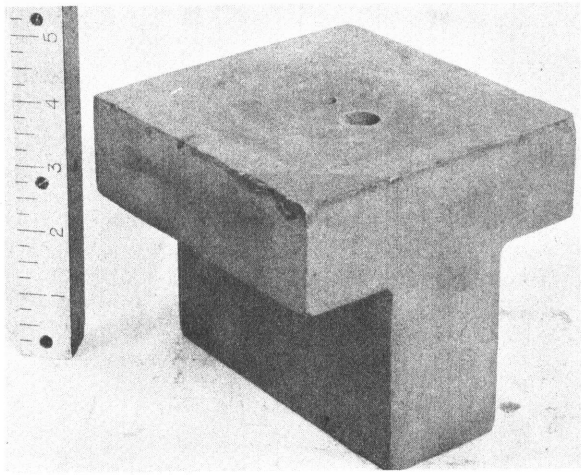

Fig. 4 - T-Block Test Pattern

A similar pair of test blocks was then poured of a Navy Grade-B-type steel

at 2900°F and again both risers were treated with anti-pipe compound. In Figure 6, the sound casting on the left had an insulating sleeve around its riser, whereas the unsound casting on the right had a normal riser of the same initial dimensions. There was an undesirable amount of penetration of metal into the insulating material and this was greatly reduced in succeeding tests by adding fireclay to the silica wash. It was found that the inner surface of the sleeve must be completely covered with a refractory coating at least 1/16-inch thick to minimize penetration by molten steel. The wash giving the best results contained, by percent, 6.25 fireclay, 57.0 silica flour, 1.25 bentonite, 2.5 dextrine and 33.0 water.

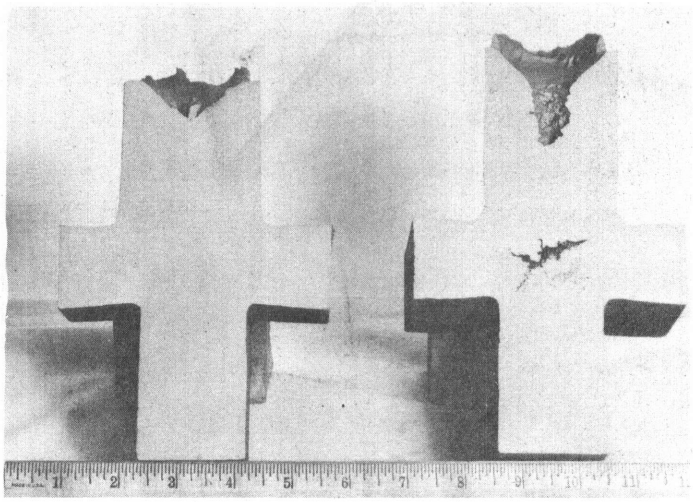

Fig. 5 - Gray Iron Test Castings - Casting on Left Made with Insulated Riser - Casting on Right Made With Uninsulated Riser

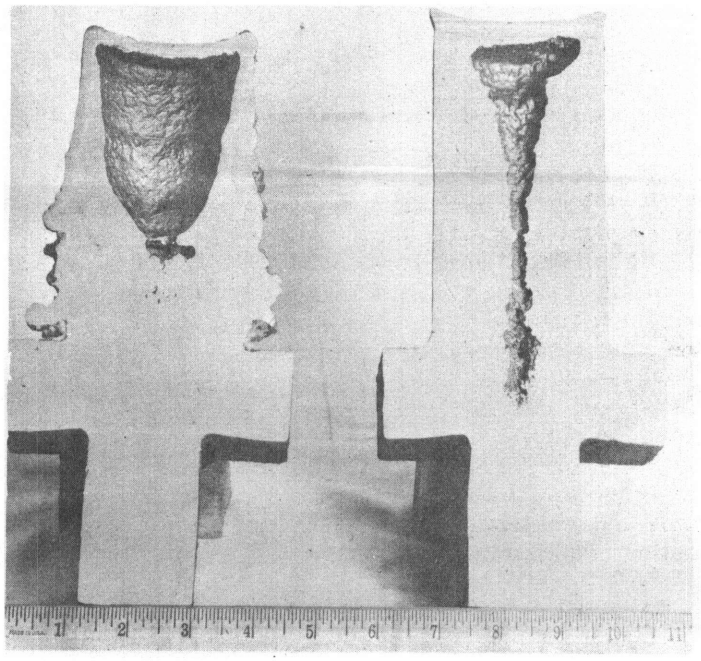

Fig. 6 - Steel Test Castings - Casting on Left Made With Insulated Riser - Casting on Right Made With Uninsulated Riser

In order to obtain more quantitative data on the feeding efficiency of insulated risers on steel castings, a series of rectangular blocks of varying size were poured. The first castings of this series were 4 x 4 x 5 inches. Again two blocks were made in a single mold, gated at the parting line from a common downsprue, with risers of equal size enclosed in sand and a sawdust sleeve, respectively. The risers were located on the 4-inch-square face and were 3 inches in diameter and $3\frac{1}{2}$ inches high. In Figure 7 the casting on the left was adequately fed by the insulated riser whereas the casting on the right with an uninsulated riser contained a shrinkage cavity. When, as shown in Figure 8, the size of the test casting was increased to a 5-in. cube and the riser height increased to $5\frac{1}{2}$ in. the same comparative

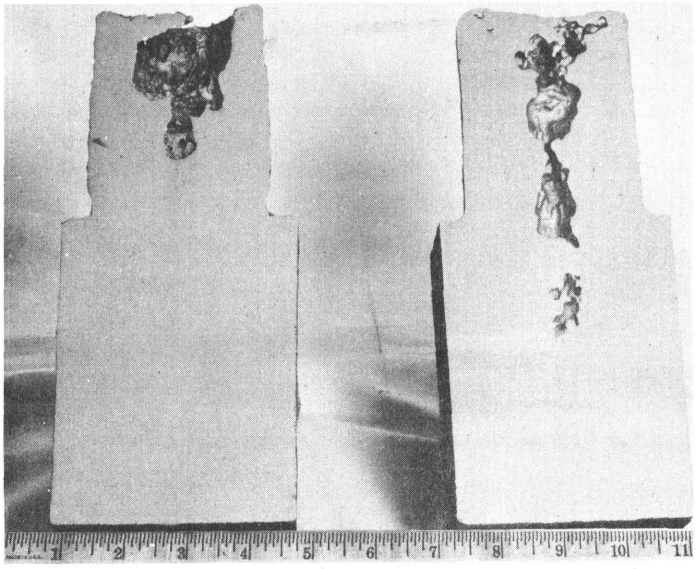

Fig. 7 - 4 x 4 x 5 in. Steel Blocks Fed by Risers 3 in. in Diameter - $3\frac{1}{2}$ in. High. Left - Insulated Riser Right - Uninsulated Riser

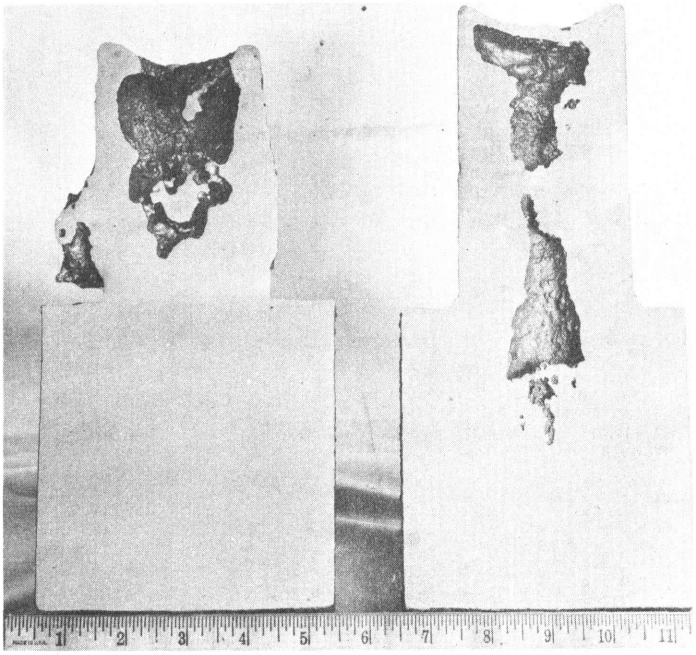

Fig. 8 - 5 x 5 x 5 in. Steel Blocks Fed by Risers 3 in. in Diameter - $5\frac{1}{2}$ in. High. Left - Insulated Riser Right - Uninsulated Riser

results were obtained. Although a crack in the refractory wash permitted the molten steel to penetrate the insulation, this did not impair the soundness of the casting. On a 5.3-in. cube, Figure 9, the 3-in. diameter by $5\frac{1}{2}$-in. high riser still proved adequate when insulated.

The sectioned casting and riser at the left of Figure 10 was a 6-in. cube adequately fed by an insulated riser 4 in. in diameter and 5 in. high. In this case the contact was reduced to make a "knock-off" riser. At the right of this figure is shown a similar casting fed by a much larger sand-encased riser 6 in. in diameter, 5 in. high. In this case the shrinkage extended into the casting.

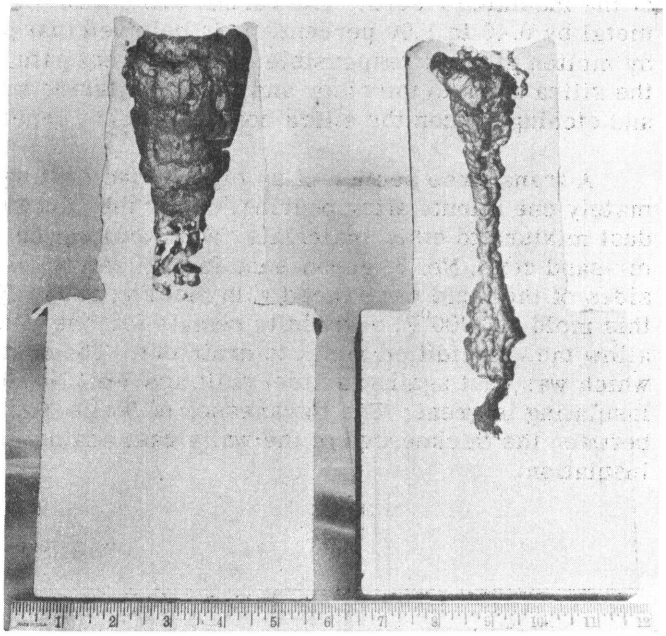

Fig. 9 - 5.3 x 5.3 x 5.3 in. Steel Blocks Fed by Risers 3 in. in Diameter $5\frac{1}{2}$ in. High. Left - Insulated Riser Right - Uninsulated Riser

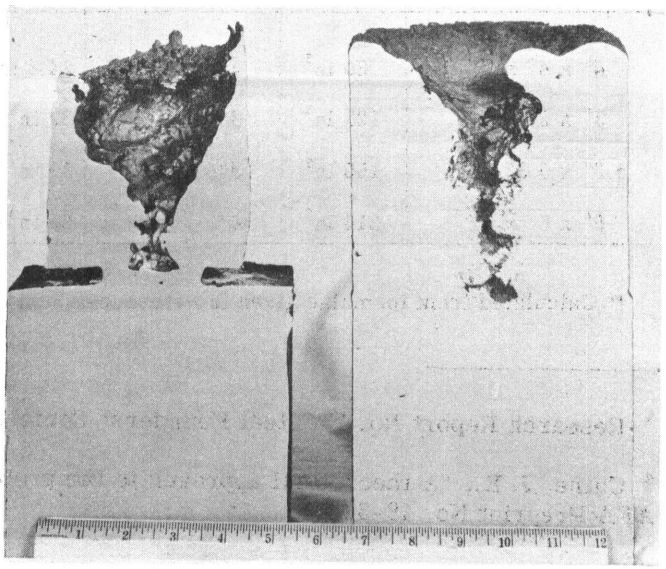

Fig. 10 - 6 x 6 x 6 in. Steel Blocks Left - Casting Fed by Insulated Riser 4 in. in Diameter, 5 in. High. Right - Casting Fed by Sand Enclosed Riser 6 in. in Diameter, 5 in. High

The Steel Founders' Society of America[3] and J. B. Caine[4] described a method of calculating the minimum riser required to feed any given casting. The dimensions of the minimum sand risers which can feed the block castings described above have been calculated according to this method, assuming that an efficient pipe eliminator was used on the risers. Table I compares the volumes of these sand risers with the volumes of the insulated risers which adequately fed each of these castings. In all cases, when the riser is insulated it can be reduced to half of the volume of the smallest riser which would be effective in sand-molding practice.

An area of higher carbon content has been found in many of the castings under the base of the insulated risers. The carbon content in these segregated areas exceeds the base metal by 0.40 to 1.00 percent. It is believed that penetration and reaction with the sawdust by molten steel is responsible since a direct path of high-carbon material from a break in the silica wash to the riser and casting interior was traced on one sample by sectioning and etching. When the silica coating was not penetrated, no high-carbon areas were found.

A transverse section of an eight-sided casting, Figure 11, which was bled approximately one minute after pouring, shows the relative insulating characteristics of the sawdust mixture to other materials. Wall No. 1 was cast against a steel chill, No. 2, an oven-dried oil-sand core, No. 3, green-sand facing, and No. 4 a sawdust insulating slab. The other sides of the mold were faced with molding sand. Navy Grade-B steel was poured into this mold at 2900°F, allowed to remain for one minute, and then the mold was inverted to allow the unsolidified metal to drain out. The contrast between the thickness of Wall No. 1 which was cast against a steel chill and Wall No. 4 which was against a slab of sawdust insulating is great. The thicknesses of Walls No. 2 and No. 3 was approximately midway between the thicknesses of the walls cast against the steel chill and against the sawdust insulation.

TABLE I

Casting Dimension (Rectangular)	Casting Volume	Insulated Riser (Cylindrical)			Minimum Sand Riser* (Cylindrical)			Percent Reduction
		Diam.	Height	Vol.	Diam.	Height	Vol.	
4″ x 4″ x 5″	80 in^3	3″	$3\frac{1}{2}$″	24.8 in^3	4.6″	3″	49.8 in^3	50
5″ x 5″ x 5″	125 in^3	3″	$5\frac{1}{2}$″	39 in^3	5.75″	3″	77.4 in^3	50
5.3″ x 5.3″ x 5.3″	150 in^3	3″	$5\frac{1}{2}$″	39 in^3	6.1″	3.25″	95 in^3	59
6″ x 6″ x 6″	216 in^3	4″	5″	63 in^3	6.9″	3.75″	140 in^3	55

* Calculated from formulae given in References 3 and 4.

[3] Research Report No. 13, Steel Founders' Society of America.

[4] Caine, J. B., "A theoretical approach to the problem of dimensioning risers," 1948, AFA Preprint No. 48-36.

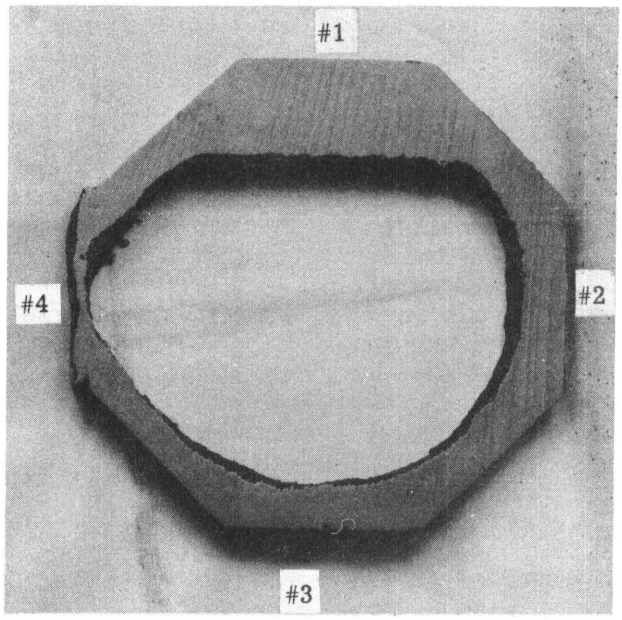

Fig. 11 - Casting Bled One Minute After Pouring; Wall (1) Cast Against Steel Chill, Wall (2) Against Oil-Sand Core, Wall (3) Against Green Sand Facing, and Wall (4) Against Sawdust Insulating Material.

SUMMARY AND CONCLUSIONS

A mixture of sawdust, dextrine, and water pressed into hollow cylindrical sleeves, baked, and coated with a refractory wash, has the following advantages and disadvantages when used to insulate riser cavities on gray iron and steel castings:

Advantages

(1) The sleeves greatly reduce the volume of metal needed to feed castings adequately.
(2) The ingredients are inexpensive, readily available, and easily formed into shape.
(3) The sleeves are strong enough to be rammed into position in a sand mold.

Disadvantages

(1) An undesirable concentration of carbon will often occur in the steel within the casting.
(2) Since the sleeves absorb moisture slowly from green sand and are then subject to a harmful reaction, they must be used soon after being placed in this molding material.
(3) The gases and heat evolved from these sleeves in use increase foundry ventilation requirements.

* * *

PRN C-7845-10-25-48-125