Comparison of Insulating and Exothermic Riser Sleeves

Jorge H. Okhuysen V.
Director of Operations
CORPORACION POK S.A. DE C.V.
Guadalajara, Jalisco, México

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Company Overview

Corporacion POK is a job shop foundry and machine shop located in Guadalajara, Mexico. The company has approximately 330 employees in 4 major areas: Sand casting foundry, investment casting foundry, conventional machine shop and CNC machine shop.

The foundry produces approximately 250 tons per month of castings ranging in weight from a few ounces to 12,000 pounds, clean-weight. POK produces several alloys such as carbon steel, low alloy steel, stainless steel, ductile iron, gray iron, bronze and other specialty alloys such as monel and inconel. The melting equipment in the foundry consists of six induction furnaces, ranging in capacity from 300 pounds to 7,000 pounds.

Most of the castings produced are finish-machined in-house by our Conventional and CNC machine shops.

Background

In the last SFSA T&O conferences, there have been substantial discussions trying to determine what the most cost-effective riser sleeve for each application is. These discussions raised questions such as:

1. When is an exothermic sleeve better than an insulating sleeve and vice versa?
2. Is there sufficient information in the software simulation packages to accurately simulate each type of sleeve?
3. What is the effect of aluminum contamination when using an exothermic sleeve?
4. Do we really know what is in the sleeves?
5. Are there any industry specifications under which riser sleeves are manufactured?
6. If not, how can such standards be developed and who should be responsible for developing and implementing them?
7. How much money are we throwing away as an industry by using the incorrect type of sleeve for a certain application?

Since every foundry does things slightly different and has access to different products and formulations, there is no absolute right answer to the questions above. This paper is intended as one foundry's practical approach to compare the results obtained from using different riser sleeves on identical castings with very similar pouring parameters.

Test Set-up

A “cube” casting was designed in order to test nominal 12” x 12” risers. The geometrical modulus of the cube was calculated at 2.07 in. The dimensions and gating system of such cube are defined in figure 1.

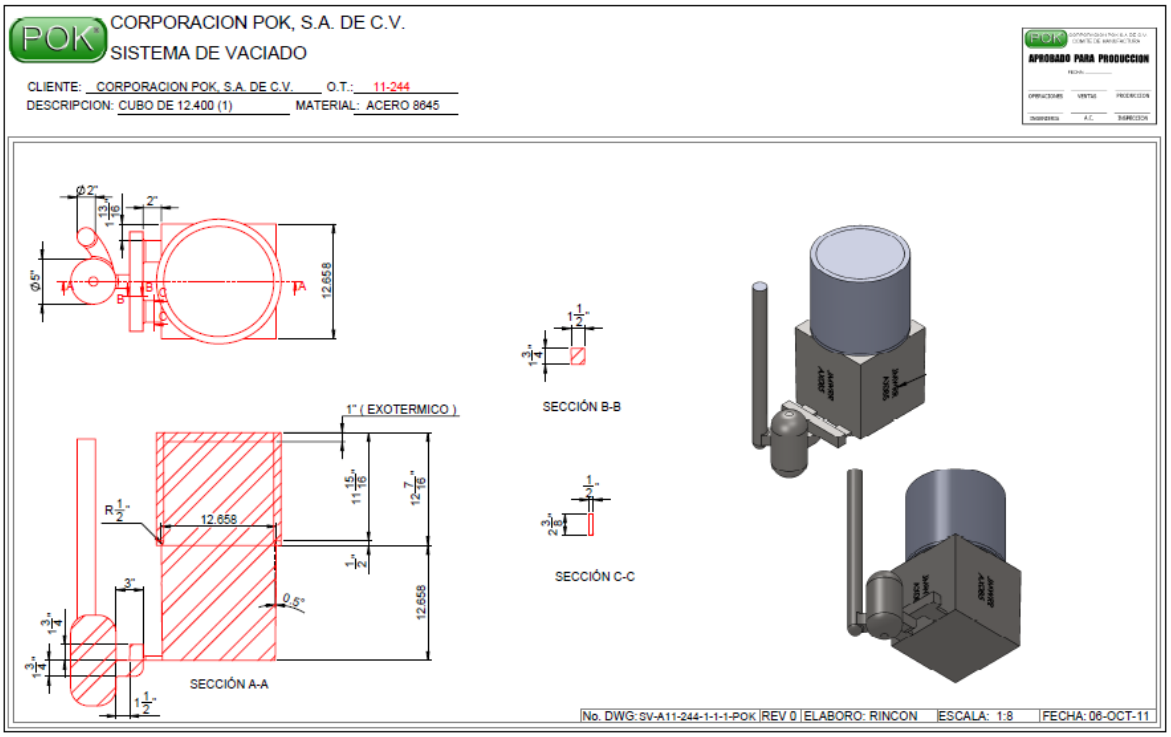


Figure 1: Cube casting gating system

The molds were made in 30” x 40” flasks, floor-molded with a 3” thick air-set sodium-silicate / AFS 40-50 silica sand mix and backed with green sand. After closing, a groove was cut-out at the top of each riser sleeve so that if the mold was over-filled, the metal would drain and all molds would remain with risers of the same height (see figure 2).

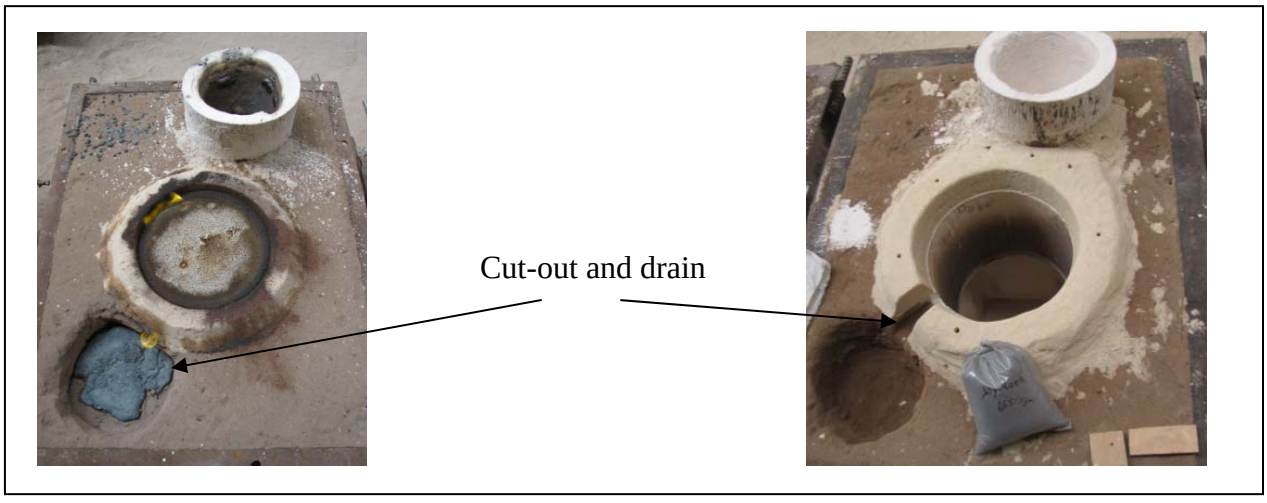


Figure 2: Top Mold View

Seven different riser sleeves were tested (see figure 3). (The description, dimensions and technical information of each of the 7 riser sleeves is found in Appendix 1). Please note that the last two sleeves were of a smaller diameter.

CASTING CODE	SUPPLIER	DESCRIPTION	NOMINAL DIMENSIONS	TYPE
JMWRR	JOYMARK	RIGIDIZED	12” X 12”	INSULATING
JMWLL	JOYMARK	NON-RIGIDIZED	12” X 12”	INSULATING
VF6000	VACUFORM	NON-RIGIDIZED	12” X 12”	INSULATING
KM1000	FOSECO	KALMIN 1000	12” X 12”	INSULATING
KF100	FOSECO	KALFAX 100	12” X 12”	EXOTHERMIC
KF100	FOSECO	KALFAX 100	9” X 12”	EXOTHERMIC
KF100	FOSECO	KALFAX 100	8” X 12”	EXOTHERMIC

Table 1: Riser sleeve description

Figure 3: Riser Sleeves

The hot-topping amount and type that was utilized with every sleeve is also found in Appendix 1. (Note: The amount used was based on the recommendation given by each of the suppliers). The hot-topping was pre-weighed and packed in plastic bags. Once the mold was full, the bag was dropped on top of the riser and it was allowed to spread on its own.

The alloy that was poured was a modified cast steel 8645. Two 3,000 lb. heats were necessary to pour all the cube castings. Table 2 shows the actual chemical analysis results from each heat. The heats were tapped at 2,950°F and metal was poured into the molds between 2,860°F and 2,880°F. Pouring time was between 31 and 36 seconds.

Heat	C	Mn	P	S	Si	Ni	Cr	Mo	V	Cu	Al
A1512	0.43	0.90	0.030	0.016	0.50	0.50	0.50	0.19	0.002	0.06	0.042
A1516	0.45	0.86	0.031	0.025	0.49	0.54	0.54	0.19	0.004	0.12	0.040

Table 2: Chemical Analysis Results

Processing and evaluating the castings

After the castings were poured, they were left idle for 24 hours and then shaken-out. The castings then had their gating system removed and were shot-blasted. Each casting was weighed after shot-blasting. The weights of the castings after shot-blasting are shown in table 3.

Figure 4: Before and after gouging and shot-blasting

Figure 5: Casting Cubes prior to saw-cutting

CASTING CODE	WEIGHT (lb)
JMWRR	851
JMWLL	853
VF6000	829
KM1000	816
KF100 12X12	833
KF100 9X12	682
KF100 8X12	645

Table 3: Weight of Cube-castings (after gating system removal)

In the “as-cast” condition, each casting was longitudinally saw cut right through the middle (see figure 6). Since the cubes were too long for the available saws in the shop, a preparatory transversal cut had to be made 2” below the riser contact face prior to the longitudinal cut; thus leaving the casting in 4 sections (figure 7).

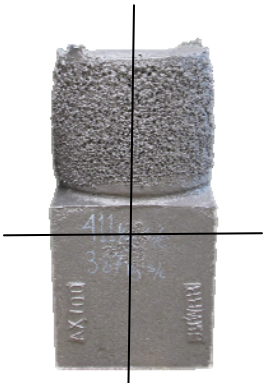


Figure 6: Sectioning Planes

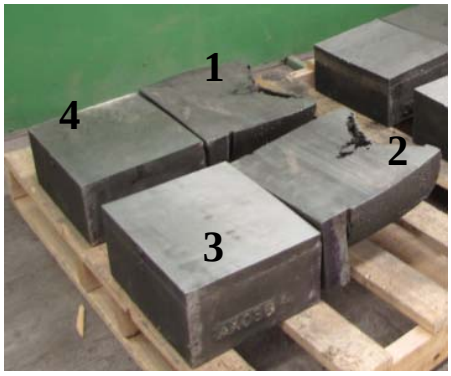


Figure 7: Sectioned Cube Casting

After the castings were sectioned, quarters 2 and 3 (figure 7) were photographed before and after a dye-penetrant test. Also, several dimensions of the riser (diameters and heights) were measured to evaluate riser sleeve dilation and riser sleeve efficiency. Then, a ½” thick slice was cut-off from the rest of the sections. This slice, which had the plane of interest (thermal centerline) on one of its faces, was milled, ground and macro-etched to allow any possible macro-segregation to be revealed. While this was done on quarters 2 and 3, quarters 1 and 4 were cut in pieces in order to obtain multiple chemical analyses to be correlated with the macro-etched surface and any possible aluminum contamination from the sleeve and/or hot-topping.

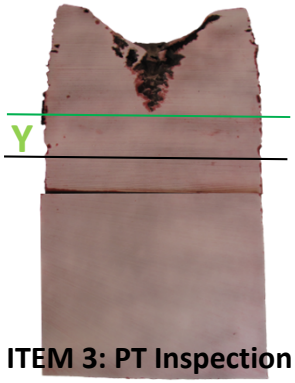
The results for all the previous tests for each cube casting are shown in the following 7 pages (one page per cube casting).

TEST RESULTS

Casting Code: JMWRR | JoyMark Insulating Rigidized (12" x 12") | Serial Number: AX100

ITEM 1: Cross-Section

ITEM 2: Complete Casting



ITEM 3: PT Inspection

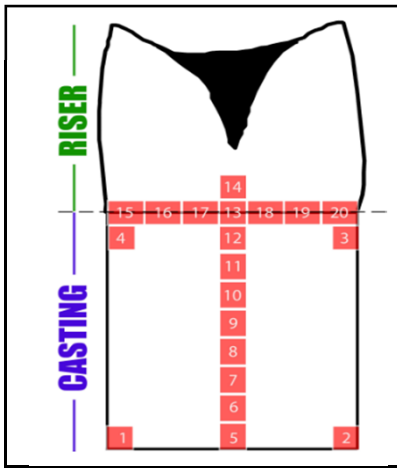
ITEM 4: Top View

ITEM 5: Macro-Etching

Actual Dimensions (In inches)	
D0	11.97
D2	12.17
D4	12.24
D6	12.20
D8	12.01
D10	11.77
H	10.43
Y	2.52
SF	24%

"Y" is the distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test. If (+) above if (-) below riser contact face.

"SF" = (S/H)*100
It measures the real safety factor obtained.

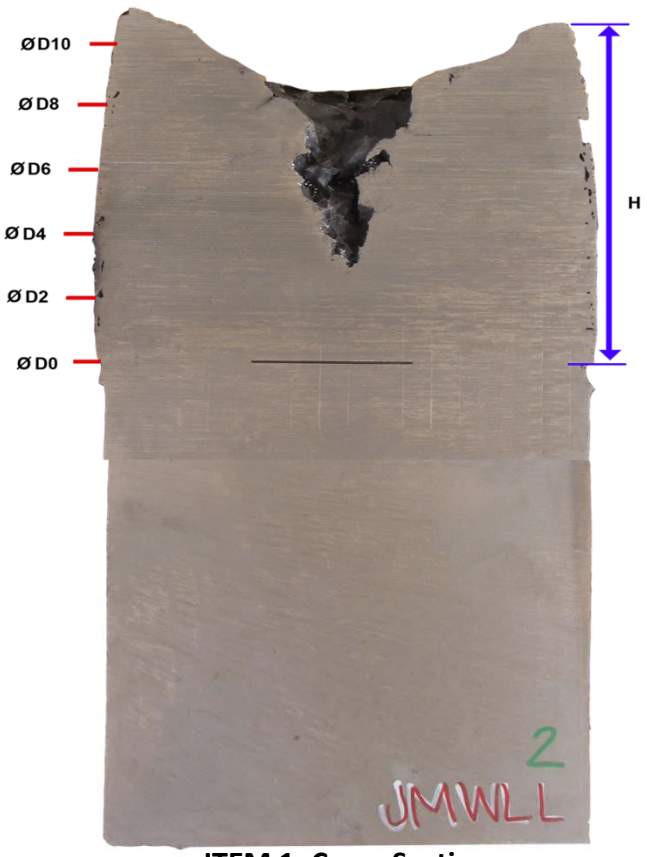


Chemical Analysis (% by W)

	C	Al		C	Al
1	0.40	0.030	**5**	0.40	0.031
2	0.42	0.029	**6**	0.41	0.031
3	0.43	0.030	**7**	0.38	0.032
4	0.42	0.030	**8**	0.44	0.032
15	0.38	0.030	**9**	0.39	0.031
16	0.39	0.032	**10**	0.41	0.029
17	0.39	0.037	**11**	0.41	0.030
18	0.37	0.030	**12**	0.44	0.030
19	0.41	0.037	**13**	0.44	0.031
20	0.40	0.035	**14**	0.37	0.032

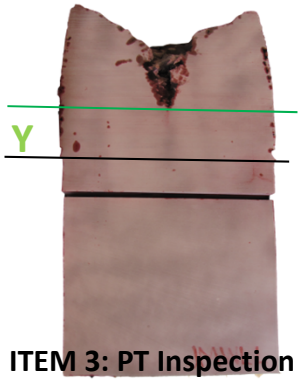
TEST RESULTS

Casting Code:	JMWLL	JoyMark Insulating Non-Rigidized (12" x 12")	Serial Number:	AX101

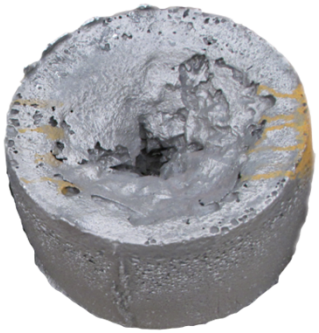


ITEM 1: Cross-Section

ITEM 2: Complete Casting



ITEM 3: PT Inspection



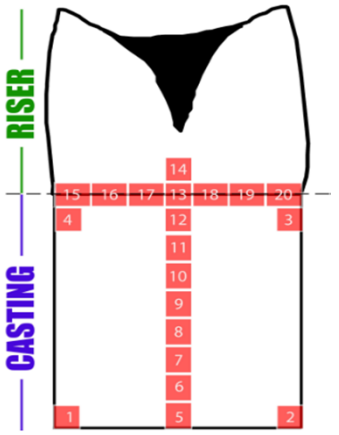
ITEM 4: Top View

ITEM 5: Macro-Etching

Actual Dimensions (In inches)	
D0	12.05
D2	12.52
D4	12.68
D6	12.60
D8	12.36
D10	12.01
H	10.63
Y	2.36
SF	22%

"Y" is the distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test. If (+) above if (-) below riser contact face.

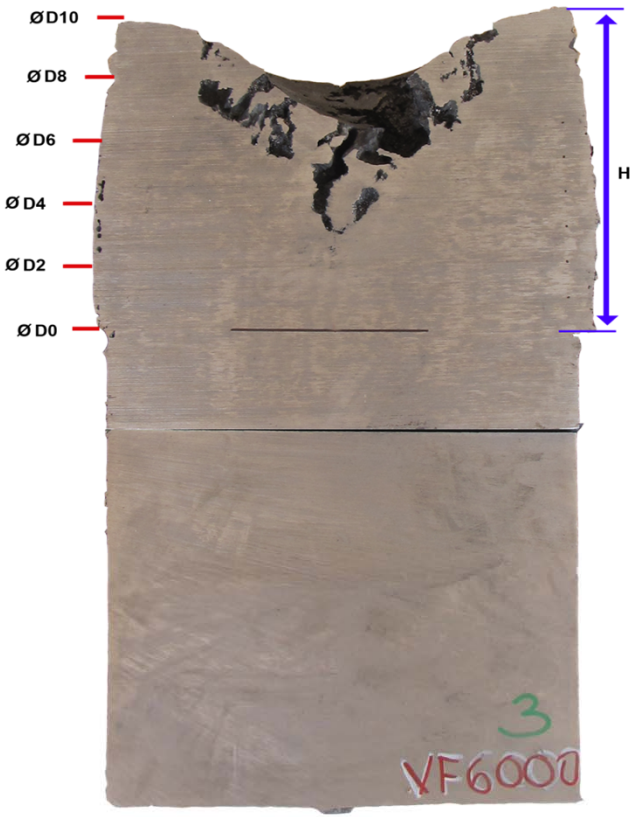
"SF" = (S/H)*100
It measures the real safety factor obtained.



	Percent by Weight				
	C	Al		C	Al
1	0.40	0.031	**5**	0.42	0.032
2	0.44	0.032	**6**	0.42	0.033
3	0.41	0.032	**7**	0.40	0.032
4	0.41	0.033	**8**	0.40	0.031
15	0.41	0.031	**9**	0.42	0.030
16	0.42	0.032	**10**	0.43	0.032
17	0.42	0.290	**11**	0.41	0.037
18	0.41	0.032	**12**	0.41	0.036
19	0.41	0.029	**13**	0.40	0.031
20	0.42	0.030	**14**	0.40	0.027

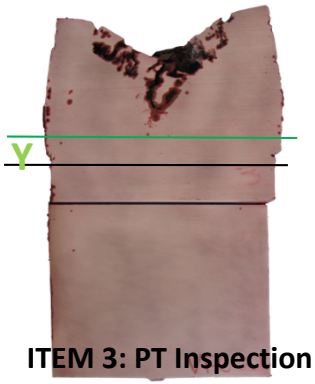
TEST RESULTS

Casting Code: VF6000 | VacuForm Insulating Non-Rigidized (12" x 12") | Serial Number: AX087



ITEM 1: Cross-Section

ITEM 2: Complete Casting



ITEM 3: PT Inspection

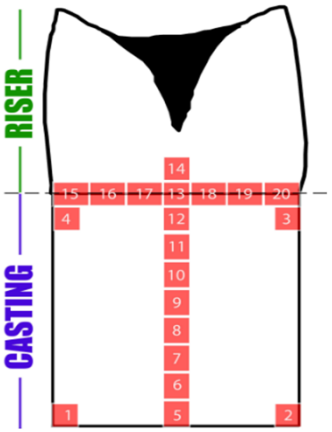
ITEM 4: Top View

ITEM 5: Macro-Etching

Actual Dimensions (In inches)	
D0	12.13
D2	12.83
D4	12.95
D6	12.72
D8	12.24
D10	NA
H	9.51
Y	1.38
SF	14%

"Y" is the distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test. If (+) above if (-) below riser contact face.

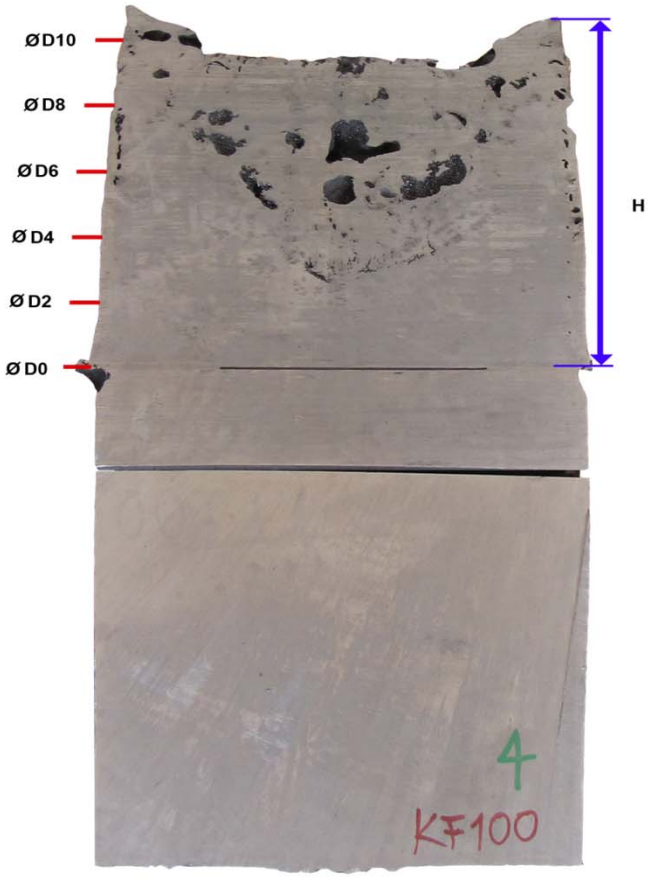
"SF" = (S/H)*100
It measures the real safety factor obtained.



	Percent by Weight				
	C	Al		C	Al
1	0.43	0.033	**5**	0.40	0.032
2	0.39	0.034	**6**	0.40	0.030
3	0.42	0.031	**7**	0.43	0.032
4	0.44	0.035	**8**	0.41	0.033
15	0.40	0.034	**9**	0.39	0.030
16	0.44	0.032	**10**	0.43	0.034
17	0.45	0.032	**11**	0.42	0.031
18	0.43	0.031	**12**	0.44	0.032
19	0.42	0.033	**13**	0.42	0.034
20	0.44	0.031	**14**	0.41	0.019

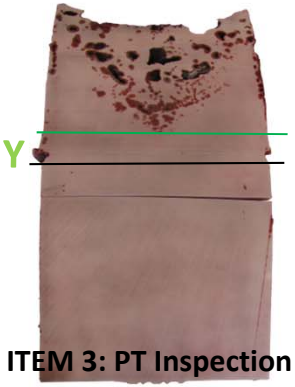
TEST RESULTS

Casting Code: KF100 | Foseco KalFax100 (12" x 12") | Serial Number: AX102



ITEM 1: Cross-Section

ITEM 2: Complete Casting



ITEM 3: PT Inspection

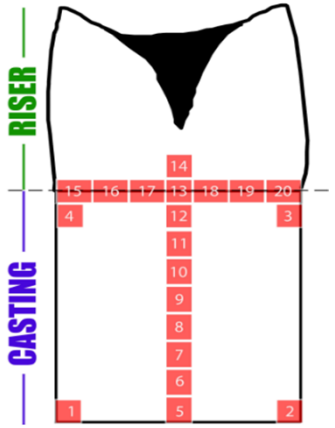
ITEM 4: Top View

ITEM 5: Macro-Etching

Actual Dimensions (In inches)	
D0	11.61
D2	11.97
D4	12.09
D6	11.93
D8	11.61
D10	11.57
H	11.16
Y	1.50
SF	13%

"Y" is the distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test. If (+) above if (-) below riser contact face.

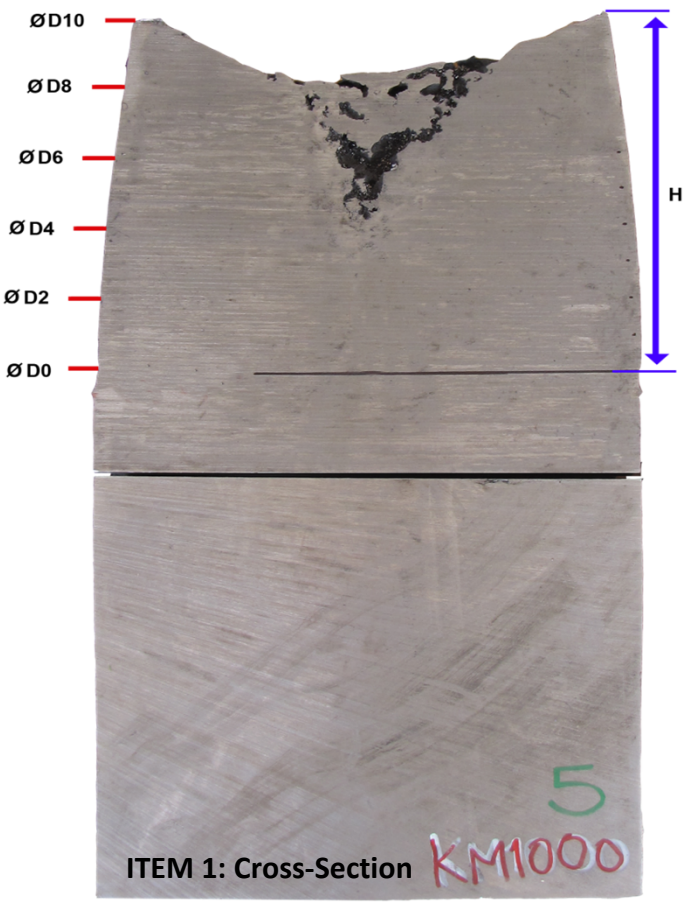
"SF" = (S/H)*100
It measures the real safety factor obtained.



	Percent by Weight				
	C	Al		C	Al
1	0.43	0.035	**5**	0.41	0.038
2	0.43	0.042	**6**	0.43	0.037
3	0.41	0.041	**7**	0.39	0.038
4	0.43	0.038	**8**	0.38	0.039
15	0.38	0.036	**9**	0.40	0.041
16	0.40	0.041	**10**	0.42	0.039
17	0.40	0.048	**11**	0.41	0.053
18	0.45	0.052	**12**	0.42	0.051
19	0.40	0.048	**13**	0.39	0.056
20	0.38	0.044	**14**	0.40	0.061

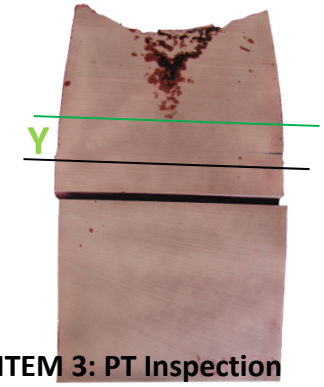
TEST RESULTS

Casting Code: KM1000 | Foseco Kalmin1000 (12" x 12") | Serial Number: AX089



ITEM 1: Cross-Section

ITEM 2: Complete Casting



ITEM 3: PT Inspection

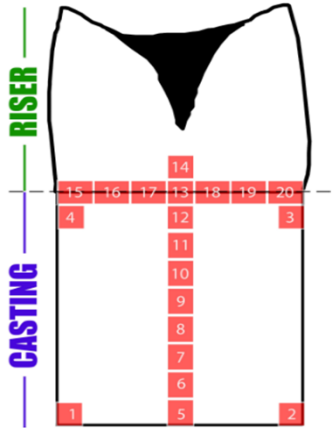
ITEM 4: Top View

ITEM 5: Macro-Etching

Actual Dimensions (In inches)	
D0	12.05
D2	12.17
D4	12.13
D6	11.93
D8	11.69
D10	11.42
H	10.41
Y	2.48
SF	24%

"Y" is the distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test. If (+) above if (-) below riser contact face.

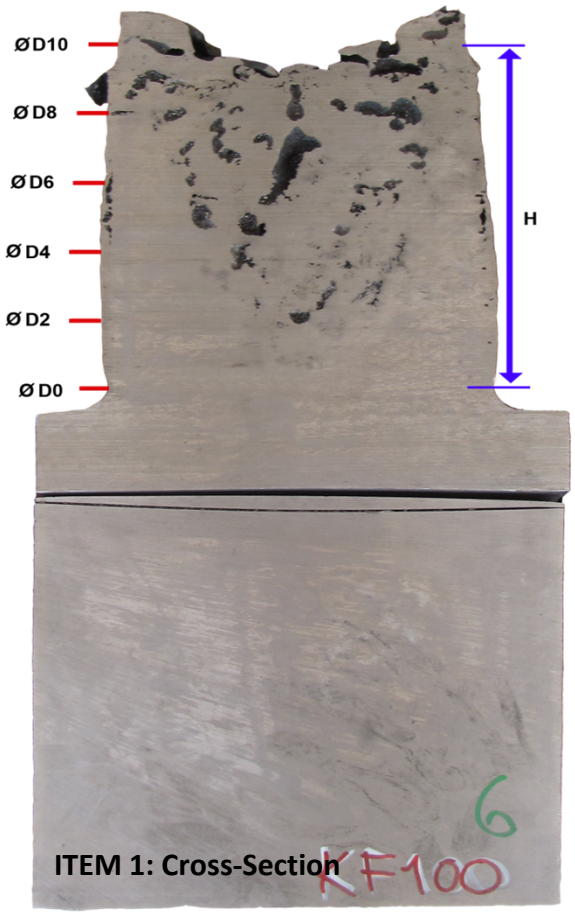
"SF" = (S/H)*100
It measures the real safety factor obtained.



	Percent by Weight				
	C	Al		C	Al
1	0.42	0.034	**5**	0.40	0.032
2	0.41	0.032	**6**	0.44	0.032
3	0.43	0.033	**7**	0.39	0.034
4	0.40	0.350	**8**	0.41	0.036
15	0.40	0.034	**9**	0.43	0.032
16	0.39	0.029	**10**	0.39	0.033
17	0.42	0.032	**11**	0.41	0.033
18	0.44	0.033	**12**	0.43	0.033
19	0.40	0.032	**13**	0.45	0.033
20	0.44	0.035	**14**	0.42	0.032

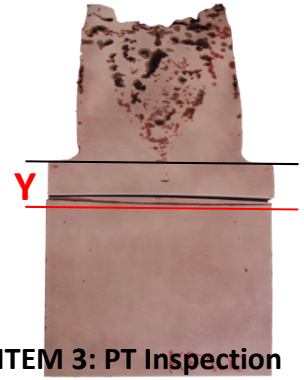
TEST RESULTS

Casting Code: KF100 | Foseco Kalfax100 (9" x 12") | Serial Number: AX090



ITEM 1: Cross-Section

ITEM 2: Complete Casting



ITEM 3: PT Inspection

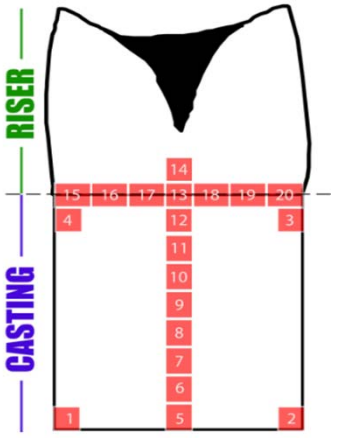
ITEM 4: Top View

ITEM 5: Macro-Etching

Actual Dimensions (In inches)	
D0	9.06
D2	9.13
D4	9.25
D6	9.02
D8	8.94
D10	8.39
H	10.77
Y	-2.25
SF	-21%

"Y" is the distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test. If (+) above if (-) below riser contact face.

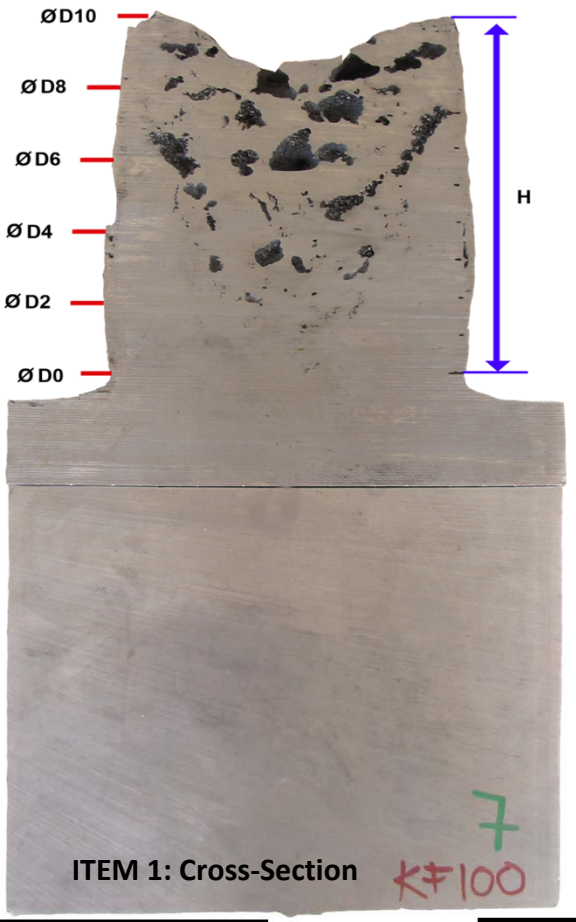
"SF" = (S/H)*100
It measures the real safety factor obtained.



	Percent by Weight				
	C	Al		C	Al
1	0.43	0.033	**5**	0.44	0.031
2	0.41	0.032	**6**	0.41	0.033
3	0.41	0.034	**7**	0.41	0.037
4	0.43	0.032	**8**	0.43	0.037
15	0.44	0.033	**9**	0.42	0.034
16	0.44	0.038	**10**	0.43	0.039
17	0.43	0.039	**11**	0.43	0.039
18	0.44	0.034	**12**	0.44	0.040
19	0.42	0.037	**13**	0.43	0.034
20	0.43	0.034	**14**	0.44	0.036

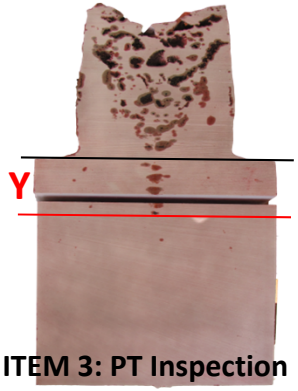
TEST RESULTS

Casting Code:	KF100	Foseco Kalfax100 (8" x 12")	Serial Number:	AX091



ITEM 1: Cross-Section

ITEM 2: Complete Casting



ITEM 3: PT Inspection

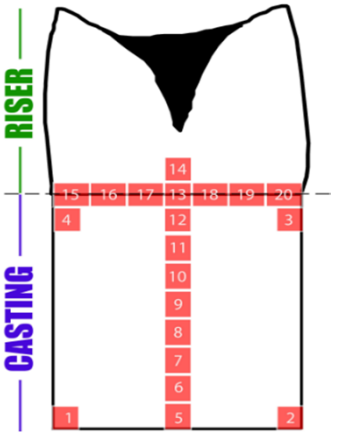
ITEM 4: Top View

ITEM 5: Macro-Etching

Actual Dimensions (In inches)	
D0	7.76
D2	8.11
D4	8.27
D6	8.07
D8	7.95
D10	NA
H	10.24
Y	-2.87
SF	-28%

"Y" is the distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test. If (+) above if (-) below riser contact face.

"SF" = (S/H)*100
It measures the real safety factor obtained.



	Percent by Weight				
	C	Al		C	Al
1	0.44	0.036	**5**	0.43	0.031
2	0.43	0.034	**6**	0.45	0.032
3	0.42	0.033	**7**	0.41	0.034
4	0.43	0.031	**8**	0.41	0.041
15	0.40	0.034	**9**	0.42	0.036
16	0.44	0.034	**10**	0.41	0.036
17	0.44	0.036	**11**	0.44	0.036
18	0.43	0.034	**12**	0.43	0.037
19	0.44	0.033	**13**	0.45	0.039
20	0.43	0.039	**14**	0.45	0.034

Conclusions

Surface reaction: JMWRR had the most aggressive reaction with the wall of the riser sleeve leaving a very rough riser surface. This increases the surface area of contact thus potentially reducing the effective modulus of the riser. JMWLL and VF600 showed a milder reaction while the rest of the sleeves (Foseco) show no considerable reaction.

Dilation: VF6000 is the riser sleeve that dilated the most. This dilation increases the diameter and decreases the height of the riser thus reducing its effective modulus. This is reflected by the resulting low 14% safety factor of the riser. JMWLL also had some dilation but not as severe. The reason for the dilation on JMWLL is probably because of the thin cross-section of the sleeve and because it is a non-rigidized sleeve. Even when KM1000 is an insulating sleeve, it is important to note that it had a very low dilation because of the thicker cross section of the sleeve. (1.25" vs. 0.74" of JMWLL or 0.97" of VF6000).

Shrinkage shape: The insulating sleeves (JMWRR, JMWLL, VF6000 and KM1000) had the typical "cone-shaped" shrinkage whereas the exothermic sleeves (KF100 12x12, KF100 9x12 and KF100 8x12) had a more "random" shrinkage shape.

Aluminum contamination: No relevant increase in aluminum content was noted but in KF100 12x12 where the aluminum content started increasing from 0.040% all the way up to 0.060% in the center of the casting at the riser contact surface. (Points 12, 13 and 14).

Carbon Macro-Segregation: No relevant carbon macro-segregation was detected with the volumetric carbon chemical analysis. Also, in the macro-etched plates, the segregation pipe depth seems to be thoroughly within the riser.

"Y" Distance from the riser contact face to the lowest shrinkage spot revealed on the dye penetrant test ("+" means that the spot was revealed above the riser contact face and "-" means it was revealed below the riser contact face):

CASTING CODE	Y (in)
JMWRR	+ 2.52
KM1000	+ 2.48
JMWLL	+ 2.36
KF100 12X12	+ 1.50
VF6000	+ 1.38
KF100 9X12	-2.25
KF100 8X12	-2.87

Riser Height:

CASTING CODE	H (in)
KF100 12X12	11.16
KF100 9X12	10.77
JMWLL	10.63
JMWRR	10.43
KM1000	10.41
KF100 8X12	10.24
VF6000	9.51

Resulting Safety Factor:

CASTING CODE	SF (%)
JMWRR	24
KM1000	24
JMWLL	22
VF6000	14
KF100 12X12	13
KF100 9X12	-21
KF100 8X12	-28

Insulating vs. Exothermic: When considering the "Y" and "SF" variables shown above, insulating sleeves seem to perform better than exothermic sleeves of the same size, for this size of riser for this type of application.

POK's riser sleeve selection: After analyzing the above results and considering the sleeve costs offered to POK from the suppliers, it is POK's decision to utilize KALMIN 1000 as their primary 12" x 12" riser sleeve coupled with Ferrux 746 hot-topping.

REFERENCES:

W.T. Adams, Jr., “Use of Riser Sleeves and toppings in risering for segregation-free steel castings” Steel Founders Society Of America 34th Technical and Operating Conference, (November 1979).

K.W. Murphy, “Under-riser segregation” Steel Founders Society of America 35th Technical and Operating Conference, (November 1980).

R. W. Ruddle, “Risering of Steel Castings” Foseco Inc. (1979).

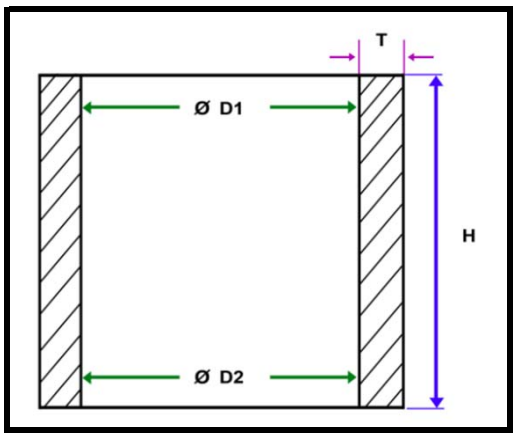
APPENDIX 1

SLEEVE / HOT TOPPING INFORMATION SHEET

Casting Code:	JMWRR	Serial Number:	AX100

SLEEVE

Brand:	Joy-Mark
Material:	CF300WR
Type:	Insulating (Rigidized)
Nominal Size:	12" ID x 12" Height



Actual Dimensions	
D1:	12.19"
D2:	12.13"
T:	0.80"
H:	11.94"

Sleeve Weight:	7.81 lb
* Retained Sand:	69.19 lb

*Sleeve was filled with AFS 40-50 silica sand and weighed.

Geometric Modulus:	2.4"	Effective Modulus:	3.3"

HOT TOPPING

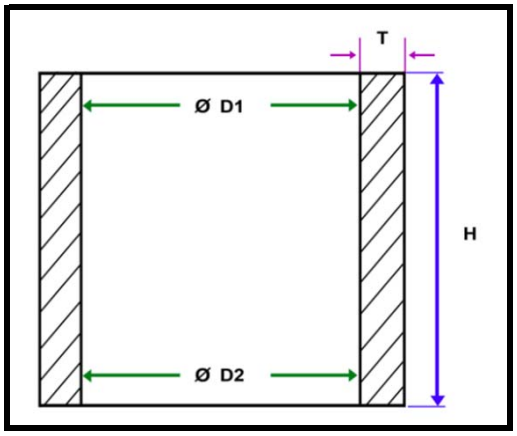
Type:	Exothermic	Material:	IX-24
Brand:	Joy-Mark	Quantity Used:	3.62 lb

SLEEVE / HOT TOPPING INFORMATION SHEET

Casting Code:	JMWLL	Serial Number:	AX101

SLEEVE

Brand:	Joy-Mark
Material:	CF300WL
Type:	Insulating
Nominal Size:	12" ID x 12" Height



Actual Dimensions	
D1:	12.13"
D2:	12.19"
T:	0.74
H:	11.94"

Sleeve Weight:	5.5 lb
* Retained Sand:	68.79 lb

*Sleeve was filled with AFS 40-50 silica sand and weighed.

Geometric Modulus:	2.4"	Effective Modulus:	3.3"

HOT TOPPING

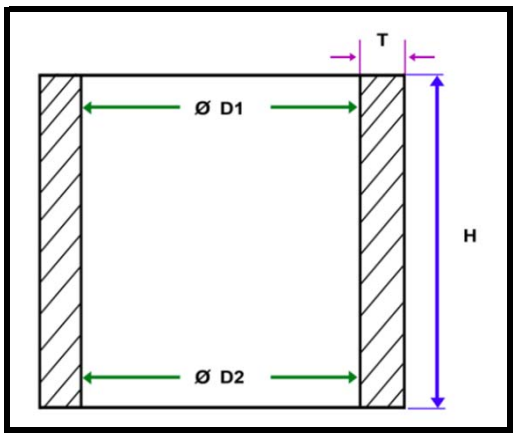
Type:	Exothermic	Material:	IX-24
Brand:	Joy-Mark	Quantity Used:	3.62 lb

SLEEVE / HOT TOPPING INFORMATION SHEET

Casting Code:	VF6000	Serial Number:	AX087

SLEEVE

Brand:	VacuForm
Material:	6000 Fiber
Type:	Insulating
Nominal Size:	12" ID x 12" Height



Actual Dimensions	
D1:	11.88"
D2:	11.94"
T:	0.97"
H:	11.88"

Sleeve Weight:	5.06 lb
* Retained Sand:	67.39 lb

*Sleeve was filled with AFS 40-50 silica sand and weighed.

Geometric Modulus:	2.4"	Effective Modulus:	NA

HOT TOPPING

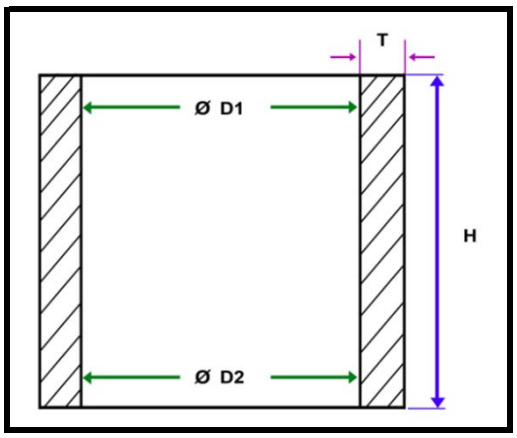
Type:	Insulating	Material:	Vaculite 178
Brand:	VacuForm	Quantity Used:	5.00 lb

SLEEVE / HOT TOPPING INFORMATION SHEET

Casting Code:	KF100	Serial Number:	AX102

SLEEVE

Brand:	FOSECO
Material:	KALFAX 100
Type:	SEMI-EXOTHERMIC
Nominal Size:	12" ID x 12" Height



Actual Dimensions	
D1:	12.00"
D2:	11.94"
T:	0.97"
H:	11.69"

Sleeve Weight:	10.00 lb
* Retained Sand:	64.98 lb

*Sleeve was filled with AFS 40-50 silica sand and weighed.

Geometric Modulus:	2.4"	Effective Modulus:	3.39"

HOT TOPPING

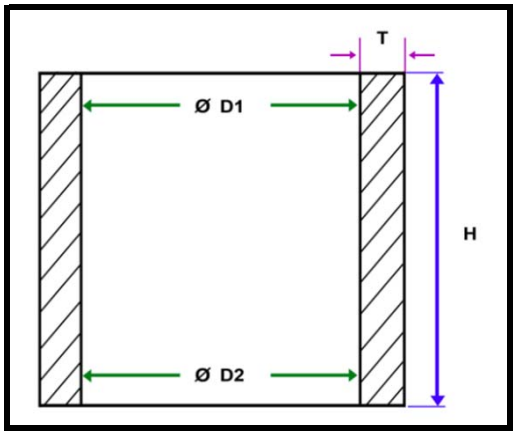
Type:	Exothermic	Material:	Ferrrux 746
Brand:	Foseco	Quantity Used:	3.00 lb

SLEEVE / HOT TOPPING INFORMATION SHEET

Casting Code:	KM1000	Serial Number:	AX089

SLEEVE

Brand:	FOSECO
Material:	KALMIN 1000
Type:	INSULATING
Nominal Size:	12" ID x 12" Height



Actual Dimensions	
D1:	11.94"
D2:	11.88"
T:	1.26"
H:	11.94"

Sleeve Weight:	14.41 lb
* Retained Sand:	66.83 lb

*Sleeve was filled with AFS 40-50 silica sand and weighed.

Geometric Modulus:	2.4"	Effective Modulus:	3.20"

HOT TOPPING

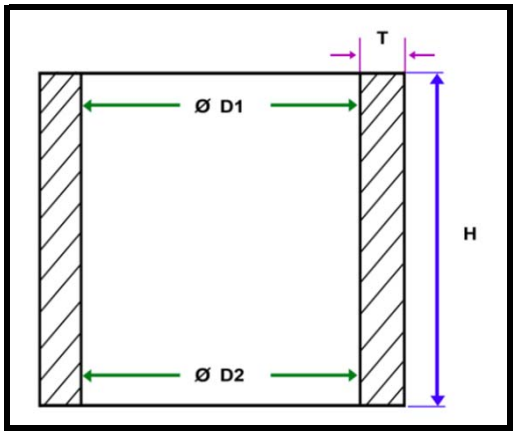
Type:	Exothermic	Material:	Ferrrux 746
Brand:	Foseco	Quantity Used:	3.00 lb

SLEEVE / HOT TOPPING INFORMATION SHEET

Casting Code:	KF100	Serial Number:	AX090

SLEEVE

Brand:	FOSECO
Material:	KALFAX 100
Type:	SEMI-EXOTHERMIC
Nominal Size:	9" ID x 12" Height



Actual Dimensions	
D1:	8.94"
D2:	8.88"
T:	1.00"
H:	11.94"

Sleeve Weight:	7.72 lb
* Retained Sand:	36.67 lb

*Sleeve was filled with AFS 40-50 silica sand and weighed.

Geometric Modulus:	1.8"	Effective Modulus:	2.68"

HOT TOPPING

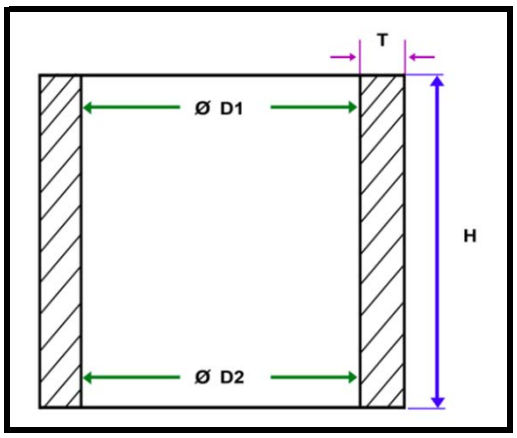
Type:	Exothermic	Material:	Ferrrux 746
Brand:	Foseco	Quantity Used:	1.25 lb

SLEEVE / HOT TOPPING INFORMATION SHEET

Casting Code:	KF100	Serial Number:	AX091

SLEEVE

Brand:	FOSECO
Material:	KALFAX 100
Type:	SEMI-EXOTHERMIC
Nominal Size:	8" ID x 12" Height



Actual Dimensions	
D1:	8.06"
D2:	8.00"
T:	.98"
H:	11.75"

Sleeve Weight:	7.28 lb	
* Retained Sand:	29.56 lb	

*Sleeve was filled with AFS 40-50 silica sand and weighed.

Geometric Modulus:	1.6"	Effective Modulus:	2.47"

HOT TOPPING

Type:	Exothermic	Material:	Ferrrux 746
Brand:	Foseco	Quantity Used:	1.25 lb