APPLICATION INSTRUCTIONS

Keycote® binder system

A long life, colloidal silica-based binder system for ceramic shell slurries.
Now with improved wetting characteristics & increased microbial defense capabilities.
Update: June 2011

The KEYCOTE binder system is a unique two-part binder system for primary slurries. It is designed to offer excellent wetting and adhesion characteristics in a neutral to acidic based binder. The KEYCOTE binder system remains "stable" at low pH values, thus extending slurry life - even in slurries that use cobalt aluminate and zircon refractories.

The KEYCOTE binder system is a two-part system (binder and concentrate) that, once mixed together, can be used similar to any existing primary binder slurry.

NOTE: KEYCOTE concentrate must be remixed before use to insure a homogeneous mixture.

WITH YOUR EXISTING PRIMARY SLURRY FORMULATION

Use the same percentages and loadings of your current refractories. To calculate the amount of Keycote system products required:

A. _____ lbs of binder required in formula

B. (A) *.8 = _____ lbs Keycote binder

C. (A) * .2 = _____ lbs Keycote concentrate

TYPICAL PRIMARY SLURRY FORMULATION FOR APPROXIMATELY 10 GALLONS (10 LITERS) OF SLURRY

These formulations are given for those users just starting out.

1. **Fused Silica/Zircon Refractory 50/50 (Ferrous)**
   KEYCOTE binder: 34.71 lbs (4.17 kg)

   KEYCOTE concentrate 8.68 lbs (1.04 kg)
   Ranco-Sil™ 4 fused silica (-200 mesh)*: 68.70 lbs (8.25 kg)
   Zircon (-200 mesh)*: 68.70 lbs (8.25 kg)
   Viscosity: 10 - 12 seconds,
   #5 Signature Series Zahn Cup
   Slurry Density: 2.150-2.190 g/ml

2. **Fused Silica Refractory (Nonferrous)**
   KEYCOTE binder: 37.59 lbs (4.52 kg)

   KEYCOTE concentrate: 9.40 lbs (1.13 kg)
   Ranco-Sil 4 fused silica (-200 mesh): 95.40 lbs (11.47 kg)
   Viscosity: 15 - 17 seconds,
   #5 Signature Series Zahn Cup
   Slurry Density: 1.690-1.730 g/ml

3. **Zircon Refractory (Ferrous)**
   KEYCOTE binder: 35.15 lbs (4.22 kg)

   KEYCOTE concentrate: 8.79 lbs (1.06 kg)
   Zircon (-200 mesh)*: 206.7 lbs (24.85 kg)
   Viscosity: 12 - 14 seconds,
   #5 Signature Series Zahn Cup
   Slurry Density: 2.990-3.030 g/ml

APPLICATION RECOMMENDATIONS

A. For best results, WEIGH ALL MATERIALS.

B. **To insure binder uniformity, remix KEYCOTE concentrate before using.**

C. A well-controlled KEYCOTE slurry can last indefinitely. There are many factors that affect slurry life. Contact the R&R Technical Department for details.

D. No water is required when making a new primary slurry, but is required later to replace water lost to evaporation.

E. When making up a new slurry, the viscosity should be increased by adding more refractory(ies) and decreased by adding more binder. As with any conventional colloidal silica slurries, a new slurry must be stabilized before it is used in production. The slurry is considered to be stabilized when there is no more than a one second change in Zahn cup reading when measured after two hour intervals.

F. SLURRY VISCOSITY SHOULD BE CHECKED AT LEAST AT THE BEGINNING OF EACH OPERATING SHIFT. Deionized or distilled water should be added as necessary to reduce viscosity, which increases as a result of evaporation. The use of tap water may lead to premature gelation.

G. Slurry density should be checked after viscosity adjustments are made and the slurry is stabilized. The slurry density should be maintained +0.02 g/cc from the density of the slurry when originally made up. If slurry density deviates out of this range, then a binder solids content determination and a gel test should be performed.

H. A slurry binder solids content check should be done at least weekly, dependent upon conditions, production rates, use of a prewet application, etc.

J. Make sure the pattern is clean and free from silicones or other lubricants and contaminants.

K. It is not usually necessary to use a prewet before applying the first primary coat to the wax pattern. However, if a

prewet is necessary, use KEYCOTE binder, without KEYCOTE concentrate, etc. Be sure to control binder solids of the prewet the same as done with the slurry.

L. A prewet application of dilute KEYCOTE binder is recommended between each primary coat. The KEYCOTE binder (without KEYCOTE concentrate) should be diluted to 24% binder solids (binder to water ratio of 5.8:1/vol, 6.9:1/wt). The prewet should be drained well so no pockets of liquid are left on the pattern. When a second primary slurry is used and it has a lower viscosity, no prewet application is recommended. When the second primary slurry is utilized, it should also be a KEYCOTE binder slurry.

M. If the KEYCOTE slurry is foaming or has entrapped air, which weakens the ceramic shell, make sure (1) the mixer propeller is not running at excessive speeds causing a vortex, (2) the mixer propeller is not running continually which does not allow entrapped air to escape and causes slurry overheating (five minutes on and five minutes off is often used), and (3) that binder solids did not increase excessively. When binder solids are above the control range it adversely affects the defoaming characteristics, can cause binder gelation, and inconsistent viscosity, which can lead to casting defects. See Antifoam Test outlined on page 4.

N. ANTIFOAM AND WETTING AGENTS are already formulated into KEYCOTE binder and other additions may not be compatible. Contact the R&R Technical Department.

O. Do not add KEYCOTE binder to another slurry system to avoid incompatibility and subsequent gelation.

P. It is best to maintain the slurry temperature within a 5F (3C) operating range and not more than 10F (6C) above ambient temperature, as with any conventional colloidal silica slurry.

Q. A slurry log of refractory, binder, water and other adjustments, as well as slurry conditions checks, should be maintained.

R. Slurry tanks, props, slurry test tools and other equipment or containers should always be rinsed well before the KEYCOTE binder material dries on the surface and becomes difficult to remove.

S. When building any slurry, add the refractory(ies) last. If more than one refractory is used, add the refractory with the lowest density first. Fused silica is 2.2, alumino silicate is 2.7, and zircon is 4.5 g/cc approximately. The refractory should be added slowly for best results.

T. Software for slurry control is also available. Contact the R&R Customer Service department for more details.

SLURRY DENSITY DETERMINATION

The following method can be used to check slurry density.

1. Pre-weigh a 100 ml graduated cylinder on a scale sensitive to 0.1 gram.
2. Fill the cylinder with exactly 100 ml of well-mixed slurry and reweigh.
3. Subtract the empty graduated cylinder weight from the filled weight. Divide the difference by 100 to obtain the density in g/cc.

SLURRY BINDER SOLIDS CONTENT DETERMINATION & ADJUSTMENT

To properly monitor and control the binder solids content of the KEYCOTE binder slurry, one of the following procedures can be performed. The binder solids content should normally be:

Primary Slurries: 27.2 – 28.8 %/wt

Determination Method A

1. Collect four 50 ml centrifuge tubes of slurry and centrifuge for approximately 30 minutes or more at 3500-4000 RPM.
2. Decant the liquid from the four tubes into two tubes and centrifuge them for an additional 30 minutes.
3. Decant the pourable portion from the tube into a clean container that can be sealed. Stir this portion well.
4. Transfer a sample with a pipette or an eyedropper into a pre-weighed, 10 ml VOLUMETRIC FLASK, not a graduated cylinder.
5. Weight the flask and sample together on a scale accurate to 0.01 grams.
6. After subtracting the flask weight, calculate the specific gravity by dividing the sample weight by 10.
7. Using the determined specific gravity and the chart on the inserted page, locate the percent of binder solids content. DO NOT USE ANY OTHER CHART. For computer application, the formula for the MARS 1 binder solids curve is $x = 155.56y – 154.00$

Determination Method B

1. Prepare a sample using Steps 1-3 in Method A.
2. Weight out a 20 +/- 0.1 gram sample.
3. Dry this sample for about one hour at 350F (180C).
4. Weight the dry sample to the nearest 0.1 grams.
5. Divide the dry weight by the original sample weight then multiply by 100 to determine the percentage of slurry binder solids contained in the sample.

   NOTE: Method B gives a slightly higher reading than Method A.

Determination Method C
(LEAST ACCURATE, NOT RECOMMENDED)
If a centrifuge is not available, this method can be used. This method is not as precise as Methods A or B and may give higher binder solid content values. To establish a comparison standard of the slurry binder solid content, follow this procedure on a freshly stabilized slurry. The value obtained from this slurry is a comparison standard and may not provide precise values.

1. Place approximately 1000 ml of slurry in a sealed container. Leave the container undisturbed for at least 16 hours. The taller, i.e. more slender, the container, the more accurate the results.
2. Carefully decant liquid for the test from the top of the container, leaving the solids settled in the bottom.
3. Steps 4-7 Method A or B can now be used to determine the slurry binder solids content.

ADJUSTMENT

If the slurry binder solids content is:

A. Above the normal range:
Add 27 oz of water per 1.0 percentage point above the normal range per 10 gallons of primary slurry (31 oz for secondary slurries). For metric applications, add 210 ml per 1.0 percentage point above normal per 10 liters of primary slurry (240 ml for backup slurries).

After mixing one hour (or after the Zahn viscosity has stabilized within one second between 15 minute intervals), collect another slurry sample and determine the new slurry binder solids content. Test and adjust further if necessary. If the stabilized slurry viscosity is within the recommended range, production can continue.

B. Below the normal range:
The slurry is substandard and evaporation should be allowed to remove excess water and bring the slurry binder solids content back into the normal range. The low binder solids content level is usually the result of too much water being added to the slurry.

GELATION DETERMINATION

The following method can be used to determine the potential for slurry gelation. It is important that the gelation test be conducted on a sample that has been adjusted and is in specification. Otherwise a false positive indication is possible.

1. Prepare a sample of binder from the slurry with either the Slurry Binder content Determination method A (Steps 1-3) or method C (Steps 1 and 2). NOTE: the sample used for the slurry Binder Content Determination by Method A or Method C only can also be subsequently used to perform the gelation test.
2. Pour 10 to 20 ml of binder into a sealable container capable of withstanding 150F (65C).
3. Place the sealed container in a temperature controlled oven at 140 +/- 5F (60 +/- 3C) for 16-24 hours.
4. Observe the viscosity of the liquid. If the viscosity has increased, slurry life will be short. If the viscosity is very high or gelled, the slurry should be discarded to avoid producing poor quality shells.

ANTIFOAM TEST

Various conditions, such as high binder solids, can degrade the antifoaming characteristics of KEYCOTE binder. To test for the presence of adequate antifoam:

1. Add approximately 10-20 ml of binder that has been centrifuged or separated from the slurry to test tube or other container that can be sealed tightly.
2. Shake the sample vigorously for 5 seconds.
3. Observe the binder and note the time for the foam to dissipate.
4. If the foam breaks in less than 20 seconds, the antifoam level is okay.
5. If the foam breaks in more than 20 seconds, a 1-3 ml/gallon of slurry addition of DCH-10 antifoam should be made.

SAFETY

OSHA approved respiratory protection should always be worn to avoid inhalation of respirable silica dust, which results in irreversible lung disease, silicosis. Such exposure includes slurry makeup, casting, knockout and cleanup. Refer to MSDS for specific details.

TYPICAL PROPERTIES
(For Complete binder made of 1:4 ratio)

Total Solids Content (incl. SiO_2)	28%/wt
Particle Size	14 nm
PH @25C	4.5
Specific Gravity	1.16
Weight/Volume	9.6 lbs/gal (1.16 kg/l)
Viscosity @25C	10 cps
Na_2O content	<0.1%/wt
Particle Charge	Negative
Color with ReDip™ indicator	Greenish yellow
Color without ReDip™ indicator	Milky white

STORAGE & HANDLING

Keep from freezing. KEYCOTE binder and concentrate should be maintained above 35F (2C) to prevent the silica from precipitating irreversibly and making the product unsuitable for use. Binder stored in transparent or translucent containers should be sheltered from direct sunlight. Shelf life is one year from date (MMDDYY) in batch lot number on label. Rotate stock to maximize shelf life. To insure binder uniformity, remix before using.

TECHNICAL SUPPORT

R&R's technical expertise and support capabilities are unmatched by other suppliers in the precision investment casting industry. Many investment casters depend on R&R's technical support and product & Application laboratory. R&R also has an R&D foundry dedicated solely to developing and testing products for precision investment casting applications. We invite you to call us, toll free.

PACKAGE/DISTRIBUTION CENTERS

KEYCOTE binder is available in a variety of package sizes and from many distribution locations. Call our Customer Service department at (800)800-7496 or (419)865-9497 for package availability and for the distribution center closest to you.

KEYCOTE Binder - Specific Gravity vs Binder Solids Chart

Specific Gravity	Binder Solids		Specific Gravity	Binder Solids		Specific Gravity	Binder Solids
1.130	21.78		1.154	25.52		1.178	29.25
1.131	21.94		1.155	25.67		1.179	29.41
1.132	22.09		1.156	25.83		1.180	29.56
1.133	22.25		1.157	25.98		1.181	29.72
1.134	22.41		1.158	26.14		1.182	29.87
1.135	22.56		1.159	26.29		1.183	30.03
1.136	22.72		1.160	26.45		1.184	30.18
1.137	22.87		1.161	26.61		1.185	30.34
1.138	23.03		1.162	26.76		1.186	30.49
1.139	23.18		1.163	26.92		1.187	30.65
1.140	23.34		1.164	27.07		1.188	30.81
1.141	23.49		1.165	27.23		1.189	30.96
1.142	23.65		1.166	27.38		1.190	31.12
1.143	23.81		1.167	27.54		1.191	31.27
1.144	23.96		1.168	27.69		1.192	31.43
1.145	24.12		1.169	27.85		1.193	31.58
1.146	24.27		1.170	28.01		1.194	31.74
1.147	24.43		1.171	28.16		1.195	31.89
1.148	24.58		1.172	28.32		1.196	32.05
1.149	24.74		1.173	28.47		1.197	32.21
1.150	24.89		1.174	28.63		1.198	32.36
1.151	25.05		1.175	28.78		1.199	32.52
1.152	25.21		1.176	28.94		1.200	32.67
1.153	25.36		1.177	29.09		1.201	32.83

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Ransom & Randolph

3535 Briarfield Boulevard
Maumee, OH 43537 USA
USA Phone (800)800-7496
Phone: (419)865-9497
Fax: (419)865-9997

European Agent: HTM Tradeco Ltd.
Phone: 181/8054200 (UK)
Fax: 181/8040127 (UK)

KEYCOTE BINDER
SLURRY WORKSHEET - METRIC

A. Tank Calculations
- A1. Tank Radius ..... _____cm
- A2. Slurry Depth ..... _____cm
- A3. Area = 3.14 x A1 x A1 ..... _____cm^2
- A4. Volume = (A2xA3)/1000 ..... _____L

B. Slurry Density Check
- B1. Weight of empty 100 ml cylinder ..... _____g
- B2. Weight of 100 ml cylinder and slurry ..... _____g
- B3. Weight of slurry = B2 – B1 ..... _____g
- B4. Slurry Density (g/ml) = B3/100 ..... _____g/ml
- B5. Weight of Slurry = A4 x B4 ..... _____kg

C. Binder Solids Check
- C1. Weight of empty 10 ml flask ..... _____g
- C2. Weight of 10 ml flask and binder ..... _____g
- C3. Weight of binder = C2 – C1 ..... _____g
- C4. Specific gravity of binder = C3/10 ..... _____g/ml

  NOTE: Check Binder Solids vs. Specific Gravity chart on the Primcote Application instructions to get % Binder Solids
- C5. Percent binder solids ..... _____%

D. Refractory Solids Check
- D1. Weight of drying pan ..... _____g
- D2. Weight of drying pan and wet slurry ..... _____g
- D3. Weight of drying pan and dry slurry ..... _____g
- D4. Weight of wet slurry = D2 – D1 ..... _____g
- D5. Weight of water = D2 – D3 ..... _____g
- D6. Weight % of water = (D5/D4) x 100 ..... _____%
- D7. Weight % of binder = (D6/(100-C5)) x 100 ..... _____%
- D8. Refractory solids = 100 – D7 ..... _____%

E. Water Addition Calculation

NOTE: Water additions should only be made if the solids are above 28.0%. If no water adjustment is required, skip to section F or G as required and substitute D8 for E7, D7 for E6, and B5 for E4 respectively.
- E1. Weight of binder = (D7xB5)/100 ..... _____kg
- E2. Silica solids difference = C5 – 27.5 ..... _____%
- E3. Water addition = E1xE2/27.5 ..... _____kg
- E4. Adjusted weight of slurry = B5 + E3 ..... _____kg
- E5. Adjusted weight of binder = E1 + E3 ..... _____kg
- E6. Adjusted weight % of binder = (E5/E4)x100 ..... _____%
- E7. Adjusted weight % of refractory = 100 – E6 ..... _____%

F. Binder Addition Calculation
- F1. E7/% refractory desired ..... _____%
- F2. (F1 – 1) x E4 ..... _____kg

G. Refractory Addition Calculation
- G1. E6/% binder desired ..... _____%
- G2. (G1 – 1) x E4 ..... _____kg