THE MANUFACTURE OF SULPHURIC ACID

Several different patents have been issued covering methods of manufacturing sulphuric acid from rock gypsum. These methods depend upon the heating or calcining the rock to very high temperatures thus releasing the sulphur dioxide gas (SO_2) which can be conveyed into lead chambers or otherwise converting the gas into SO_3 which, as it is passed into water, forms sulphuric acid. This method has not been commercially successful in this country but is said to have been used in Germany during the first World War. One method said to have been successful abroad consists of heating gypsum and clay at high temperatures forming a Portland or hydraulic cement clinker and sulphur dioxide, thus manufacturing a cement and sulphuric acid in one plant. Another method is to heat gypsum to a molten mass and pass an electric current through this mass releasing both oxygen and sulphur dioxide.

TERRA ALBA (PAPER, CLOTH AND PAINT FILLER, ETC.)

A white rock gypsum when ground very fine or bolted through silk cloth is known as Terra Alba. It is used to a large extent as a filler in paper and cloth, its function being to close up the pores and enable the paper or cloth to take a better finish. It is frequently used in fine grade writing and printing papers. Terra Alba is also used to some extent as a cheap paint filler, in the brewing industry and in the baking industry. Bestwall cannot as of 1958 make a product to sell as TERRA ALBA.

MINOR USES OF GYPSUM

Alabaster for carving statuary, yeast accelerator, crayon manufacture, beer manufacture, flux in smelting,,etc. Alabaster is a fine grained white gypsum rock which is quarried in large blocks in Europe and carved into statuary and other forms of decoration. In arid regions in the southwestern part of this country quarried blocks of gypsum have been used for the walls of buildings and also for building roads. Rock gypsum, however, is too soft and soluble in water to be used satisfactorily for exterior purposes except in very dry, warm regions.

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A fine ground pure gypsum is used by many yeast manufacturers as a yeast accelerator or food as it very notably speeds up the action of the yeast in baking. Thus, there is a small amount of gypsum in the bread and yeast that we consume.

Black board crayons or chalk are sometimes made of a finely ground uncalcined white gypsum rock. A binder and sometimes a pigment for coloring purposes are added and the mixture molded into the required shape under pressure. Most crayons, however, are made from calcined gypsum which is mixed with water and cast into a mold, the setting of the plaster giving the required hardness and strength.

Rock gypsum is used as a flux in reducing lead ores and in the smelting of some of the nickel ores in Canada where it furnishes the sulphur necessary to form a nickel matte and to slag the siliceous ore.

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PLATE GLASS STUCCO (FIRST AND SECOND SIDE)

Bestwall Plate Glass Stucco is used to firmly cement the rough plate glass sheets to the grinding tables or machines so that the surfaces of the glass can be polished and ground. This is a continuous process in modern plants where the glass is cemented to a series of flat cars hooked together that pass slowly down a line on a track where the sheets are first ground by revolving cast iron shoe grinders fed with rouge. When the glass, finished on the top side, emerges from the polishers, it is turned over, the polished side cemented to the tables and again run through the grinders and polishers. The material used for the first operation is termed First Side or Yard Stucco. When the glass is turned over, it is very important to have a gut free from material to bed the polished surface in. This material is known as Second Side Stucco. Some large plants now spray the plaster slurry on the tables by means of a fan-tail spray head. This gives a more even layer of plaster and speeds up the laying operation. Thickness of the plaster layer under the bedded glass sheet is of the order of 0.005 to 0.010 inches. The glass is then placed on the slurry and pressed down firmly by heavy rollers. The stucco is often accelerated at the gypsum mill so that it will set on the grinding and polishing line in from 5 to 8 minutes depending on the speed of the machine and the distance on the line from where the glass is bedded until it runs under the first grinders where it must be set and sufficiently hard to hold the glass firmly in place.

Large size window plate glass is polished on large round revolving tables 30 feet or so in diameter on which various sizes of glass are cemented with a slower setting stucco. These tables revolve with the top of the glass in contact with a series of large grinding and polishing shoes that revolve in opposite direction to that of the table.

Plate glass stucco as made at the Blue Rapids Plant is unexcelled and is sold for Second Side Stucco. It is grit free, exceptionally strong and of a very uniform set. While it is not absolutely necessary to use this grade of plaster for first bedding, some large concerns use it for both sides due to its strength and uniformity of performance. As soon as the proper setting time is determined for a particular operation, no trouble is experienced with Blue Rapids' plate glass stucco.

Stuccos of somewhat lower purity, such as those produced at the Ft. Dodge Plant, are sometimes used for first bedding of "First Side" purposes. However, they are not sufficiently grit free for use as "Second Side" stucco.

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CORRECTIVE PLANT PRACTICES

The usual difficulties experienced with plate glass stucco are (1) slow set, (2) quick set, and (3) lack of adhesion. The setting time of plate glass stucco is very important. If the stucco sets too quickly, it may be difficult or impossible to bed the glass properly. If the stucco sets too slowly, it will not be strong enough to hold the glass on the table when the glass passes under the first grinders. The usual remedy for a slightly quick set is to lower the temperature of the mixing water. Conversely, a slow setting stucco may be accelerated by using warmer water. Most plate glass plants have a thermostatically controlled water supply and are able to vary water temperatures between about 60° F. and 110° F. With this water temperature range, it is possible to vary the set of the stucco about 3 minutes in either direction.

Difficulties with poor adhesion of the plaster to the glass may be caused by quick set, lack of sufficient lime or alkaline material in the mix, or too high a percentage of water in the mix. The remedy for quick set has been discussed above and the preventive measuresto be employed in the other cases are obvious.

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STATUARY CASTING PLASTERS

These plasters differ from Sunflower Molding Plaster in that they contain a special ingredient which "case hardens" the finished cast. Objects cast with these plasters will have an extremely hard surface, resistant to marring and dense enough to be painted without preliminary sizing. Statuary Casting Plasters were especially developed for use by casting shops desirous of producing superior merchandise. They are admirably suited to the production of high grade statuary which may be solid or hollow.

USES

For high grade statuary, plaques, and art novelties where a hard, abrasive resistant surface is desired.

CORRECTIVE SHOP PRACTICES

Same as for Sunflower Molding. In drying statuary plaster, care must be taken in removing the cast from a warm drying room to a cool or cold atmosphere as the quick shrinkage will cause small crazing cracks on the surface. If dried at too high temperatures or for too long a period, casts made from either Statuary or Sunflower will calcine and soften. A temperature of 130° F. should be the maximum allowed in such dryers.

CHARACTERISTICS

For the physical characteristics of Bestwall Statuary Plasters, refer to the table on the next page.

LIGHT LUBRICATING OIL

A light (SAE 10W) engine oil or thin white medicinal mineral oil may be used if sparingly applied. An excess is liable to cause separator runs.

CAMPHOR

Spirits of camphor is used as a parting medium on fine work such as the reproduction of jewelry.

METAL MOLDS

In the manufacture of plaster molds for metal casting the molds are cast over metal patterns. For this work the following formula is sprayed on the pattern.

SAE 10 Mineral Oil	10.0%
Bayberry Wax	2.75%
Aerosol O. T.	0.25%
Water	87.00%

IMPRESSION, LABORATORY AND ORTHOPEDIC

These Industrials are made at Blue Rapids, Kansas and can be made at Acme, Texas.

IMPRESSION PLASTER

A fine ground, white, pure, quick-setting plaster made from carefully selected rock. It is mixed by the dentist to a rather thick consistency and placed in a small tray about the size of the jaw which is inserted in the patient's mouth. It hardens very quickly leaving a perfect impression of the entire upper or lower part of the mouth. This plaster is accelerated to set in from 3 to 5 minutes when shipped and is frequently accelerated with powdered potassium sulphate by the dentist. Such plaster must be free from voids, low in water carrying capacity to provide strength and must be of such density that it will break away from the casting easily with a clean break so that the broken pieces can be perfectly cemented together. Bestwall Impression Plaster meets these requirements in all respects. It is purchased and resold in small containers by some of the largest dental supply dealersin the country.

If stored for several months under damp conditions, impression plaster may become too quick setting to be used. If stored in a dental laboratory in metal containers with tight covers, this trouble will not occur.

PHYSICAL CHARACTERISTICS

	Laboratory	Impression	Orthopedics
Job Consistency.....		45-50 cc. (heavy mix)	
Pouring Consistency.....	70 cc.	70 cc.	
Job Set		2-3 min.final	
Initial Set at P.C.....	9 min.		
Final Set at P.C.....	13 min.	10 min. final	
Setting Expansion at P.C.....	0.175%	0.16-0.17%	
Dry Compressive Strength (Job Consistency).....		3500 p.s.i.	
Dry Compressive Strength P.C.....	2400 p.s.i.	2400 p.s.i.	

LABORATORY PLASTER

Is the same high grade fine ground white plaster as Impression Plaster, the main difference being that it possesses a slower set of 10 to 12 minutes. The dentist uses this plaster for general laboratory work and for making models or casts over which vulcanizing can be done immediately. As considerable strength is desired, the plaster should be mixed as thick as possible as both sections of the mold between which the rubber plate is vulcanized are subjected to considerable pressure. No troubles are ordinarily experienced with dental laboratory plaster unless it becomes quick setting from age or extreme dampness.

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ORTHOPEDIC PLASTER

A fine ground, white plaster that will make a strong rigid cast. Ordinarily it is accelerated to set in from 10 to 15 minutes, but a quicker or slower set may be desired according to the particular technique employed. It is used to make a rigid cast over a broken bone by immersing bandages in a rather thin plaster mix and wrapping the bandage tightly around the injured part. Very often the bandage is impregnated with dry plaster after which the roll may be immersed in water and wound around the injury. If a quicker set is desired, powdered potassium sulphate can be added to the water. Bestwall Orthopedic plaster is produced both at Acme and Blue Rapids.

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MISCELLANEOUS PLASTER PRODUCTS

SAFE FILLER STUCCO

Safe Filler Stucco is an ordinary medium grind plaster, gray in color and adjusted to any specified setting time. It is used to fill the space between the inner and outer steel walls of safes. In the process of manufacture, the inner box of the safe is inverted in the center of a removable square steel mold and the stucco slurry is poured around the sides and over the back of the box. When the stucco has set, the mold is removed and the unit, consisting of the box embedded in plaster, is dried. When bone dry, the outer steel plates are applied. In the finished safe, the thick wall of plaster (4 to 6 inches) acts as a fire barrier to protect the contents of the inner box. The safe doors are also filled with plaster.

POLISHING PLASTER

Ordinary Manufacturer's Stucco is sold to the stone cutting trade for use in the polishing of marble, granite, etc. The stones are placed on the polishing table and the spaces between stones are poured full of plaster and slurry. When set, the plaster binds the stones together and holds them in place during the polishing operation.

SECOND SETTLE STUCCO

Second settle stucco contains only .02% to .06% combined water when freshly made as compared to 6.0% to 6.4% in first settle stucco. This gives second settle stucco a great affinity for water and, if exposed, it will pick up water from the air quite rapidly. This property is utilized by insecticide manufacturers in the preparation of lethal crop dusts. A number of insecticide chemicals retain their killing power only so long as they do not come in contact with water. In such cases the chemical is mixed with second settle stucco as a carrier and dusted on the crop to be protected. The second settle stucco protects the chemical against hydrolysis by preferentially taking up moisture from the leaves of the plant or the surrounding atmosphere, and thus prolongs the useful life of the chemical. The most common insecticide chemical of this type is tetraethyl pyrophosphate, referred to by the trade as T.E.P.P. This product is available from Fort Dodge and can be produced at Acme and Sigurd.

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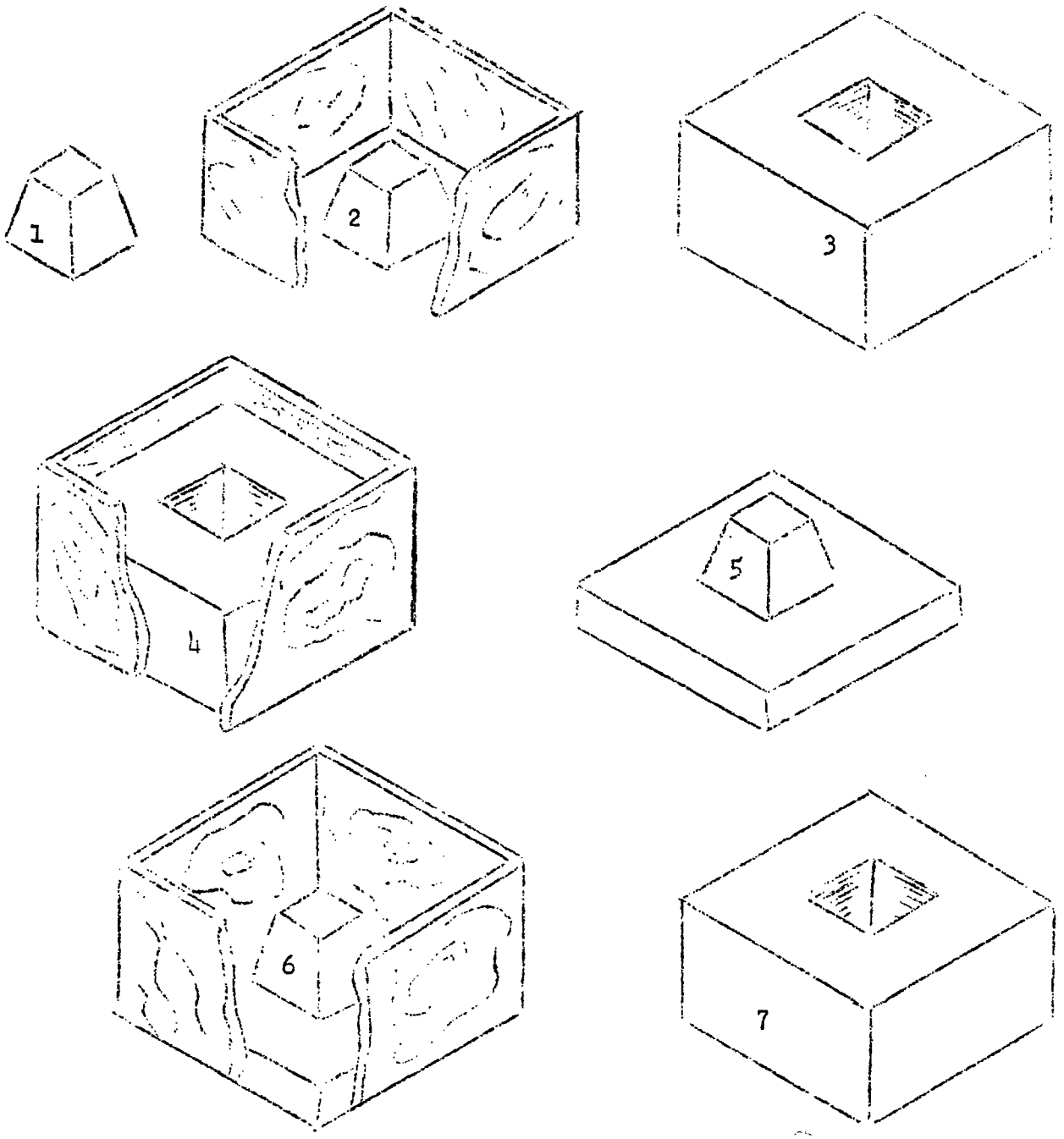
POTTERY PLASTER

Pottery and sanitary ware plants in this country use thousands of tons of plaster products each year. The larger proportion of this is pottery plaster. This plaster is made into molds which are used in forming clay to produce dinnerware and other ceramic objects. A model of the object to be produced is made of clay or plaster (Fig. 1). This model is then boxed up as in Figure 2 and a mold is cast from it using a low expanding, very hard plaster such as our Low Expansion Densite. In the case of the simple object shown, this mold would appear as in Figure 3. (More complicated objects often necessitate production of split molds) The mold shown in Figure 3 is called a "block mold". This mold is boxed-up and a cast is taken from it (Figure 4). The resulting cast, (Figure 5) is called a "case mold" and a number of these are made from block mold. The block mold is then stored together with the model for future reference. The case molds are used on the production line to form the actual working molds used in shaping the clay pieces. Figure 6 shows the case mold set up for pouring the working mold (Figure 7). Since the case mold must be used many times to produce new working molds, it should always be made of the strongest plaster available. Our Low Expansion Densite is probably the best material for case molds available today.

The working or production mold is always made of pottery plaster. Pottery plaster is a fine ground, white plaster containing set regulating chemicals. Casts made from pottery plaster are much more porous than Densite casts and are able to absorb considerable amounts of water. Working molds may be either jigger molds or casting molds. A jigger mold is a mold used to form clay having a consistency similar to modeling clay. A slug of this relatively stiff, moist clay is placed in the center of the jigger mold and the mold is rotated on a potters wheel or automatic machine. A metal template is pressed against the clay which is thereby forced to spread evenly over the mold surface, any excess being screeded off by the template. The mold bearing the finished clay piece is then placed on a dryer until the clay has dried enough to permit its removal from the mold. The mold is then used to form another piece, etc. Only round or oval pieces such as plates, cups and platters can be made by the jiggering process. A good jigger mold is expected to produce several hundred pieces of ware before it wears to the point where it must be replaced.

More complicated pottery objects such as pitchers, teapots, figurines, etc. are made in casting molds. Clay which has been thinned with water to a pourable slurry is poured into the casting mold and allowed to remain for a specified time. The casting mold, being porous, draws water from the slurry thus depositing a layer of clay on the face of the mold. The excess slurry is then poured out, leaving the surface of the mold lined with a layer of stiffened clay. After drying, the clay piece shrinks away from the plaster surface and may be removed. The mold is then dried and used again. All casting molds are hollow, while jigger molds may be either flat or hollow. Most casting molds are two or three piece molds which may be taken apart to release the clay piece.



(1) MODEL - Low Expansion Densite or mix of L. E. Densite and Pottery Plaster.
(2) Model set up for casting Block Mold.
(3) BLOCK MOLD - Same materials as Model.
(4) Block Mold set up for casting Case Mold.
(5) CASE MOLD - Low Expansion Densite.
(6) Case Mold set up for casting working mold.
(7) WORKING MOLD - Pottery Plaster - this mold used on production line.

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The requirements for a good pottery plaster are high purity, low water carrying capacity to develop maximum strength, fine grind to insure even texture and a minimum amount of voids on or near the surface of the mold. For best results, jigger molds should be made with a lower water-plaster ratio than that used for casting molds, since the jigger mold need not have much absorption or porosity. Most modern potteries, however, use the same water-plaster ratio for both types and try to hit a mid-point at which both types of mold will work satisfactorily. This is admittedly not good technique but is necessitated by local labor practices which stipulate that mold makers must make both types from a single mix. Each pottery has its own preferred water-plaster ratio and these will range from 65-100 to 85-100. It is, therefore, important to determine what water-plaster ratio, mixing time and setting time are desired before submitting samples of our plaster to any pottery. Such data should be gathered on the salesman's initial call and passed on to his District Office together with the request for samples. The District Office can then handle the sample order through the laboratory and plant and make sure the sample will meet specifications.

In mixing plaster and water for pottery molds, a machine mixer should be used as about a 20% increase in strength and durability is obtained as well as a mold practically free from all small voids and pin holes. Plaster so mixed will give longer life to the mold and will result in better finished dishes than the old fashioned hand mixing method by which it is impossible to properly remove the air bubbles. In order to get the best results with a mechanical mixer, the double or triple bladed mixing propeller should be placed near the bottom of the mixing bucket and be large enough so that the ends of the blades are within two or three inches from the sides of the bucket. To insure uniform molds, the weighed amount of plaster should be sprinkled into the weighed or measured amount of water, allowed to soak three or four minutes and then mixed in the mixer for four minutes if possible, or until the slurry "draws" or slightly thickens due to the starting of the setting action when it should immediately be poured into the case molds which have previously been carefully lubricated with a good grade of soap paste such as English Potters soap. The mixer should be run at a speed of approximately 300 r.p.m., and best results are obtained if a baffle plate extends out from the side of the bucket which aids in eliminating the air and prevents the contents from swirling over the edge. Most mold makers, however, do not use the baffle plate as it makes it more difficult to clean the bucket between batches. A thorough cleaning of both bucket and propeller between batches is necessary to avoid quick setting slurry which cannot be mixed the proper length of time and which results in inferior molds.

Another type of mixer now increasing in popularity employs a direct drive motor turning at 1750 r.p.m. driving a triple blade propeller of 2 or 3 inch diameter. The propeller shaft is placed at a 10° angle off vertical to bring the blades near one side of the mixing bucket. The buckets are usually made of stainless steel with concave bottoms to facilitate cleaning.

A few modern potteries have built mixers in which a vacuum may be applied to the slurry furing mixing. This effectively de-airs the slurry and prevents pinholing. In some cases, however, it has been found that molds made from de-aired plaster are too dense, resulting in a very slow rate of water absorption and consequent increased casting time.

CORRECTIVE SHOP PRACTICES

Pottery plaster may be too quick setting for satisfactory use if it is very old, or if the bags have been wetted or stored in a damp place. Quick set can be caused by dirty mixing equipment, impure mixing water, water which is very warm or too long a mixing period. Slow set complaints may result from too short a mixing time or the use of very cold water. Some waters contaminated with organic material will also cause slow set. Another common complaint is on cracked molds. This is usually caused by poor drying facilities which overheat and calcine the molds, or too very rapid changes in temperature, either at the entering or discharge ends of the drier. Poor wearing qualities of pottery plaster molds is sometimes the subject of a complaint and is usually the result of using too much mixing water. Wear can also result from too high a concentration of chemicals in the clay slurry. Uneven wearing qualities result from pouring the plaster before it has reached the "creaming" stage, the thin slurry tending to settle in the case and yield a mold denser in some spots than in others.

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BESTWALL POTTERY PLASTERS

K-55 and K-56

Bestwall pottery plasters are high purity, white plasters with excellent strength and wear resistance. K-55 is a high absorption general purpose plaster. K-56 plaster differs only slightly from K-55 and contains a small amount of chemical additive to give increased surface hardness to the cast. This product is not available for sale and is produced exclusively for the account.

Bestwall Pottery Plaster K-55 may be recommended for general mold making in all types of potteries and sanitary ware plants. It may be used to make casting and jigger molds and models. K-55 Pottery Plaster is also used by some casting shops for production of art objects such as plaques, statues, novelties and decorative castings for use on walls and ceilings. It is especially suited for production of large sanitary ware casting molds where high absorption is important.

Bestwall K-55 is made at Blue Rapids, Kansas. It is competitive to United States Gypsum's Regular Pottery Plaster available from Southard. United States Gypsum offers Regular Pottery Plaster from New Brighton (made of Canada Rock) and Plaster City.

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BESTWALL POTTERY PLASTERS

K-58 and K-59

Bestwall Pottery Plaster K-59 requires less mixing water than K-55 (or K-56). This plaster was especially designed for customers who prefer plaster of lower-than-normal water requirement. K-59 Pottery Plaster will yield casts of great smoothness and practically free from pinholes. The high fluidity of K-59 allows the user to employ a water ratio as low as 64 lbs. of water to 100 lbs. of plaster. At this low ratio, the resulting casts are considerably stronger than casts made with regular plasters. This property is very desirable in the case of jigger molds which must stand abuse on automatic machines.

K-59 is recommended for general mold shop use in potteries and sanitary ware plants where a plaster of higher-than-normal fluidity is required. It is especially suited for the production of jigger molds in dinnerware plants where smooth, long wearing molds are desirable.

K-58 is the same as K-59 with an additive to improve the resistance to thermal shock.

Bestwall K-59 is made at Blue Rapids, Kansas and is competitive to United States Gypsum's #1 Pottery Plaster made at Southard, Oklahoma.

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BESTWALL POTTERY PLASTERS

K-61 and K-62

These plasters were developed to give the trade the highest strength and fluidity with the finest, smoothest working material for pottery work. They are the finest ground Bestwall Pottery Plasters, pour at the lowest water ratio and, as a result, give the greatest strength. They are used where finest grind plaster and strongest molds are required.

K-62 differs from K-61 in having a small amount of an additive which gives the molds better thermal shock resistance. K-62 produces a cast which is of a light blue color.

These products manufactured at Blue Rapids, Kansas, are competitive to United States Gypsum's Puritan Pottery Plaster made at Southard, Oklahoma. Both are premium products. Puritan produces a cast with a light green color.

Physical Properties - Pottery Plaster

Pottery Plasters	Pouring Consistency	Shop Set minutes	Minimum Compressive Strength at P.C.	
			Wet	Dry
K-55	70	25-30	1000 p.s.i.	2300 p.s.i.
U.S.G. Regular	70	25-30	1000 p.s.i.	2300 p.s.i.
K-58	65	25-30	1200 p.s.i.	2800 p.s.i.
K-59	65	25-30	1200 p.s.i.	2800 p.s.i.
U.S.G. #1	63	25-30	1200 p.s.i.	2800 p.s.i.
K-61	63	25-30	1200 p.s.i.	2800 p.s.i.
K-62	60	25-30	1300 p.s.i.	3000 p.s.i.
U.S.G. Puritan	60	25-30	1300 p.s.i.	3000 p.s.i.

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CORRECTIVE SHOP PRACTICES

Pottery Plaster may be too quick setting for satisfactory use if it is very old, or if the bags have been wetted or stored in a damp place. Quick set can be caused by dirty mixing equipment, impure mixing water, water which is very warm or too long a mixing period. Slow set complaints may result fromm too short a mixing time or the use of very cold water. Some waters contaminated with organic material will also cause slow set. Another common complaint is on cracked molds. This is usually caused by poor drying facilities which overheat and calcine the molds, or to very rapid changes in temperature either at the entering or discharge ends of the drier. Poor wearing qualities of pottery plaster molds is sometimes the subject of a complaint and is usually the result of using too much mixing water. Wear can also result from too high a concentration of chemicals in the clay slurry. Uneven wearing qualities result from pouring the plaster before it has reached the "creaming" stage, the thin slurry tending to settle in the case and yield a mold denser in some spots than in others.

Chapter V

NON-FERROUS METAL CASTING PLASTER

GENERAL DESCRIPTION

The casting of non-ferrous metals in plaster base molds has increased to an enormous extent during the past few years. The use of gypsum casting plaster is preferred to sand wherever a smoother cast is desired. Little or no machining is required and the overall cost of the finished casting is lowered. Of further value to the user is the fact that plaster is a better insulator than sand and the metal cools more slowly, giving less shrinkage and better physical properties.

There is no standardized process of casting non-ferrous metals in plaster molds, but there are two processes used more than others and which will be discussed later in this bulletin. The great majority of firms in the non-ferrous casting business have developed their own processes which are kept confidential for competitive reasons. There are probably as many different plaster compositions as there are ways to use them. This bulletin will attempt in a general way to outline the present metal casting techniques in the non-ferrous field.

Generally speaking, an ideal molding medium must have easily controlled shrinkage or expansion characteristics (ideal, of course, would be a medium devoid of either shrinkage or expansion), high permeability, a fine surface texture, high green strength, but low strength after pouring and a controllable thermal conductivity factor.

So far as plaster molds are concerned, the difficulty in the past has been the development of mixtures and processing techniques which would give all these features. Many methods have several but none has all of these features. This requires a constant juggling of qualities to suit each individual casting job.

SPECIFIC PRODUCTION TECHNIQUES

I. CAPACO (Hagemeyer) Process

Briefly the procedure is as follows: The plaster is mixed with fibrous talc to give it strength, and then mixed with water, and poured in mold over pattern. This is followed by a backing of the mold after the pattern has been withdrawn. Cores, also of plaster, are inserted after baking, then cope and drag joined, and the casting poured.

The requirements of the plaster composition are that it contains sufficient permeability to provide a ready egress for all air and gas in the mold during pouring; that it be sufficiently strong to withstand the metal without distortion until the metal sets; that it be sufficiently weak so that it will collapse during the shrinkage of the casting after solidification and thus avoid setting up cooling stresses; and lastly, that the composition be devoid of moisture

The voids in the mixture are created by adding surplus water over the mixing amount, then drying out all the water, the space previously occupied by the water creating a network of spaces, thus providing an effective passageway for gases to leave the mold.

A tubed stucco, which is highly plastic, isused for this process as such a plaster has a high water carrying capacity and excess water is needed for void space. The volumetric ratio of solid material to voids in backed molds is about 1:5 which appears to be the ideal condition for strength and permeability.

The molds are calcined or backed until all but 5% of the chemically combined water is removed. The molds pass on an oven conveyer through a high heat zone of 1450° F. in twenty minutes and then through a 450° - 500° F. zone so that inside mold temperature attains a temperature of 350° - 450° F. for about 1 hour and 20 minutes. The cope and drag, plus cores, are assembled and metal poured by means of a continuous mechanical assembly line. The castings areshaken out and the excess plaster in cored and indented sections removed by high pressure water streams. No further cleaning operations are performed and only a slight amount of trimming of gates and parting lines is necessary before shipment. The amount of surface finishing required is comparable to that in die castings.

II. ANTIOCH Process

This process uses an investment composition which better enables the casting to meet all the good qualities so desired. The investment is mixed in accordance with the casting requirements, the density of the mix having a controllable effect upon the thermal characteristics of the mold. The proportion of the various materials is also varied. A typical mixture is 40 parts of plaster, 60 parts of silica sand, with a small amount of fibrous talc added to accelerate the formation of granules in the recrystallization process. To this dry mixture water is added, the average amount being about 58 parts of water to 100 parts of dry mix. The patterns are surmounted with a flask and the mixture poured in. The molds are set on racks and autoclaved for 9 hours at 15 lb. steam pressure and 260° F. The molds are removed from oven and permitted to reset in the air for the purpose of allowing the granular structure to develop. Roughly 10 hours are required for this re-setting. Excess water is removed in drying ovens where air at 350° F. is circulated around them. After cooling to room temperature, the metal is poured into the molds by gravity.

The autoclave treatment is regulated so that approximately 3/4 of the water of crystallization of the plaster is liberated, but the liberated water is not evaporated because the treatment takes place in an atmosphere saturated with water vapor.

Upon the release of pressure from the autoclave, the mold is wet through and recrystallization of the calcium sulphate to dehydrate begins immediately. The free water is drawn away from the surface toward the interior by capillary action so that the granular structure stops just short of the surface as the mold resets.

III. PRECISION CASTING ALUMINUM IN MOIST INVESTMENT MOLDS

A new process has been developed by using a permeable plaster composition which requires the addition of a foaming agent to stabilize the beaten-in air bubbles.

The amount of moisture retained in the mold is controlled to give a percentage which give maximum tensile strength to the aluminum. The main points of this process are (1) retained moisture in investment molds causes a significant improvement in the mechanical properties of aluminum-copper-silicon alloys; (2) molds prepared by this technique are less expensive than standard investment type molds; (3) burn-out of molds is simpler and less costly than with the standard investment material.

IV. BESTWALL METAL CASTING PLASTER DIRECTIONS FOR USE

WATER PROPORTIONING

Use 105 to 115 parts of water by weight to 100 parts of Metal Casting Plaster. The foundry's own experience will determine the best ratio to use for a particular job or a particular metal.

PATTERNS

The normal metal, sealed wood or thin-coated plaster pattern can be used. Remember, the final casting will be only as smooth or as accurate as your pattern.

MIXING

Weigh water and place in mixing bucket. Add weighed plaster to water and soak two minutes. Bucket dimensions should be such that depth of slurry is about twice the diameter. Use a power mixer to get a uniform slurry and eliminate pinholes. Best mixing is obtained by placing mixer shaft at 15-20° angle and using a speed of rotation which will force the mix downward. Whether you are using hand mixing or power mixing, be sure to mix until "creaming" stage is reached. When you notice the slight thickening or "creaming" pour the molds. Vibrate molds mechanically, if possible, while pouring to aid in reducing pinholes and to provide a smooth face to mold.

The plaster is allowed to set completely (30 to 60 minutes) and is then removed from the pattern carefully, as the fresh cast is somewhat fragile. The second half of the mold is made in the same manner, after replacing the pattern in the first half, greasing the pattern lightly and also greasing the entire exposed edges of the first half pattern edges. The second half mold may then be poured to any convenient thickness.

When making the first half mold lay the pattern on a smooth, non-absorbent flat surface which has been greased. Wood forms may be placed around the pattern to give the mold the proper outside dimensions. Screed the back with a straight edge to give a smooth level surface.

Be sure to support molds face up, or on edge on a flat perforated metal plate or rigid metal grid. A last precaution against warpage can be taken by using a thin layer of talc to permit any slight volume shrinkage.

PARTING AGENTS

Use a light coating of paraffin oil, potters soap, or lard oil on the pattern. Avoid heavy greasy coatings which soften mold surface and give poor detail. Two separating mediums seem to be used more than others with good success. One mixture is 75% kerosene, 25% light oil and 0.05% - 0.1% wetting agent "Ultrawet" added. The second is so-called "stearine" and is made by shaving 6 ounces of stearic acid into 3 pints of hot kerosene and spread warm on pattern surface. Addition of a wetting agent helps to give a smooth, even coverage.

SPRUEING AND GATING

Sprues and gates are carved in wet mold to determine best gating for a particular piece. It is best to vent high parts of the mold to prevent momentary back pressure as the metal fills the mold. The final gating should be molded and made part of the master pattern. Since plaster has a high insulation factor, make gates smaller than in sand. This has a tendency to cut down turbulence in the molten metal flow.

DRYING AND BACKING OF MOLD

Before a mold can be used for casting, all of the free water must be removed and the mold calcined or baked until all or most of the chemically combined water is driven off. The mold must reach a dull red heat or an inside temperature reading taken by means of a light base metal thermocouple which should be embedded in the center of thickest section of mold.

1. High Temperature Ovens

Rapid calcination can be attained by using an oven which operates in the 1000° F. range. The wet molds are placed in the oven at full heat until the 700-900° F. range is recorded by the thermocouple at which time the inside mold temperature should be slowly reduced to 400° F. before removal and pouring of metal. Three to six hours suffice for calcination.

2. Low Temperature Ovens

If your foundry has a core oven which operates at a maximum temperature of some 500°F. and time is not a factor, the mold can be calcined at that temperature in approximately 14 to 16 hours (for molds of 2 to 4 inches thickness).

To make sure of calcination, heat mold to constant weight. Shrinkage of the mold varies as to which heat treatment is used. The low temperature treatment generally give 1.00 to 1.25% by measurement of gauge marks made on the mold before calcination. High temperature treatment will average 1/4 to 1/2% more shrinkage.

CASTING OF MOLTEN METAL

The best castings are obtained when the mold is used directly from the oven and the metal poured at the lowest temperature possible for good crystal growth. Never pour into a cold mold or at a high metal temperature.

The mold halves are carefully fitted together and clamped tight enough to prevent metal leakage and metal poured at a much lower temperature than would be used for a sand mold. The casting will be completely normalized as there is no chilling action involved on one surface and no internal strain within the casting created by uneven cooling.

REMOVAL OF CASTING FROM MOLD

When the metal has frozen completely, and water can be used without fear of thermal strain, the plaster is broken from the casting and discarded. Risers, gates and sprues are removed in regular manner and the casting cleaned by either pickling solution, wire brushing or tumbling. A smooth finished appearance is characteristic of a plaster casting and the cast surface is annealed and less likely to show a spongy or porous structure.

Chapter V

COMPETITIVE PRODUCTS

Both United States Gypsum and National Gypsum produce and sell a Metal Casting Plaster. See Price Schedule , Page . United States Gypsum also sells "Hydroperm", a patented combination, for which Bestwall does not have a competitive product.

CHAPTER V

SERVICING METAL CASTING PLASTER ACCOUNTS

I. Precautions

Common defects encountered in making plaster molds for pressure cast aluminum match plates can usually be attributed to failure of the shop to control one or more of the variables in their operation. The manufacturer of metal casti or match plate plasters concentrates on making a plaster to suit the average needs of all. Very likely most shops would like the formulation adjusted in one way or another to suit their particular needs. For the most part this is not practical from the standpoint of the plaster manufacturer. However, all users of plaster have within their own operation the ability to alter many of the characteristics of the plaster by simple manipulations of their techniques.

What happens when changes are made in shop variables? Let us examine the variables in the order in which they are encountered within an average shop and see what happens when changes are made.

Shop Variables

1. Storage:

If the plaster is stored in a building we can expect it to take on a little water which may manifest itself as a scale of set-up plaster just inside the bag or as set-up lumps of plaster. Such scale or lumps will accelerate the set of the plaster and tend to decrease the permeability of the final mold. It is possible to accommodate the accelerated set by adjusting the mixing time or changing the amount of water used. The decrease in permeability can be offset by increasing the mixing consistency. Water can also contaminate the plaster prior to use if it is kept in a bin. This happens all too frequently when the plaster bin is placed next to the water source.

2. Water:

The water should, of course, be fit to drink. Water high in soluble salts can effect the set and also some salts bring about efflorescence.

3. Consistency:

Consistency is the ratio of water to plaster by weight expressed as pounds of water per 100 pounds of plaster. Most shops use a consistency of from 130 to 160. The consistency of the slush pour should be higher than the consistency used for the segments.

As consistency is increased:

(A) Its green strength is decreased
(B) Burnout strength is decreased
(C) Density is decreased
(D) Permeability is increased in burned out mold

(E) Setting expansion is decreased
(F) Burnout shrink is decreased
(G) More water must be driven off in oven.
(H) Pattern removal made easier.

Recommend - Highest consistency that will give adequate strength.

Recommend - Standardization of consistency within shop. Suggest a chart for mixer to use including these points for each sized mix:

(A) Place bucket on scale and zero
(B) Add water until scale reads X pounds
(C) Add plaster until scale reads Y pounds
(D) Allow to soak for "A" minutes
(E) Mix for "B" minutes.

4. Mixer:

There are variations in mixer types. Some are propeller type mixers, some turbine type mixers, some simply disc type mixers. All work. The propeller type is the favored one by most shops. The size of the propeller in relation to the size of the bucket, the size of the mix, the speed of the mixer, the power input are all variables. The positioning of the mixer agitator in relation to the depth of the slurry, the angle at which it enters the slurry all have a bearing on the results. It is impossible to set down rules covering these variables for all cases. Generally the mixer must perform so that:

(A) It does not suck air into the mix
(B) The whole of the slurry must be agitated
(C) The mixing must be completed before setting starts

In short, mixing must be adequate. Most manufacturers recommend machine mixing rather than hand mixing because it is more uniform from one time to the next, and because it gives slightly greater strength in the mold in the green state. If mixing is not adequate:

(A) The mix will settle when it is poured
(B) The face of the mold will be harder than the back
(C) Excessive watering out will be apparent
(D) Set will be slow
(E) Setting expansion will be minimized, but not uniform
(F) Burnout shrink will be minimized

If mixing is prolonged:

(A) Set will be accelerated
(B) Burnout shrink increased

The best way to control mixing is to weigh the plaster and measure the water, to use a few standard sized mixes, and to mix for a definite time interval. Consistent results can only be attained if the variables of mixing are minimized.

5. Pouring:

It is important to pour the mix as soon as it is ready and not to delay until it becomes stiff and thick. Detail is often lost because the mix is poured too late.

All molds going into one flask should be made as nearly as possible in the same way, i.e. at the same consistency, the same mixing, the same pouring etc. After they are made they should be assembled into the flask as soon as possible. Failure to do so may result in soft molds with greater shrink than can be tolerated. If mold segments or green plaster molds in the flasks are allowed to sit around in the average shop shrinkage sets in. The longer the molds sit before going into the oven, the more pronounced this will be. It is important to get them into the oven as quickly as possible.

When pouring the plaster it is usually a good idea to pour it so that the plaster flows slowly over the face of the pattern. This prevents entrapping air in small depressions on the pattern and enhances the reproduction of fine detail. When pattern design permits, the pour should be made on a noncritical surface. Pouring directly on the pattern or in one spot can lead to difficulty later on when the mold is burned out since there is a variation in density where the plaster is poured that can cause surface imperfections in the casting.

6. Parting:

Wooden and other porous patterns should be first sealed. After the sealer has dried, a parting compound is then applied. There are many parting compounds on the market. All seem to work fairly well. A suitable parting compound can usually be made using a light cut oil with mica or stearic acid dissolved in kerosene. Patterns made from more than one metal should also be sealed to prevent such patterns acting as a battery and forming gas bubbles in the surface of the mold. A clear lacquer or shellac will usually suffice as a sealent.

Parting plaster from plaster can be troublesome. This is necessary when the cope and drag sections of the mold have to be parted. The drag section has been poured over the pattern. The drag is then turned over and the pattern set in place. The flask is extended up and the cope section poured. There are several favored method for parting the cope and drag. They involve wetting down the drag half with an emulsion of oil and water until it will absorb no more. This makes a satisfactory part.

7. Oven Construction:

Ovens should be of such a design that they actually dry the molds and not just heat them. In order for them to function dry air must be taken into the oven and heated. Stagnant air in the oven soon becomes saturated with water at which point the oven stops drying and just heats the molds. A good oven would be one that provided circulating air. It would include

provisions for venting a good portion of the air on each trip round and picking up fresh dry air. The products of combustion would not enter the oven proper, but would have their own flue. At the very least, the molds being dried should not be able to "see" the flame. Inadequately dried molds result in blows in the casting.

8. Drying or Burnout:

Plaster as received in the bag has the chemical formulation $CaSO_4:\frac{1}{2}H_2O$. This means that it does contain some water of crystalization from the start. When the plaster is added to the water in mixing, some of the mixing water, about 18%, combines with the plaster to form $CaSO_4:2H_2O$. This results in the plaster setting. Most of the mixing water is entrapped in the set mass as free moisture. The greater the excess over the theoretical 18 consistency that is used, the more free water the mold will contain. When the plaster mold is dried, the free moisture is first removed. This leaves voids. As drying is continued, the chemically combined water is driven off. It is necessary to drive off both the free and the chemically combined water before the metal can be cast. When completely dried the plaster mold becomes $CaSO_4$. Under standard conditions water will be vaporized a 212 degrees F. As long as water remains in the mold, it is impossible for the mold temperature to go above 212 degrees. This fact is the basis for one test of mold dryness. A thermo couple is embedded in the center of the thickest portion of the mold with the lead to a recording device. The oven temperature is raised above 212 degrees and as long as the thermo couple reading stays at or below 212 degrees the mold contains water. When it does increase to the temperature of the oven, the mold is dry. Another common method for determining burnout is to make successive weighings until constant weight is obtained. As long as the oven temperature is kept below the disassociation temperature of $CaSO_4$, 1700 degrees F., yet above 212 degrees, it is safe to assume that all the water will go off and nothing else. As long as the water is vaporizing the weight of the mold is decreasing. When the weight stops going down it is also safe to assume that all the water has been removed. The usual practice is to put the mold in the oven at 400 to 500 degrees F. After six hours it is removed and weighed and the weight recorded. This practice is kept up at half hour intervals until two successive weights are the same. The mold is then dry and ready for casting. Failure to dry molds properly can result in warping. They should always be supported on a flat surface. Causing the mold to dry from the mold face is also bad practice since minute quantities of soluble salts can be carried to the surface and deposited by the water as it is drying. Salts so deposited can cause flaking of the mold surface when the metal is poured, resulting in pitted casings.

For very accurate work it is usually best to dry the molds closed. This protects the mold surfaces and also minimizes flash due to unequal warpage between cope and drag sections. As mentioned above, the theoretical temperature necessary to dry a mold is only 212 degrees. At 212 degrees the process is usually too slow for most operations, so higher temperatures are

necessary. However, the higher the drying temperature used, the greater will be the burnout shrink. The conversions of the $CaSO_4:2H_2O$ to $CaSO_4$ is accompanied by a definite shrink. The extent of this shrink is in part a function of the speed with which the change takes place. Therefore, it is essential that drying be carried out at the slowest speed practical for best results. Failure to dry molds adequately results in:

(A) Blows in the casting
(B) Excessive shrink marks
(C) Very porous castings
(D) Cracked molds

These are obvious defects with obvious remedial actions indicated.

II. PROBLEMS AND CURES

1. Snap Set

A common complaint is that the plaster fails to body up the way it should. It remains runny and thin, won't thicken and then all of a sudden it is too stiff to use. Such trouble in most shops is usually corrected by simply using water that is warmer. However, it might also be due to incorrect mixing or set gypsum. Many shops have found that increasing the speed of their mixer, speeds up the making of the molds. They go through a series of speed ups, and fail to adjust the size of the propeller and bucket to insure uniform mixing. Finally, one speed up of the mixer results in the propeller doing nothing more than boring a hole in the slurry and mixing it furiously around the shaft, but leaving the periphery of the bucket comparatively quiet. Such practice can cause sloppy set troubles. To correct it, either use a narrower bucket or slower mixer. Perhaps the most common cause of this trouble is in the consistency at whic the plaster is mixed. Such trouble will usually occur at high consistency.

(A) Check for contamination with set plaster
(B) Check for the water temperature
(C) Check the consistency
(D) Check the mixer speed
(E) Take the corrective action indicated

2. Fast Set

The first thing to look for when there is fast set trouble is the condition of the mixing equipment. Usually, when fast set occurs, it is the result of dirty mixing buckets or mixers. "Set up" plaster is in evidence. The solution is to clean up the equipment. If that fails to correct the trouble, then look carefully at the plaster to see if it has any "set up" lumps. If it does, determine where they are occurring; around the sides of the bags, or if distributed in the bin, etc. Most manufacturers fill their bags on a machine that screens as it fills. If large lumps are present, check the shop to see if water contamination is occuring there. If the lumps are around the sides and edges of the bags, chances are the bags have been wet. Solution - use fresh plaster from a new bag. If trouble still persists, check the proportioning of plaster to the water. Perhaps the shop has changed the consistency. If so, put it back where it belongs. Another cause that should be checked is the mixing time. Has the mixer been speeded up, has the mixing time lengthened, has the propeller been changed? Water termperature effects set. If set is fast, use colder water. All could cause a change in setting time.

3. Slow Set

If there is slow set trouble, first try as a corrective measure increasing the mixing time. Consistency should be checked as a matter of course. Water impurities can also effect set. Water should always be fit to drink.

If it isn't, get some that is. The temperature of the water may also be causing set problems. If too slow use warmer water. Many times slow set complaints are a result of storing the plaster in a cold shed during the winter months. It is brought in directly from the cold storage, mixed with water at the usual temperature and fails to set up as soon as expected. The cold plaster has simply cooled the slurry down to too great an extent. The solution is simple; if your storage facilities are cold in winter, bring in enough plaster each evening to last a full day so that at the time it is used it has been warmed to room temperature.

4. Watering Out

Occasionally there is no apparent problem with set, yet when the plaster is poured into the flask around the pattern and allowed to stand, a film of water appears on the top of the pour. This water film, sometimes referred to as "watering out" is inherent to Match Plate plasters. This results from the high consistency used in mixing. Excessive watering out should be avoided because it results in a settling of the heavier plaster particles onto what will be the face of the mold, with a varying density from the face of the mold to its back. This can lead to trouble in the burnout or casting phase of the operation. When "watering out" is excessive it should be corrected by either increasing the mixing time or by cutting down on the consistency.

5. Shrink in Green State

Assuming that their is no trouble anywhere through the mixing and pouring operation, trouble can still occur. The next place where trouble can occur is when the segments are trimmed. They appear to be soft and punky, are weak, and when tested for size are found to be undersized. This again in an inherent weakness of metal casting plasters. It is a result of the high use consistency used in mixing. This trouble is slow in developing. Care should be taken to plan the work. If the various segments are locked into the flask with the slush pour and the whole flask put into the oven within twelve hours from start to finish, this trouble will not usually show up. If it is not possible to do this, the segments should be stored in a closed container and drying retarded. This is effective, but even at best not as good as completing the molds quickly and putting them into the oven.

6. Shrink or Burnout

This is the most common complaint on metal casting plaster molds. Sometimes shrink is greater in the segments than in the slush portion of the mold. The segments seem to pull away from the slush and from each other and in extreme cases mis-match results. At other times the shrink takes place only around the edge of the mold where it appears to pull away from the metal flask. In extreme cases of this type, the pull away can be so great as to permit the mold to fall from the flask altogether.

Excess shrink detracts from dimensional stability and is to be avoided. It should be noted that shrink sometimes is confused with expansion of the flask. The flask being cast iron expands when it is heated. This expansion is greater than the thermal expansion of the plaster mold and a slight crack appears around the periphery of the plaster mold. When only thermal expansion is involved, this crack disappears as the flask cools. Once it is established that burnout shrink is the troublesome factor and not thermal expansion of the flask, the following steps are recommended:

A. It has been established that burnout shrink increases as setting expansion increases. Conversely, any decrease in setting expansion is accompanied by a decrease in burnout shrink. Setting expansion can be decreased and also burnout shrink by shortening the mixing time, using warm water when mixing the plaster, or adding hydrated lime to the mix. Amount of lime needed will vary, depending on P.H. of slurry. Optimum P.H. is 10.6, from 1 to 5%.

B. Burnout shrink can also be the result of the drying operation. High temperatures or prolonged time in the oven after burnout is completed will increase burnout shrink. Make sure oven temperature has not been increased above the usual 400 to 500 degrees. Do not subject molds to repeated heating and cooling. Once the molds are dried out, they should be allowed to cool to handling temperature of approximately 150 degrees and poured immediately. If conditions make it impossible to pour on such a schedule, molds may be permitted to cool. They should not be stored at temperatures above 200 degrees. If cooled, they should be reheated preferably in the oven to 150 degrees before pouring. This reheating should not be carried on at the usual 400 to 500 degree oven temperature.

7. Flaking of Surface

Flaking off may evidence itself when the molds are removed from the oven or not until the casting is made. It shows up as pits or depressions in the casting itself. Usually such flaking off occurs in the thicker sections of the mold. It is seldom found in sections one inch thick, occasionally in sections two inches thick, and fairly common in sections three inches thick and over.

Metal casting plasters whether mill formulated or shop formulated, contain the stucco and one or more other ingredients, such as talc, lime, accelerators or retarders, sand and the like. All these materials can and do contain small amounts of soluble salts. As the molds dry these soluble salts are carried to the surface of the mold from which the drying occurs, where they are deposited. This is known as efflorescence. The degree of efflorescence depends on the amount of salt in solution and area of the drying surface and the total mass of the mold. The salts on the mold surface do not cause the flaking. Those immediately under the surface expand when heated and cause the surface to pop off. Depending on the salts, and the amount, flaking may result from the heat of the oven or the heat of the molten metal.

Another cause of flaking of mold surface also more prevalent in large molds has been traced to setting of the plaster. Cases have been noted where for various reasons the plaster on the face of the mold set before that at the back. This early setting of the face results in a varying density of the mold from its face to its back. This difference in density results in unequal thermal expansion when the mold is heated. The face which is thin will sometimes flake off as a result. This early setting layer of plaster on the mold face may be the result of an accelerator in the parting agent used to part the pattern from the mold. It is usually due to pouring the mold with plaster that is too stiff. In the case of flaking because of efflorescence, the flake is usually quite thin, say less than 1/8" thick. In the case of flaking because of early set of the face, the flakes are usually greater than 1/8". In the case of efflorescence caused flaking, the best corrective action is to see that all additives are as clean and pure as possible. They should be kept to a minimum. Potassium salts are particularly bad offenders in this respect, and they should be avoided if at all possible. The shop having the best possible formulation, but still experiencing this difficulty, should try thinner mold sections and drying their molds closed or upside down, so that evaporation takes place from the less critical surfaces of the mold, the back. Shops experiencing flaking trouble due to set should cut down on the mixing time and then immediately pour the molds after the mixing is finished. In extreme cases where large pours are necessary, it may be necessary for the shops to add a retarder to their mix. In no case should several pours be used to fill a mold without first blending the various slurries before the pour is made. If, because of equipment limitations, this is not possible, shops are urged to make the first pour at least 1 inch thick.

Flaking of mold surface may be due to contamination of the surface and absorption into the surface of foreign matter. Manifestation of this type flaking is much the same as in the case of flaking due to efflorescence. The cause is the same. The only difference is that in one case the causitive salts are internal and in the other external. Parting compounds, oils, mold washes and the like will sometimes cause this trouble. In many cases it can be traced to the mold maker using an excess of parting compound on his pattern. When flaking of this sort occurs, careful step by step investigation should be made to locate where the contamination is taking place.

Chapter V

Metallurgical Problems:

There are many defects which may be brought to your attention. It is important to remember that these are not our responsibility. In all such cases the foundry man should be referred to his metal source for help in solving these problems. Some common complaints are:

(A) Blows in casting. These are usually caused by wet molds - check oven function - check for water contamination after molds come out of the oven. Have dried molds been wet?

(B) Cuts & washes - not common in plaster molds - a mold washes or cuts when metal enters producing ridges and also pits in finished casting - usually a gateing or feed problem - not ours.

(C) Check marks - caused by metal chills in mold - look like metal was drawn to a section of the casting - chills not correctly placed in mold - not our problem.

(D) Flow line on casting - gateing and feed problem - pouring temperature - not our problem.

In spite of fact that these are not really our problems, you may be pressed for comment. Do not make recommendations concerning gates or risers unless you are qualified to do so. This is a very contraversial subject and usually leads to arguments. Hardly a good subject on a sales call.