Gypsum Cements

USG

A Guide for Market Planning, Production, and Installation

Casting Fireplace Surrounds

With over 100 years of experience as a manufacturer of building materials, United States Gypsum Company has a proven record of innovation and success in developing new products that have become industry standards. We specialize in the manufacture of wallboard systems, ceiling panel systems, building products distribution, flooring products and systems and a wide variety of plasters and gypsum cements for industrial and commercial applications.

Photo credit: Buffalo Plastering and Architectural Casting, Buffalo, NY

Overview

Cast fireplace surrounds have become increasingly popular, including those made from gypsum cements, foamed polyurethanes and Portland cement materials.

This manual is a guide to the use of gypsum cements in manufacturing decorative fireplace surrounds. Because there are so many variations of design, finish, and placement relative to the firebox, this manual addresses the factors affecting the finished piece when it is installed.

Review this information, making the basic decisions about target markets, designs, raw materials, and output before deciding how to create the surrounds. Although similar to other ornamental gypsum cement markets, some factors differentiate this market, including the safety issues of creating a product used in high-temperature environments.

The information provided here will help you create high-quality fireplace surrounds that meet performance expectations.

Planning

Answering the following questions about market planning before you start the manufacturing process is critical to minimizing production planning mistakes.

Will products fall within the high end or low end of the market?	Is the business primarily intended to be a low volume/high profit product offering, or a high volume/low profit offering?
What is the look of the product?	Will the surrounds be aggregated, smooth, paint-grade, textured, or integrally colored?
What are daily production and shipping output expectations?	Seventy-five units per day is considered extremely high production. Daily output depends on inventory ability, production techniques, drying capacity of daily production, and installation arrangements.
Will you maintain inventory, or use JIT production to meet demands?	JIT production is not always matched to daily production due to the need to fully dry the parts.
Will you offer custom products only, a standard product offering, or a combination?	Mold type, mold material, and subsequent costs are affected by this decision.
Are you willing to produce interior products only?	Gypsum cements for fireplace ornamentation are not to be used outside, regardless of coatings or treatment.
Are you willing to define and enforce installation recommendations?	Quality control does not end with the fabrication of the fireplace surround in the shop—installation recommendations must be met to ensure product safety.
What type of warranty will you offer?	Your warranty should take into account your installation techniques and the type of firebox with which your product will be used.

Firebox and Insert Knowledge

Due to the wide variety of fireplace inserts that are replacing traditional masonry fireplaces, it is important to understand how the inserts' temperature profiles can affect cast fireplace surrounds. There is no comprehensive public source for technical information (mainly thermal mapping and the impact on surrounding areas) that is so crucial to the design, style, and formulation of fireplace surrounds, and yet ignorance of these issues can be life-threatening. Fireplace inserts should be UL-rated since there is a life-safety issue. Since it is impossible to know the heat-related effects for all potential combinations of surrounds, fireboxes, and inserts, we strongly recommend that you contact insert manufacturers for thermal profile information for their products.

Fireplace Insert Types

Circulating Firebox	A fireplace with multiple-wall construction around the fire chamber that permits air to circulate between the walls, become heated, and enter the house directly or via short ducts. This firebox typically uses a blower kit to assist in air circulation.
Direct Vent	An appliance that draws combustion air from outdoors and exhausts its combustion products to the outdoors, eliminating the need for a standard chimney system. The glass panel in direct vent units keeps the combustion system sealed from the home, maintaining high efficiency and indoor air quality.
Gas Fireplace Insert	A gas appliance designed for installation within an existing fireplace. Usually this consists of gas logs within a metal enclosure surrounding the logs and covering the space between the insert and the fireplace opening.
Mechanical Sidewall Vent	A firebox that vents combustion by-products horizontally through the wall with an electric fan. This configuration is commonly referred to as direct vent, but termination conditions differ.
Top-Vent	A vented appliance that is primarily aesthetic, with lower heat efficiency than other types of fireboxes. Top-vent inserts include standard masonry chimneys and non-masonry flues placed above the firebox.
Vent-Free or Ventless	A gas appliance with no need for a flue. Although these units offer high efficiency, some areas may not permit their use. Review local building codes before installation. For clarification, a *zero-clearance fireplace* is any firebox with associated ornamentation directly adjacent to it *without clearance or setbacks*.

Planning

Building Code Considerations

In most cases, building codes leave the final installation and configuration up to the general contractor or installer. Building codes may not be clear regarding installation procedures; some may not even address gypsum cement fireplace surrounds and how heat can affect them.

However, there is a definite trend toward the development of specifications as part of building codes. Therefore it is important for you to understand that you must periodically check building codes in relevant market areas, since it is easier to modify your products as codes are developed than to have codes adopted and enforced without your knowledge.

Code requirements may address flame spread, smoke contribution, structural considerations, and setback distances of the surrounds from the firebox. *All products used in fireplaces should conform to your local and state building code regulations, along with the firebox manufacturers' recommendations regarding placement and installation of surrounds.*

Code documents in your geographic region will include one or more of the following:

- International Building Code (IBC)
- International Residential Code (IRC)
- Uniform Building Code (UBC)
- National Building Code (NBC)
- Southern Building Code (SBC)
- Local Building Code

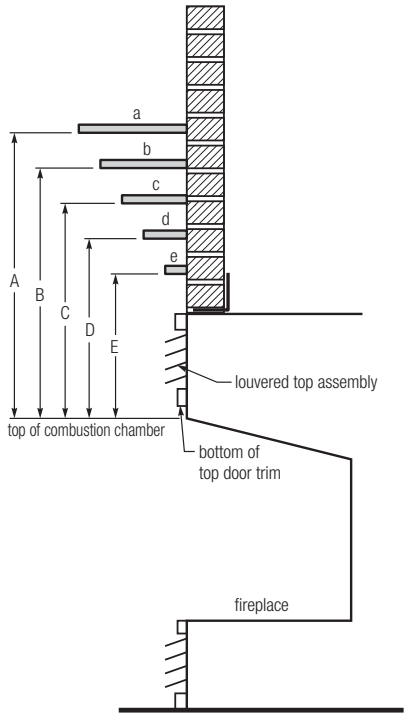
There are also other relevant documents to be aware of, such as National Fire Protection Association (NFPA) information.

While the gypsum cement products used for fireplace surrounds are considered noncombustible by various building codes, gypsum cements will deteriorate when exposed to high temperatures for extended periods. For this reason we recommend, when possible, that setbacks for the fireplace surrounds and mantels follow code recommendations for combustible materials to minimize the effects of prolonged heat exposure to the surround.

Since there are many types of fireboxes and inserts, follow the manufacturers' requirements along with the recommended building codes. While it is possible for gypsum cement fireplace surrounds to be placed closer to the firebox than a surround made from combustible material, it is essential to understand the heat effects of specific fireboxes and inserts on the gypsum cement fireplace surrounds you manufacture. Understanding this will allow you to match your surround designs with thermal profiles of specific fireboxes and inserts.

The following diagrams help illustrate the relationship of combustible materials to the firebox opening:

Minimum Mantel Vertical Clearances



There are minimums for clearances for combustible mantel height above a fireplace. NFPA codes for minimum clearances are as follows:

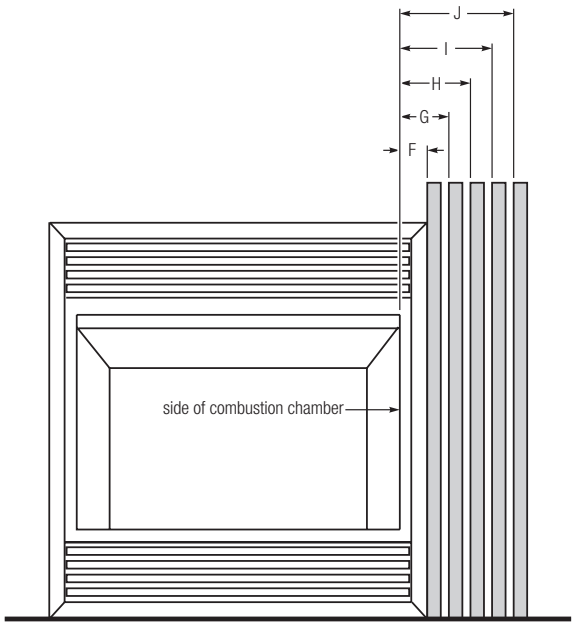
Reference	Mantel Shelf or Breast Plate Depth	Reference	Mantel from Top of Combustion Chamber
a	10″	**A**	19″
b	8″	**B**	17″
c	6″	**C**	15″
d	4″	**D**	13″
e	2″	**E**	11″

Building Code Considerations

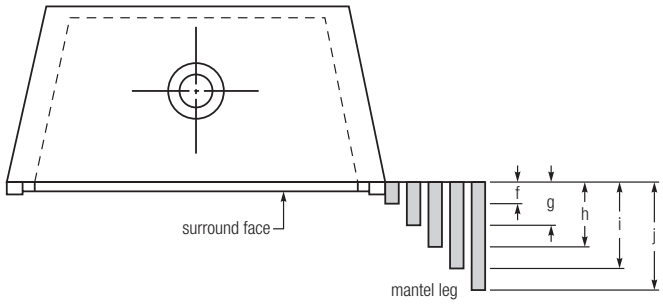
Minimum Mantel Horizontal Clearances

There are minimum clearances for combustible mantel width beside a fireplace. NFPA codes for minimum clearances are as follows:

Mantel Leg from Side Opening



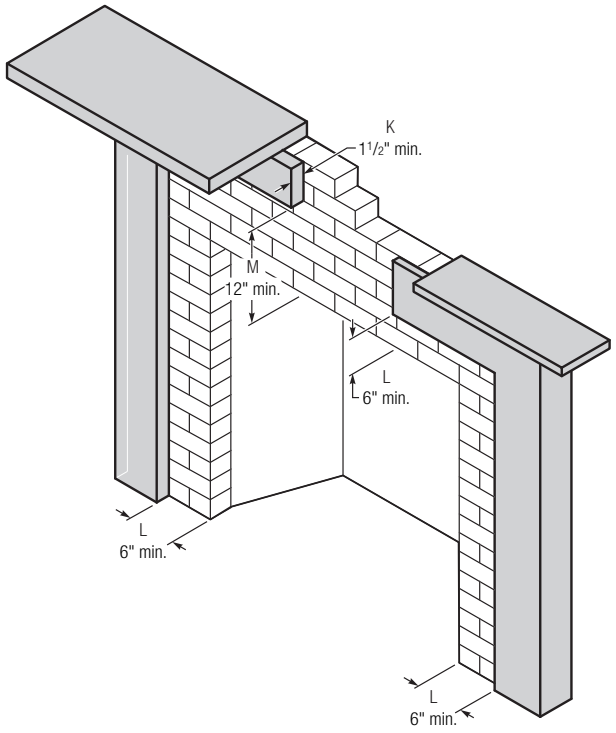
Mantel Leg Depth



Ref.	Mantel Leg Depth	Reference	Mantel Leg from Side of Opening
j	10″	J	11.5″
i	8″	I	9.5″
h	6″	H	7.5″
g	4″	G	5.5″
f	2″	F	3.5″

Minimum Mantel Horizontal Clearances

Flat Trim



– If the trim projects from the facing *less than 1.5 inches* (K), it must start at least 6 inches (L) from the fireplace opening.

– If the trim projects from the facing *more than 1.5 inches* (K), it must start at least 12 inches (M) from the fireplace opening.

Production

Getting Started

To get going, start simply and think about this four-step process:

Mold Making

The actual fabrication process begins with making the mold. Mold quality will directly affect the quality of the finished piece, so select a mold maker whose skills complement your desired market positioning. Many fireplace surround fabricators have in-house expertise in mold-making.

Raw Material Selection

The only gypsum cement products that USG endorses for this application are HYDROCAL® FGR, ENDURACAST™ Gypsum Matrix, or other custom-formulated alpha gypsum cements manufactured by USG for fireplace surround production. (See *Raw Materials*.) Your USG sales representative will help you select the material to match your plans. You will need to have fiber reinforcement such as glass fiber or glass matting, mold release materials, a clean water source, safety glasses, dust masks and gloves. Keep all gypsum cements and aggregates dry and above freezing temperatures before use.

Fabrication Method

Start by using a hand-layup method of filling the molds to get to know the gypsum cement product's setting time, expansion, pigmentation and aggregation capabilities, and how easy it is to work with. In this way you will also gain experience with how easily the cast parts remove from the mold, the quality of the mold details, and how easily the mold is cleaned and serviced. Properly supporting the cast surround immediately after removal from the mold is also important, and there are various methods to ensure dimensional stability during drying. The time required to fully dry the parts is also important, due to its effect on daily output. *A surround is not ready to finish and install until it is fully dried of all free moisture.*

Waste Management

Preparations for disposal of wooden pallets, paper bags, and wash-out and waste water should be part of the early stages of business planning, along with dust-control procedures. Gypsum cements are environmentally friendly, but cleaning molds and mixing the gypsum cement products produces water and gypsum waste that is messy if not properly managed. Properly designed shops take waste-control procedures into account in the production flow process, and good planning will minimize waste from the operation.

Design Considerations

Design includes the physical appearance of the fireplace surround and the mold configuration. Consider the following items when deciding on the mold design:

- Amount of time required to cast the surround
- Fabrication method (spray, hand-layup, solid-cast)
- Amount of material used per unit
- Type of gypsum cement used
- Depth and configuration of mold and resulting effects from heat exposure
- Drying efficiency
- Finishing options
- Installation method and procedures

The primary design consideration that affects all of the above is the cross-sectional depth of the mold design. In other words, how far will the mantel and legs protrude from the wall? A deep and narrow backside mold opening restricts access for both spray guns and hand-layup methods. Solid-casting a deep and narrow opening will produce a heavy piece requiring a large amount of gypsum cement material. In turn, the large amount of material increases drying time, complicates the material's thermal response, and complicates the installation process. In general, heavy solid-cast surrounds are undesirable because dissimilar thermal movement of the cast piece often results in cracking. Also, the weight of a large solid-cast surround can pose life-safety issues during and after installation. Hollow surrounds are lighter in weight than solid-cast pieces and produce more evenly distributed wall thickness, thereby producing a more even material response to thermal forces.

Other design factors, such as sharp corners and the depth of detail, influence the types of aggregates used, the method and time needed to fabricate a piece, dimensional stability, finishing options, and ease of installation. Generally, less complicated and smooth detail transitions will result in easier, faster, and efficient fabrication and installation. However, highly detailed and intricate surrounds command higher prices in the market.

Mold Materials

Cross-Sectional Depth of Mold Design

Gypsum cements can be fabricated in either rigid or flexible mold materials. The choice depends on the design and texture of the fireplace surround. In general, the flatter and smoother the surface, the more likely it can be done in a rigid mold. Another factor to consider when selecting molds is the ease of reassembly after removing a finished part. Rigid molds generally will have more parts to reassemble compared to flexible molds.

Rigid molds may be made of wood, metal, or plastic, but since gypsum cement products are water activated, some rigid mold materials may require sealing to prevent water penetration, while others will need sealers as well as parting agents to prevent the fabricated piece from sticking to the mold surface.

When aluminum metal is used as a mold material, alkaline-formula gypsum products may attack it unless it is protected with a coating. In some cases there may be an advantage in using molds that have a combination of flexible and rigid properties.

Flexible molds are usually more expensive than rigid molds, but do not typically require the use of sealing or parting products and can usually be made in fewer pieces than rigid molds. The best flexible material for fireplace ornamentation is polyurethane rubber. Silicone rubber will also perform well, but is more expensive than polyurethanes, so its use should be limited to special situations. If silicone molds already exist due to production of resin materials, they can be used for casting gypsum cements. Other flexible mold materials like latex are available, but the curing shrinkage of this rubber makes it very difficult to use for large pieces. Regardless of the flexible mold material you select, you will need a matching rigid support to hold the mold firmly when the casting procedure takes place.

Molds can be designed and fabricated to allow for specific textures on the finished parts, such as an antique or travertine look, or an uneven surface resembling natural limestone or granite. It is important to consider your target market when designing and fabricating molds.

Raw Materials

Using gypsum cements to create fireplace surrounds has many benefits, because they:

- Have zero flame spread and zero smoke developed when tested in accordance with ASTM E84 – meet the requirements (uncoated) of the building code for Class A surfacing material
- Provide excellent detail reproduction
- Allow quick demolding, reducing the total number of molds required for high production
- Can be decorated to resemble many different raw materials, such as natural stone

The preferred products for fireplace ornamentation are HYDROCAL FGR, ENDURACAST, and other custom-formulated alpha gypsum cements manufactured by USG. HYDROCAL FGR and ENDURACAST gypsum cements are formulated for hand layup and spray processes. These are the only products USG supports for fireplace surround production. Your USG representative can assist you with product selection.

Fiber Reinforcement

Fiber reinforcement should always be used when manufacturing fireplace surrounds. Glass fiber matting and/or chopped glass fiber strands can be used for hand-layup and spray processes. The recommended proportion of fibers is 5% - 6% of the weight of the mix. (See *Manufacturing*.) This proportion provides increased impact strength, flexural strength, and resistance to breakage during shipping, handling, and installation. Using glass fiber will also minimize the potential for cracking during normal use.

A Surround without Fiber Reinforcement Exhibits Cracking During Thermal Testing

There are several different types of glass fibers. Use fibers that are compatible with the gypsum cements you are using, as some alkaline gypsum cement formulations can have a detrimental effect on fibers. To maximize the benefits of fiber reinforcement, review fiber thickness and chopped lengths. The type of fabrication process you use will also determine the type of fibers you need. Your USG sales representative can help with selection of the best fibers for your specific products.

Manufacturing

There are basically three ways to manufacture fireplace ornamentation: hand-layup, spraying or solid-casting. The best process to use depends on many factors. It may seem that the more automated process is better and more efficient, but product design, number of pieces per finished unit, and the required level of production are also factors. It is always good to do some development work by hand until the manufacturing issues have been resolved. If the target market is low-end with high production, it is especially important to understand the manufacturing needs of a high-production shop.

Fireplace surrounds can be fabricated in one piece, three pieces, or many pieces. Your decision on the number of parts in the finished unit will affect the fabrication method and the arrangement of your casting area, packaging, shipping, and installation.

The initial design and manufacture should use the hand-layup process to make the fireplace surround parts. We do not recommend an immediate investment in spray equipment, because the choice of spray equipment should wait until other manufacturing details are ironed out. Some designs lend themselves to spraying and some do not, so in the first phase of business development ensure that the spray system will actually produce the appropriate quantity and quality of products.

Hand-layup

This process uses layers of glass fiber mat that have been impregnated with the gypsum slurry. Initially, a coat of gypsum slurry is applied to the mold face to ensure there is no air entrainment, and when this coat has stiffened but not set, a coat of gypsum slurry and a layer of glass fiber mat are applied behind the first coat. Additional layers of mat saturated with slurry are added until the proper thickness is achieved (at least 3/8"). After each glass coat is applied, it is important to compact the glass and slurry before the next layer is added. Use a small roller or your hands (protected by thin rubber gloves). Good compaction will impregnate all of the fiber with the slurry and keep any air voids from occurring, resulting in good strength development and a high quality part. The proper ratio of glass to slurry is 5% - 6% glass by weight of the total weight of the slurry. For example, to determine 5% fiber using HYDROCAL FGR at 30 consistency (30 parts water to 100 parts HYDROCAL FGR), you would take 30 + 100 = 130 lbs. of mix, multiplied by .05 = 6.5 lbs. of fiber. Hand-layup is usually done with HYDROCAL FGR or ENDURACAST gypsum cements that have been formulated to provide sufficient working time to carry out the process. One of the most common problems with this method is to use too little gypsum cement, and as a result "starve" the glass.

Spraying

This usually consists of a mixer, a pump, a spray head and the support systems that help the equipment function properly. With this method, the slurry is sprayed into the mold at the same time as the glass is being chopped into the slurry spray. As with hand-layup, the first coat on the mold contains no glass so there will be complete capturing of the detail in the mold. Also, it is important to compact the glass with a roller or by hand to ensure that all of the slurry has impregnated the glass. The spraying and compacting proceeds until the proper thickness

Manufacturing

is achieved (at least 3/8"). In some systems, the slurry is retarded so it will run through the equipment without setting, and is accelerated at the nozzle to facilitate maximum production. USG recommends spray equipment from RimCraft Technologies, Inc. (www.rimcraft.com).

The fiber reinforcement does tend to "bridge over" in certain mold areas (highly detailed areas and sharp corners), so pressing the sprayed material down will prevent any voids in the piece. Spray equipment may be specially designed to fit your production needs, or it may be off-the-shelf components linked together in a workable fashion. Either way, the spray equipment must be matched to the design of the pieces and the required daily production. Until this has been fully analyzed, the spray system, which at first may appear to be the best option, might not perform as needed when the final details have been worked out. As in the hand-layup system, the goal is to have 5%-6% of fiber based on the weight of the mix.

Molds designed with deep and narrow openings are not good choices for spray processes.

Solid-casting

Liquid slurry is prepared and poured into the mold and allowed to set. When solid-casting, use a displacement plug and/or framing in the back of the part. A displacement plug is typically made of wood or sometimes foam, and is inserted into the mantel part of the surround to make it lighter. The displacement plug can also be part of the mechanism that anchors the surround to the building structure. USG highly recommends the use of a displacement plug when solid-casting to reduce the weight of the surround and to allow for a cavity that can be used in conjunction with a wall-mounted ledger or other means of mechanical attachment to the building structure. Also, the displacement plug can be designed to be left in the surround as a reinforcement and to help attach it to the building structure. Other methods may include a built-in frame when the surround is cast. The frame will not only reinforce the surround but can also be used to attach the surround to the structure. Treat displacement plugs and reinforcements made from wood with a non-flammable sealer before use to prevent water penetration. Metal framing materials need to be epoxy-coated to prevent reactions with the gypsum cement. Regardless of how carefully the plug or frame is developed, cast pieces are always heavier than hand-layup or sprayed pieces. Large solid-cast fireplace surrounds are not recommended due to excess weight, amount of material required to fabricate, difficulty of installation, life-safety considerations due to weight, and dissimilar movements from thermal forces which can result in cracking when the surround is placed closer to the firebox than a combustible material should be positioned.

Process Flow

It is extremely important to design your shop so that the production process flows smoothly. By ensuring that each step of the process operates without delays and bottlenecks, and that one step flows into the next efficiently, you will maximize production, maintain high quality, and keep costs as low as possible.

Your shop should include the following departments that flow smoothly from one to another:

- Raw material storage
- Mixing/processing area
- Casting area
- Cleaning/trimming area
- Drying room
- Finishing area
- Storage/packaging area
- Shipping

Incoming Raw Materials

You will need a place to receive and store raw materials, including gypsum cements, mold-making materials, buckets, water hoses, and other items like lumber. Keep this area and the entire shop, if possible, at optimal room temperature of 65°– 80° F, since the raw materials perform best within this range.

Mixing

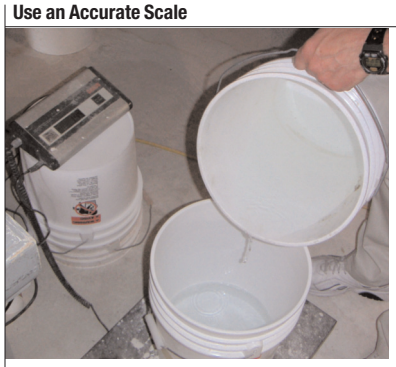
Successful mixing of gypsum cements requires following exact procedures. USG manufactures gypsum cements that have very specific formulations, and shop practices must be standardized to gain the full benefits of the products. *You must follow the same procedures every time you mix.* Any variation may result in poor product performance.

Use potable water source for mixing gypsum cements. Dirty water is never recommended, since impurities affect setting times and can cause mineral deposits on the surface of the finished parts. Constant water temperature is also recommended to achieve uniform, high-quality results. Sift plaster into the water and soak to allow replacement of the air surrounding the plaster particles with water. Use an accurate scale that includes a "tare" feature for weighing, clean buckets (which must be kept clean for re-use as mixing or water-holding buckets), waste containers (30-50 gallon plastic drums), and mechanical mixing equipment. Refer to USG publication IG503 and your USG representative for details on proper mixing procedures and the types of proper mixing equipment.

Production

Process Flow

Use an Accurate Scale



Use Proper Mixing Equipment

High-Volume Mixing and Automation

When your business grows and you need to increase production, you will need to evaluate the use of high-volume equipment, especially for mixing. There are several good high-volume mixers available, including those manufactured by Blastcrete Equipment Company (www.blastcrete.com). At this point you may also want to consider automating parts of your manufacturing process, such as pumping the gypsum cement slurry to the casting area from the mixer. Any high-volume mixing and automation steps will also require additional molds and raw materials for increased production.

Casting

After the gypsum cement is mixed, it will then be immediately used in the molds. The molds need to be clean and positioned properly for efficient casting. To ensure good casting techniques, you'll need a work area that is not too cramped and has large, sturdy tables with level surfaces.

First, a "face coat" is applied to the entire mold surface. This is the coat that will be seen on the finished part, so it is extremely important to completely cover every mold detail with the face coat, removing trapped air and replacing it with the slurry. When this coat begins to set but is still tacky, then subsequent coats containing 5% – 6% glass fibers or glass mat are applied. Sometimes the coats following the face coat can be poured, depending on the design of the mold. We recommend that you first use the hand-layup method to cast your parts, to gain familiarity with the materials and your processing capabilities. If pouring, we recommend that a sealed displacement plug be used for thick parts to hollow out the back side of the mold. This will allow for lighter parts, provide a means of anchoring the finished surround to the structure of the building, and minimize the effects of the thermal forces on the finished product. If the plug is to be removed, make sure it is tapered or beveled to simplify removal.

The Hand-Layup Process

Demolding

When the gypsum cement part has completely set in the mold, it needs to be removed from the mold. Do not remove the part until it is completely set. Even though it has set, the part is still far from its full strength. Carefully remove the part without damaging it. Several methods can be used to help demold your parts:

- Gently peel the flexible mold away from the piece around the perimeter of the mold.
- Use wedges placed around the edge of the mold-part interface to separate the part from the mold.
- Suspend the mold and lightly tap around the mold perimeter so the weight of the mold or part helps the separation.
- Use compressed air in the back or side of the mold. This requires the installation of air-nozzles in the mold design, but can be a good option, especially for large fireplace surrounds.

Consult your USG representative for more information about these techniques.

It is extremely important that you keep your parts fully supported after demolding, since parts that have not been dried can sag, warp, or move, resulting in a misshaped part.

Cleaning and Trimming

After the part is demolded, trim it to the final shape since it is easier to do when the part still contains some free water. After drying, there is more dust and the edges will be more likely to chip.

After trimming and sanding, the part must be oven-dried to gain full strength and prepare it for painting or other finishes. If the part is thin-shelled, which is possible with hand-layup, the drying time will be relatively short compared to a solid-cast part or a part cast with a plug to reduce weight. If no plug is used in solid-casting, drying times can be very long because of the thick mass of plaster. When the part is fully dry it can be painted, stained or given a metallic finish or other surface decoration. If it is to be left as cast, the preparation of the slurry and mold is very important. Undermixing, dirty equipment, dirty molds, or contamination anywhere may result in a visible defect on the surface of the fireplace surround. Also, if the casting is to be left without further surface treatment, it may absorb smoke, oil from the hands, and other potential contaminants which may result in an unacceptable appearance after just a few years.

Production

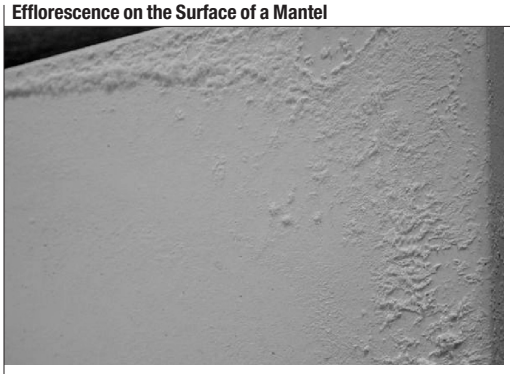
Process Flow

Drying

To achieve uniform results and optimal physical properties, all gypsum cement castings must be properly dried. *This is probably the most important step in the entire process of fabricating fireplace surrounds.* Make sure parts are completely supported after demolding so that the shape does not change. Proper drying will allow for:

- Maximum strength development
- Uniform absorption
- Increased production capabilities
- Reduced efflorescence (soluble salts that migrate to the surface of the part and cause chalky spots on the part – see photo below)
- Mold and mildew prevention
- Better paintability/finishing

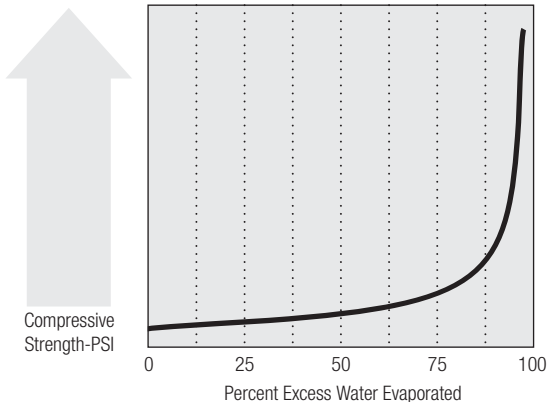
Efflorescence on the Surface of a Mantel



Gypsum cements require approximately 19 lbs. of water per 100 lbs. of powder by weight for complete hydration in the setting process. However, additional amounts of water are needed to obtain a mixable slurry. After the material is mixed, cast, and has set, any water in excess of the 19 parts needed is considered excess or "free" water and must be removed by drying. In addition, moisture left in the part may lead to the growth of mold or mildew.

The chart below shows the importance of *fully drying* the parts.

Fully Drying Parts Increases Compressive Strength



The compressive strength of the finished part increases only slightly until 93% of the free water has been removed. Strength then increases dramatically as the remaining water is removed.

Controlled drying conditions are best. Drying equipment can be designed to remove the excess water in a specified time. A forced-air dryer with controlled humidity is the quickest and best way to dry the part, and will yield the best results. Rarely will gypsum cement castings become 100% dry without the use of a forced-air dryer.

When a newly made wet part is placed in the dryer, rapid evaporation of the free water begins. The initial evaporation keeps the part cooler than the temperature in the dryer. Water from the interior of the casting will move to the outside surface to replace evaporating moisture. As evaporation continues, sufficient water does not move to the surface of the part to keep it cool and the surface temperature will rise although the center of the part is still moist.

When the part's surface temperature reaches that of the dryer air, the remaining free water comes to the surface slowly and evaporates. As this occurs, the temperature of the part increases throughout. When the center of the part reaches the temperature of the dryer air, drying is complete. One way to know if the part is completely dry is to weigh the part at intervals during the drying process. When the part does not lose weight after it is weighed at least three times, it is considered dry.

Recommended maximum dryer temperature for most gypsum cements is 110° to 120° F. Higher temperatures (130° – 140° F) may be used initially, but must be reduced during the drying process as water is removed from the part. Extended high temperatures may calcine, or overheat, the surface. Humidity controls in the dryer can facilitate a quicker drying process. It is important to size the dryer so it matches your production plans.

Make sure you do not allow your parts to undergo "thermal shock." It is best to gradually raise and lower temperatures in the dryer to avoid cracking from quick changes in temperature. For more information on drying, see USG publication IG502, *Drying Plaster Casts.*

Production

Process Flow

Decorative Finishing

After the part is fully dried, it can be painted, sealed, or finished with a number of different treatments. Finishes can vary dramatically, so experiment on samples until you achieve the desired look. Apply finishes in a clean location to avoid contamination of finished parts.

Packaging

Once the parts are finished, you will need to provide packaging so they can be shipped without in-transit damage. Shipping large pieces safely is difficult, regardless of how the item is made, but proper fabrication with glass fiber reinforcement is the best insurance. Parts that are properly supported internally, with a design that avoids easily chipped square corners, will have the best chance for safe arrival.

The packaging method will depend on how far the part will travel, the mode of transportation, and the design of the finished piece. Pallets increase the incidence of safe arrival. If individual packages are used, they may easily be dropped and you need to take necessary packaging steps to avoid damage.

The packaging approach should be developed to fit the market segment, but a few general possibilities are:

- Formed-in-place packaging, where a container is designed to fit the product and foam fills the open space around the part inside the container.
- Pre-formed foam, which is made to fit the product and is fastened around the piece with plastic banding. The piece is then placed in a crate or on a pallet or in some other type of container.
- Attachment of a rigid sheet (usually plywood) to the support inside the finished piece with protection between the sheet and the part. This assembly is secured inside a crate or carton and is protected on the side opposite the rigid sheet with some type of plastic material.

The final packaging may be a combination of the above, or it may be custom-designed by a packaging company. Often planning for packaging is an afterthought, because the emphasis is on production and marketing. Any packaging method that uses a sealed container, foam, or a tightly wrapped part will require that the finished product is completely dry. If not, the product will sweat, and mold could form on the part and inside the packaging.

Since the arrival of an undamaged piece ready to be installed is your best marketing tool, consider packaging designs from the beginning of the planning process.

Shipping

Ship with a carrier who understands your needs. It is worth spending more for a conscientious carrier who will deliver your products undamaged and ready to install. Discuss the importance of treating the shipment with care and delivering parts on time. As business increases, you may want to design your own method of packaging, shipping, and delivery. This might include specially designed trucks and trailers to accommodate your products.

Installation

Safety

When developing the final design of the fireplace ornamentation, think about the best installation method. If internal supports and built-in fastener attachments are part of the product design, they will need to be included when the parts are made. Since these products must be attached to existing structural members in the building, you'll need to consider do-it-yourself installation or using a trained crew. Because of the many design possibilities and corresponding installation considerations, we cannot provide specific placement and attachment recommendations. However, there are a few general guidelines about gypsum products:

- Parts made from gypsum cements are not load-bearing. *The side pieces cannot be the mantel's sole support.* We recommend that the cross-section (mantel) not be solid-cast so that some type of support (either wood or metal) can be placed in the hollow back of the mantel. A wood support cast into the part must be sealed to resist moisture, and metal supports should be epoxy-coated. Anchor supports to the structure of the building to minimize both movement from thermal forces (expansion and contraction) and the risk of cracking. The legs of the surround also need to be anchored to the structure, but typically are not exposed to the same temperatures as the mantel. *Make sure the entire surround is fastened securely to the structure of the building for life-safety reasons.*
- Heavy parts make the installation more complicated, because you'll need to use large fasteners.
- You must use mechanical attachment to the building structure. If using adhesives in conjunction with mechanical anchoring, ensure that the adhesive is not flammable in the cured state and has a service temperature above the maximum heat to which the fireplace surround is exposed. *Do not use adhesive as your only means of attachment.*
- Mechanical fasteners should have a large-diameter washer such as a plaster washer at the head when the gypsum cement is the bearing surface. When the bearing surface is wood or metal, any conventional fasteners except plastic may be used.
- The use of adhesives to bond brackets or other attachment devices to the finished gypsum cement part is not recommended unless endorsed by the adhesive manufacturer.

Repairs

After the installation, repairs to the surround may be needed because of the holes made from fastening the surround to the building structure. Typically these holes are from a drill and can be easily patched using joint compound, spackle, or caulk. In some cases, you may want to bring a small amount of the gypsum cement you used to produce the surround, and mix a small amount by hand to use as a repair material.

There may be some gaps or uneven surfaces around the perimeter of the surround after it is installed. Seal these gaps with a high-temperature caulk or similar material.

Any repair or finishing material used should be capable of withstanding the temperature environment created when the firebox is in use.

Appendix

Gypsum Cements

In addition to the products recommended for fireplace ornamentation, other plaster products can be used. However, making these choices will almost always lead to a reduction in performance. *Again, USG recommends and supports only HYDROCAL FGR, ENDURACAST, or custom-formulated alpha gypsum cements manufactured by USG.* Contact your USG representative for more information.

The major difference between the various products is the amount of water used per 100 lbs. of plaster. This is called the consistency of the product, and is a very important factor in the performance of the finished product. In general, the higher the consistency (parts water per 100 parts gypsum cement), the lower the strength, the more difficult and expensive the drying process, and the greater the chance for "cold flow." Cold flow is also referred to as "cold creep."

Set gypsum cements are not load-bearing, meaning that if a large enough load is placed on a gypsum part, it will slowly become misshapen. This can be prevented by using a low-consistency alpha gypsum cement and drying it completely before putting it in service. If the consistency is high, the gypsum part will flow just from its own weight unless it is fully supported. This is one of the reasons we support only the use of HYDROCAL FGR, ENDURACAST, or custom-formulated alpha gypsum cements made by USG for fireplace surround manufacturing.

Some gypsum cements have an alkaline pH as a result of their formulation. If these products are used with glass fiber for reinforcement, the fiber must be AR type (alkaline resistant), otherwise strength loss will occur over time as the glass fiber degrades.

If you use products other than HYDROCAL FGR, ENDURACAST, or recommended custom-formulated gypsum cements for fireplace ornamentation, consult a USG representative.

Many "invented" products comprising several raw materials are sold to manufacturers of fireplace ornamentation. These combined materials really have no advantage over a single product in a bag, except water-based polymers added to the liquid mix. Some of these additives work well aesthetically, but may reduce fire ratings of the finished parts. For more information on using polymers, contact Ball Consulting, Ltd. (www.ball-consulting-ltd.com).

Mold Materials

There are several manufacturers of flexible mold materials. Eventually you will find the best source. Two sources are Smooth-On, Inc. (www.smooth-on.com) and Polytek Development Corporation (www.polytek.com).

These companies both have a complete product line and distributors in many markets. These are very good initial sources because they have a lot of literature and support for the new user of flexible mold materials.

Decorative Materials

For a unique look, you can add other products to the slurry after the water and powder have been blended. Obviously, some of these additions will prevent spraying, and *every* additive will reduce the strength of the gypsum cement, depending how much is used. Therefore, use additives cautiously.

Colors or Stains

For a special effect, water-dispersible dyes or pigments can be added to the slurry. First disperse materials in water using a high speed mixer, and then replace a portion of the mixing water with the pigment dispersion. Putting the dye or pigment directly into the slurry will produce streaking or splotches of color.

Internal colorants are not a substitute for surface-applied coatings because the color will not be uniform in all areas. Because the color is water-dispersible, the areas that dry first will be darker in color. This effect can work where an antique coat or a wash coat is used as the final surface.

Sand or Other Fine Aggregates

To give the surface a texture to convey a stone-like look, add the material to the slurry of water and powder when the two are mixed. Use no more than 10%-15% of the total weight of powder and water. Using HYDROCAL FGR at 30 consistency as an example, a range of 13 to 19 lbs. of aggregate per mix (30 lbs. of water and 100 lbs. of powder) would fall into the 10%-15% range. If the sand choice makes the slurry too thick in this weight range, reduce the quantity of sand. Adding aggregate will reduce strength; adding aggregate plus additional water will reduce strength even more. Unlike cements, there is no bond between the set gypsum and the aggregate.

Perlite, Beads, or Other Weight Reduction Materials

Difficult to use, these products are the most likely to result in dangerously low strength safety margins because they require more water in the slurry. Thus, there is a two-fold strength reduction — first from the addition of the material, and second from the extra water added to the slurry.

There are many different choices of materials and since each will have a different impact on the amount of water required, there is no general rule for the acceptable quantity. Each raw material has different advantages as well as disadvantages, so usage must be carefully analyzed.

However, there are some general points:

1. Most weight-reduction materials will float, so there is danger of an excessive amount in some areas producing planes of weakness.
2. Large-diameter products affect the strength to a greater degree because the voids of low strength are larger.
3. Purchase porous particles like perlite in a treated state, or they will absorb tremendous amounts of water which will reduce strength and impede drying.
4. The best choices for reducing weight (but also the most expensive) are man-made products like ceramic beads or glass beads. These materials do not absorb water and are available in narrow particle size ranges. As with all additives used in large quantities, it is best to evaluate their impact on your product performance before going to market. It is possible to check strengths of formulas with these additives through local test labs for reasonable costs. Contact your USG representative for assistance.

Appendix

Fabrication

Parts made for fireplace ornamentation are much larger and heavier than most products made from gypsum cements, so you need to establish manufacturing procedures that account for this size and weight. The major issues that can occur with large pieces are expansion and warping. While these potential problems are related they are not identical, but may produce similar results. Sometimes there is confusion about the cause of these problems.

Expansion is the natural result of the rehydration of gypsum cements. There are products formulated to minimize expansion, but there is no way to eliminate it without causing other problems. For example, consistency is a factor in the amount of expansion and typically the higher the consistency, the lower the expansion. High-consistency plasters produce lower strengths, so they are not a good choice for surrounds.

Expansion occurs somewhat uniformly in all directions but is most noticeable in the longest dimension.

The net effect of expansion is usually not a major concern and is generally considered a benefit, since very minute mold details will be well-reproduced. However, there are a few situations when it might cause a problem:

- Rigid molds can produce restricted points which may cause the part to bow because of expansion.
- The product design may produce long straight areas where there is a cumulative effect from expansion that cannot be relieved, even in a flexible mold.
- The product has significant differences in cross-sectional dimensions, causing higher expansion in thicker areas compared to thinner areas.
- Solid castings with no reinforcement tend to present more problems with expansion.

Warping is due to "cold creep" of the undried part after it has been removed from the mold. The greater the changes in thickness or in design elements on the part, the more likely it is that the piece may warp. This condition can usually be remedied by supporting the piece correctly after demolding. With some designs this means placing the piece flat on a rigid surface so it is properly supported. In other cases it may be necessary to construct a frame to provide proper support when the part is removed from the mold.

Installation

Building codes do not contain much data on fireplace ornamentation made from gypsum cements. Over time, the code bodies will likely generate data to provide for standards in this area. Currently, codes are primarily concerned with the safety of the building itself and combustible materials and not too much with the interior finish, but this is expected to change. At present, each manufacturer is responsible for establishing installation criteria to protect the product from failure and provide long-term durability.

There are several types of fireplaces that burn fuel, and these are the only units that require guidelines concerning gypsum cement fireplace surrounds. Purely decorative fireplaces have no potential problems that require guidelines. Older fireplace designs are vented, which means a chimney or some other exhaust system to carry the smoke and some heat out of the building. Originally these fireplaces burned wood, but some newer ones burn only propane or natural gas and some can burn either gas or wood. Because these fireplaces are vented, the temperature around the fire box opening is relatively moderate depending on the construction of the fireplace and the location of the burning spot as well as the vent or chimney. With this type of fireplace, placing the fireplace ornamentation directly next to the firebox is probably not going to cause failure due to heat, but with high-BTU fireboxes, there may be problems associated with calcination.

In recent years, many fireplaces have been installed that are ventless, or are lacking a chimney or other means of heat escape. These fireplaces only burn natural gas. Ventless fireplaces are manufactured to permit a blower to be installed on top of the fireplace. This blower, which operates when the fireplace is on, blows heat from the fire out into the room. Some people do not want the blower because they don't want the heat, only the aesthetic effect of the gas flame in the fireplace.

In terms of potential heat damage to fireplace ornamentation, a ventless fireplace with no blower represents the greatest potential for damage because of the high temperature adjacent to the firebox. *We do not recommend that gypsum-based fireplace ornamentation be placed adjacent to a ventless fireplace without a blower.* If the fireplace is equipped with a blower, the temperature at the firebox is reduced and gypsum-based ornamentation can be placed adjacent to it. All of this depends on the BTU rating of the firebox and exactly how close the surround is to the firebox opening. High-BTU fireboxes with or without a blower, ventless or vented, could cause unwanted heat-related effects to gypsum cement surrounds.

We recommend, when possible, that any fireplace surround made from gypsum cements be installed with enough clearance from the firebox to prevent any heat-related damage. Again, we strongly urge you to learn about specific fireboxes and inserts that will be associated with your products. Gaining thermal effect knowledge will allow you to properly design surrounds for specific firebox BTU ranges and venting configurations.

Although rare, there are a few fireplaces where there are extensive bars and brackets around the fire box. In use, these metal parts become very hot and over time will radiate heat onto surrounding surfaces. Radiant energy can cause heat damage as well as thermal energy, but it is slower to occur. It can also be easily blocked so that the energy is reflected away from areas that can be affected by heat.

Glossary

Alpha Gypsum
Specially processed calcium sulfate hemihydrate.

ANSI (American National Standards Institute)
A nonprofit, national technical association that publishes standards covering definitions, test methods, recommended practices and specifications of materials. Formerly American Standards Assn. (ASA) and United States of America Standards Institute (USASI).

BTU (British Thermal Unit)
The primary heat measurement unit used by the hearth industry, this is the amount of heat required to raise the temperature of 1 lb. of water by 1 °F at sea level.

Calcine
The process of heating a mineral to produce a change in its chemical structure.

Calcined Gypsum
A dry powder; primarily calcium sulfate hemihydrate, resulting from calcination of gypsum; cementitious base for production of most gypsum plasters: also called plaster of Paris; sometimes called stucco.

Carbon Monoxide
A practically odorless toxic combustible gas formed in incomplete combustion. At moderate levels, symptoms include severe headaches, dizziness, mental confusion, nausea, or feeling faint.

Caryatid
A sculptured female figure used as an ornamental support in place of a column or pilaster, often flanking a doorway or as a decorative detail around a fireplace.

Catalytic
Catalytic wood stoves and fireplace inserts have ceramic honeycombed chambers coated with a metal catalyst (usually platinum or palladium) that increases the rate of combustion. The catalytic combustor burns away gases and particulates normally emitted into the air. Catalytic wood stoves allow the burning of wood at lower temperatures for longer periods of time.

Chimney
A portion of the venting system through which flue gases are vented to the outdoors and by which penetrated combustible surfaces are protected; a primarily vertical shaft enclosing at least one flue, the design of which results in a natural draft.

Circulating Firebox
A firebox with louvers at the top and bottom so that a fan can be installed.

Circulating Fireplace
A fireplace with multiple-wall construction around the fire chamber that permits air to circulate between the walls, become heated, and enter the house directly or via short ducts.

Clearance
The air-space distance required by building and fire codes between firebox, stove, smoke pipe or chimney and combustible materials such as wood furniture or carpets. Clearances must be observed even if noncombustible plaster or other masonry materials protect the combustible materials.

Consistency
A term denoting the fluidity or viscosity of a plaster or cementitious paste; also refers to the amount of water required to bring a given quantity of dry cementitious material and aggregate to a given fluidity.

Decorative Gas Appliance in a Vented Fireplace
A self-contained, freestanding fuel gas burning appliance designed for installation only in a vented fireplace, with a primarily aesthetic function. Gas hearth appliances which are listed to ANSI Standard Z21.60 include gas log sets.

Direct Vent
An appliance that draws combustion air from outdoors and exhausts its combustion products to the outdoors, eliminating the need for a standard chimney system. The glass panel in direct vent units is critical to keeping the combustion system sealed from the home, maintaining high efficiency and indoor air quality.

Factory-Built Fireplace
Prefabricated metal fire chamber and its chimney, commonly called zero clearance. Consists of listed manufactured components that are assembled to form the completed fireplace.

Firebox
The portion of the solid fuel appliance where the fuel is located and where primary combustion occurs.

Fireplace
An enclosure, open in the front for burning fuel. Solid fuel fireplaces may contain and vent gas log sets or fireplace inserts. Gas fireplaces are metal appliances open in the front and containing artificial log sets.

Fireplace Surround
The raised decorative moulding that surrounds the opening to a firebox or a marble, plaster, or tile frame between the fireplace itself and the wooden mantel.

Fire Resistance Rating
The time a material will withstand, without igniting, flame and heat as specified by code and specific test conditions.

Floor Protector
Floor protectors are intended for use with solid fuel heat producing appliances for the reduction of the surface temperature of combustible floor materials. They are intended to be placed over combustible floor construction materials beneath and adjacent to Listed fireplace stoves, solid fuel room heaters, factory built fireplaces, and fireplace inserts.

Gas Fireplace Insert
A gas appliance designed for installation within an existing fireplace. Usually this consists of gas logs within a metal enclosure surrounding the logs and covering the space between the insert and the fireplace opening.

Gypsum Cement
A hydraulic cement made from calcium sulfate hemi-hydrate.

Hearth
The floor of the firebox, most commonly used in reference to fireplaces. More generally, the foundation upon which fires for aesthetic and heating purposes are built. *Differs from Floor Protection.*

Hearth Extension
Noncombustible floor protection extension beyond the opening of a fireplace or stove. The term is also sometimes used to denote the floor protector under or around any residential solid fuel burning appliance.

Incombustible
(also see Noncombustible)
A material that will not burn when subjected to fire. Specific use in the building codes is limited to the types and materials used in certain buildings. Defined as meeting criteria of ASTM E136 "Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 °C" This term does not apply to surface finish materials.

Inserts
Heating units that retrofit into an existing masonry or factory-built fireplace. Inserts burn wood, gas, or pellets.

K Value
Indicates the amount of BTUs of heat that will flow in one hour through one square foot of a uniform material one inch thick for each degree Fahrenheit of temperature rise. Used in calculating floor protection materials and thickness when one noncombustible material is used.

Label Service (also see UL)
Program allowing a manufacturer to place Underwriters Laboratories Inc. labels on its products that have met UL requirements. A UL representative visits the manufacturing site to obtain samples of the products for testing by UL. In some cases, samples are also purchased on the open market for testing. The public is thereby assured that products bearing the UL label continually meet UL specifications.

Lintel
A horizontal structural member, such as a beam or stone that spans an opening, as between the uprights of a door or window or between two columns or piers. The area above the firebox.

Glossary

Listed
Included in a list published by a recognized testing laboratory or inspection agency, indicating that the equipment meets nationally recognized safety standards.

Mantel or Mantelpiece
a) Flush Mantel—Another finishing option for direct vent and ventless fireplaces. It can be wood, marble, plaster, or stone. The mantel does not encase the entire fireplace, but frames it, and is usually only 1-3/4 to 2-1/2 inches deep. Mantels are used when the fireplace is installed inside the wall or on the outside wall of the house. b) Shelf over and above the fireplace opening. c) The finish around a fireplace, covering the chimney-breast in front and sometimes on both sides. The term is especially applied to a shelf above the fireplace, and its supports.

Manufacturer's Installation Instructions
Instructions and recommendations for proper assembly, adjustment, and installation of listed equipment.

Mechanical Sidewall Venting
Totally horizontal through-the-wall venting of combustion by products under positive pressure by means of an electric fan. Commonly referred to as direct vent, but termination conditions differ. See Direct Vent.

NFPA
National Fire Protection Association, Quincy, MA.

Noncombustible (also see Incombustible)
Definition excerpted from the ICBO/CC: Material of which no part will ignite and burn when subjected to fire. Also defined as a material with a structural base of noncombustible materials as defined, with a surface not over 1/8" thick that has a flame spread rating of 50 or less. The term does not apply to surface finish materials.

ODS (Oxygen Depletion Sensor)
A safety device that activates the fire's flame monitoring device in case excessive levels of CO (carbon monoxide) are detected. This reduces the level of oxygen, causing the pilot flame to become unstable and lift off the thermocouple tip. The fire then turns off automatically before the situation becomes dangerous.

Radiant Heat
Heat that moves out in waves from a central point and heats objects in its path. The closer you get to a source of radiant heat, the more heat you will feel.

R-Value
A measure of how resistant a substance is to transferring heat.

Surround
The moulding which outlines an object or opening.

Therm
100,000 British Thermal Units (BTUs).

UL (also see Labeling Service)
Program allowing a manufacturer to place Underwriters Laboratories Inc. labels on its products that have met UL requirements. A UL representative visits the manufacturing site to obtain samples of the products for testing by UL. In some cases, samples are also purchased on the open market for testing. The public is thereby assured that products bearing the UL label continually meet UL specifications.
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Vented Decorative Appliances
A vented appliance whose only function lies in the aesthetic effect of the flames. Gas hearth appliances tested to ANSI Standard Z.21.50 include gas fireplaces, fireplace inserts, and freestanding appliances.

Vent-Free or Ventless
Gas appliance with no need for a flue. Although these units offer high efficiency, some areas may not permit their use. Please check with your local building official.

Zero Clearance Fireplace
A factory-built fireplace that is constructed so that it can be placed safely close to combustible material. A Zero Clearance fireplace is any firebox which has associated ornamentation directly adjacent to it without clearance or setbacks.

References

United States Gypsum Company Publications:
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IG503 *Plaster Mixing Procedures*
www.gypsumsolutions.com
www.usg.com

Underwriters Laboratories, Inc.
www.ul.com

ASTM International
www.astm.org

National Fire Protection Association
www.nfpa.org

Hearth, Patio, and Barbeque Association
www.hpba.org

Fireplaces Now
fireplacesnow.com

Warning
Spraying mist or vapors created from product may cause eye, skin, nose, throat or upper respiratory irritation. Avoid inhalation of mist or vapors. Inhalation of vapors or mist may cause headache, nausea or irritation of nose, throat and lungs. Use in a well-ventilated area. Keep container closed when not in use. Wear a NIOSH/MSHA-approved organic vapor/mist respirator as necessary. Use proper ventilation to reduce mist/vapor exposure. Avoid eye contact and prolonged skin contact. Can cause severe eye irritation. Wear eye protection. If eye contact occurs, immediately flush thoroughly with water for 15 minutes. Prolonged or repeated contact with skin can cause irritation. Wear waterproof gloves and protective long-sleeve work clothing for skin protection. If skin contact occurs, wash thoroughly with soap and water. If eye or skin irritation persists, get medical attention. Do not ingest. If ingested, call physician. Product safety information: (800) 507-8899 or www.usg.com
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Manufactured by
United States Gypsum Company
Industrial Products Division
125 South Franklin Street
Chicago, IL 60606

800 487.4431
www.usg.com

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