



Glass Plants


Menomonie Wisconsin

Portage Wisconsin

Mooreville North Carolina

Durant Oklahoma

Winlock Washington



◆ Cardinal Glass Industries

Superior
glass products
for residential
windows and doors

cardinalcorp.com



CARDINAL CARES

Our Guiding Principle

People making glass for people – that is our guiding principle. It's what motivates us to do our jobs well. It's the reason we continue to develop superior products and services and consistently set the standard in float glass manufacturing. We at Cardinal care about you, the people who use our products to get warm, stay cool and take in the view.

Our Quality Commitment

We are proud of what we do at Cardinal. Our tried and true operating principles, teamwork and open communication allow us to provide the high-quality products and service we are known for.

Our Philosophy: Glass Is Green

We care about the environment, which is why we make recycling a big part of our business. From repurchasing and reusing cullet to developing energy-conserving processes and products, our dedication to protecting the environment is evident in everything we do.

Our Management Style

Our entrepreneurial culture, decentralized management philosophy and team-focused structure foster a healthy, creative, solution-based environment. All Cardinal team members are empowered and encouraged to make decisions and solve problems.



Cardinal



Float Glass Manufacturing

Top-of-the-line residential window and door manufacturers all rely on high quality float glass from Cardinal. It's the base upon which their products are built. And they know they can depend on Cardinal quality, thanks to our exclusive I.Q. program.



SAND
LIMESTONE
SODA ASH
DOLOMITE
SALT CAKE
NEPHELINE SYENITE
ROUGE
CARBON

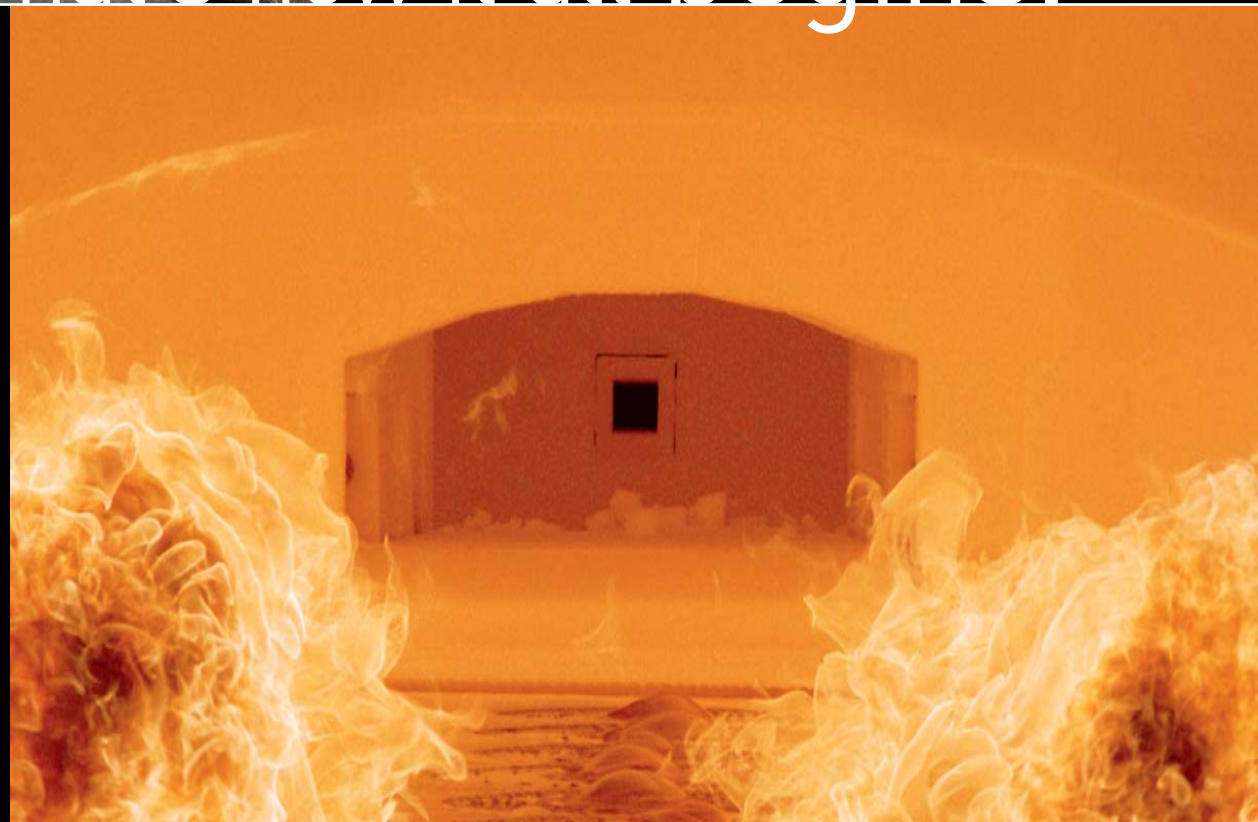
The precise formulation of these materials is mixed in the batch house and then conveyed to the batch hopper where it is uniformly charged – or loaded – into the furnace. The exact location where this occurs is commonly referred to as the “doghouse.” During the melting process, gases are released as the raw materials become molten. These gases then enter the exhaust stream, which is directed through an exhaust purification system.

OUR UNIQUE FURNACE DESIGN ENSURES OPTIMUM QUALITY

Our furnace design has given Cardinal an excellent system for producing high quality glass. The capabilities that have been built into the process allow our operations to have maximum flexibility to produce the many different thicknesses of glass - from 1.6 to 7.0mm - that are required for the residential market.

A grain of sand. That's how it all begins.

Our clear float glass is actually made from a precise formulation of the eight different raw materials you see listed above. Cullet, which is recycled glass that has been broken into small pieces, is also added.





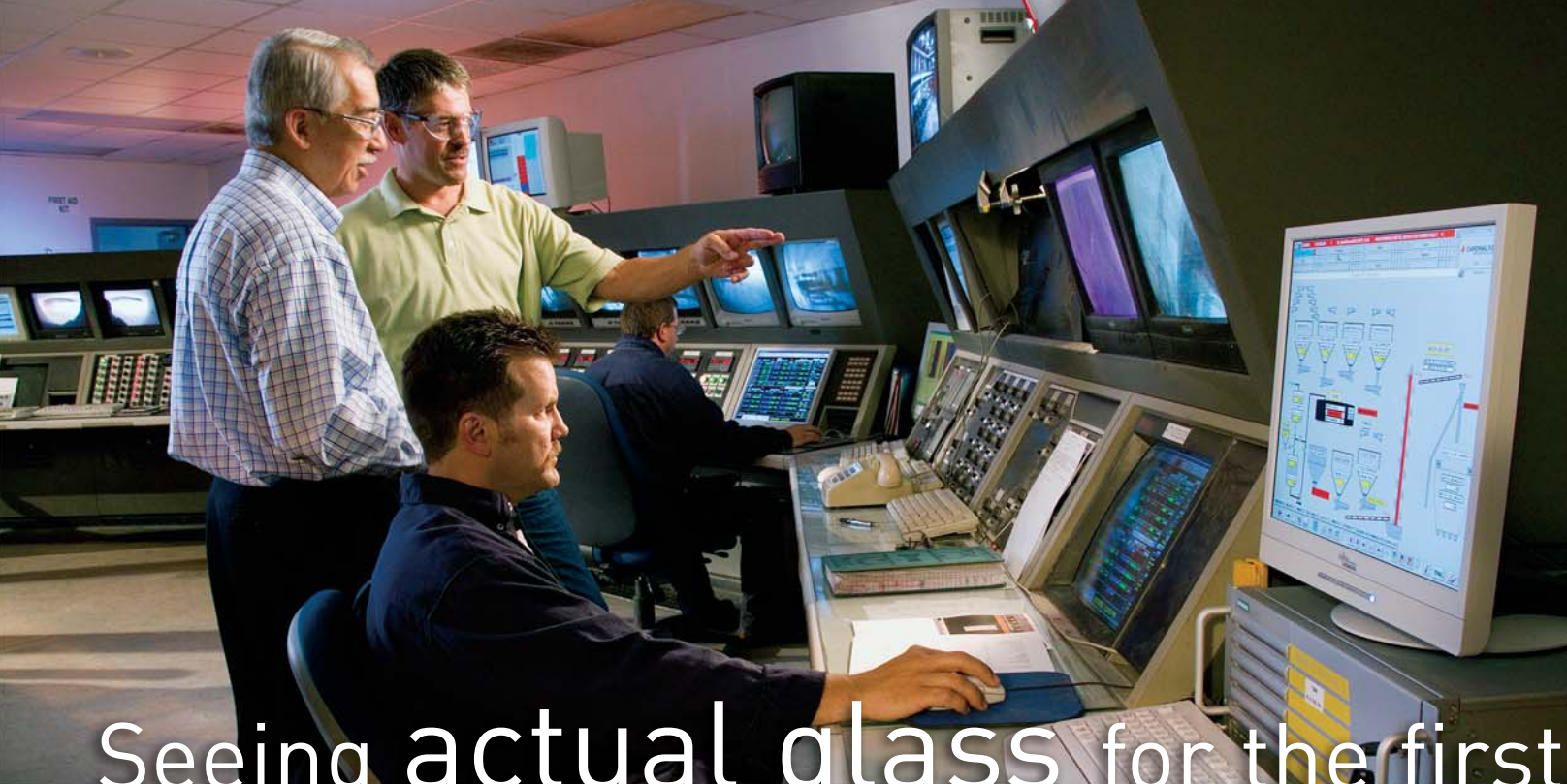
Cardin

The furnace has three sections – the melter/refiner, the working end and a narrow area between the two sections called the waist. The hot spot in the melter is maintained at approximately 2,900°F. Each furnace in the Cardinal system is slightly different, but in general the total furnace length is in excess of 165 feet, with a width of about 36 feet. There is a 4-foot deep pool of molten glass in the furnace in any given day, weighing approximately 1,700 tons.

FLOAT GLASS REALLY “FLOATS”

The tweel is a refractory “gate” that controls the flow of molten glass from the working end of the furnace to the tin bath. The molten glass flows through a channel called the canal before it enters the tin bath at approximately 2,000°F. The tin bath is the key to modern float glass technology, as the molten glass actually “floats” on top of 2 inches of molten tin.

The molten glass continues its flow, exiting the bath at an approximate temperature of 1,150°F. Top roll machines are used to precisely control the width and thickness of the molten glass or the “ribbon” during the forming process in the tin bath. The tin bath chamber uses an atmosphere of 92% nitrogen and 8% hydrogen to prevent oxidation. The combination of this environment and temperature allows the glass to achieve a natural fire polished finish. Cardinal tin baths are over 150 feet long, up to 23 feet wide at the front end and 14 feet wide at the exit end.



Seeing actual glass for the first time.

The glass is openly visible for the first time at the tin bath exit, where lift-out rollers pull the ribbon from the bath into the lehr. The annealing lehr is a large horizontal chamber consisting of two sections, an enclosed section and a forced air section.

The critical range for obtaining proper annealing of the glass occurs in this section of the lehr.

ANNEALING IQ ✓

The enclosed portion of the annealing lehr uses electric heat and radiant cooling to gradually lower the glass temperature to around 750° in a uniform manner. Carefully controlling the cooling process lets us create the proper inherent strength of the glass, while maximizing the ability to cut the finished product.

TEMPERATURE CONTROL IQ ✓

Our lehr pyrometer system measures glass ribbon temperatures from edge to edge, which is critical to the annealing process. These temperature measurements also help us determine ribbon width early on. This minimizes our cutting losses and ensures that you will be able to cut down stock sheets with minimal cutting losses as well.

The ribbon then enters the first forced air section called the rets. In the rets heated air is blown onto the ribbon to gently cool the hot ribbon before more concentrated cooling takes place in the mass air section. The glass temperature leaving the rets is around 550°F.

The glass then enters the second forced air section or the mass air. Here more rapid cooling of the ribbon is obtained by using ambient air to blow on the ribbon. The glass temperature leaving the mass air is around 160°F. The speed of the ribbon at this point will be between 200 and 1,100 inches per minute, depending on the thickness being produced and the overall production rate.

The entire cooling process is controlled so as to create the proper inherent strength of the glass, while maximizing the ability to cut the finished product. Our lehrs are designed to maintain control and yet have rapid response capability to the thickness changes that are necessary as we produce the 1.6 to 7.0mm products for our residential customers.



THICKNESS PROFILE IQ ✓

The thickness gauge measures thickness across the entire ribbon, determining if any portion is out of spec. If so, that portion is marked and it is discarded.

At this point in the process, the ribbon is considered to have left the hot end and now enters the cold end – or packaging end – of the plant.

LASER INSPECTION IQ ✓

The inspection booth is positioned over the line and permits a close analysis of the ribbon for defects. Lasers are used to locate any defects and feed their location to the cold end control computer for marking and optimization.



Our laser system inspects 100% of the glass, detecting defects as well as ribbon edges, knurl mark and distortion, so customers can be confident of the glass quality they receive.

DEFECT DETECTION IQ ✓

• STRAIN MEASUREMENT

Three different strain measurements are taken, so we can precisely control the strain on the ribbon which affects the cuttability of the glass.

• EDGES ON AND OFF/SQUARENESS

A camera inspection system focuses on edge quality and squareness, ensuring that edges meet specification.

• DISTORTION

The laser system reads the “zebra” pattern across the ribbon, making sure that distortion is minimal and well within spec.

OPTIMIZATION SYSTEM IQ ✓

The Cardinal optimizer determines how best to cut the ribbon, thereby maximizing yields and improving efficiencies – which helps keep costs down.

This allows the line to have tremendous flexibility and relates well to today’s market conditions that require shorter runs and smaller batch sizes. This system is ideally suited for higher volume runs like patio doors, casement and double-hung windows.

Computer-controlled cross cutters score the glass. These cross cutters score the glass across the direction of flow of the ribbon to form the “X” cut or cross cut. The “Y” cuts are 90° from the “X” cuts and are made by an overhead bridge system. The dimensions of these scores determine the plate sizes being produced and are dictated by the particular customer order. Several sizes may be scheduled at any time during the day.

The main line snap roll breaks the glass along the “X” score lines by applying upward pressure. At each packing destination, the “Y” score lines are broken with additional rollers. Edge trim – glass that has been marred during the initial production phase – is broken off at the edge trim section. This glass is crushed and recycled back into the furnace as cullet.



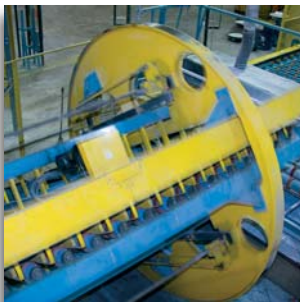


Protecting the glass...

Our packaging and shipping systems are designed to minimize handling, thereby protecting glass surfaces. Reusable racks and shipping materials reflect our concern for the environment by minimizing waste.

SOPHISTICATED PACKING SYSTEM PRESERVES GLASS QUALITY

State-of-the-art glass packing is done on the automatic or manual spur lines, depending on size. The need for clean production has resulted in a system that minimizes contact with the glass surfaces during packing. This capping system uses 90° rotators, barrel turnovers, robots and stackers to insure the proper glass lite orientation for downstream operations such as LoE™ production, where the top surfaces are generally used for the coating. A camera system inspects edge quality during this process as well.



COMPUTERIZED INVENTORY PROGRAM SUPPORTS THE CHANGING MARKETPLACE

The glass warehouse – which can be as large as 350,000 square feet – accommodates storage of up to 25,000 tons of glass for our customers. This glass logistics center ensures rapid, quick turnaround service. A computerized tracking and stock locator system connects this inventory with our customer demands to ensure that the plant has the proper on-hand inventory. This quasi “Kan Ban” system is critical in supporting today’s ever-changing marketplace.

The shipping area consists of outside truck docks and inside shipping bays. Overhead cranes transport the heavy glass racks or jumbos when necessary.



DID YOU KNOW?

- Float glass plants are enormous – over 350,000 square feet under each roof.
- Each plant uses \$500,000 of natural gas and \$85,000 of electricity every month.
- Plants run 24 hours a day, 365 days a year.
- Each FG plant ships 35-40 trucks of glass every day, at almost 35,000 square feet per truck.
- Glass is cut in sizes as small as 16” x 20” to as large as 130” x 204.”

PATENTED RACK SYSTEM MINIMIZES HANDLING

A new patented rack system – called a collapsible A-frame – has also been introduced to further streamline the process by reducing the times a pack of glass must be handled. This system is designed to ship glass racks from our floor via standard sized trailers directly to the customers’ line for processing. The racks need minimal separating or bracing materials which saves time and factory space in the process, and reduces waste.



Simple things like our focus on packaging reflect not only our understanding of the entire business, but also reinforce Cardinal’s environmental stewardship by controlling and reducing waste. In fact, Cardinal is the glass industry’s leader in conserving America’s energy resources.



Cardin

and the environment.

RETURNABLE METAL RACKS REDUCE WASTE

Cardinal incorporates returnable, reusable metal racks that have been designed specifically to store the multiple sizes that make up our running active inventory. Using these steel racks eliminates more than 20,000 tons of landfill waste a year and the countless man-hours required to construct 500,000 wooden boxes annually (the traditional industry approach).

BROKEN AND REJECTED GLASS SCRAPS ARE REUSED

Cardinal repurchases these glass scraps (cullet) from our customers for reuse in float glass manufacturing. Each FG plant reuses an average of 70 tons of cullet a day, which eliminates more than 150 million pounds of glass in landfills each year.

Our cullet shipments are scheduled as back-hauls from customers' facilities. So instead of back-hauling empty trucks, Cardinal trucks back-haul cullet for recycling, conserving fuel and manpower.

PACKING MATERIALS ARE ALSO REUSED

Cardinal reuses a large percentage of packaging materials every day and when possible, initiates programs with customers to recycle packaging materials.

ALL PLANTS ARE EQUIPPED TO REDUCE EMISSIONS

Using the Best Available Control Technology (BACT), the Menomonie and Portage plants each invested \$5 million for scrubbers and precipitators. The Mooresville plant utilizes a DeNOx system (to reduce NOx emissions) licensing the Pilkington® 3R™ clean air process.

CARDINAL PRODUCTS ARE EXTREMELY ENVIRONMENTALLY FRIENDLY

The usage of energy-efficient LoE² glass coatings and insulating glass conserves energy that is equivalent to the annual production of fourteen offshore drilling platforms.

Cardinal believes that environmental stewardship is the key to a national future which will provide affordable heating and cooling options for us all.



I.Q. Intelligent Quality Assurance Program

This series of industry-leading inspection processes is the assurance that Cardinal glass will always meet or exceed specifications. We thoroughly examine every piece of glass from start to finish. Most of our inspections rely on carefully calibrated scientific instrumentation. So results are objective, not subject to human interpretation.



This objectivity also assures product uniformity plant-to-plant as well as time-after-time. Some of our float glass I.Q. assurance steps are highlighted throughout the brochure.