

# BOC GLASS TECHNOLOGIES

*Glass specialists ...  
worldwide*

- industrial gases
- oxy-fuel melting
- oxy-fuel burners
- process control systems
- conditioning equipment
- turn-key installations

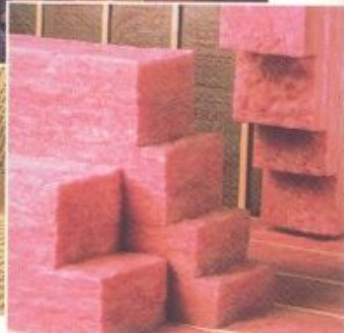
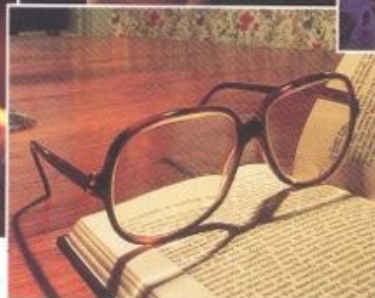
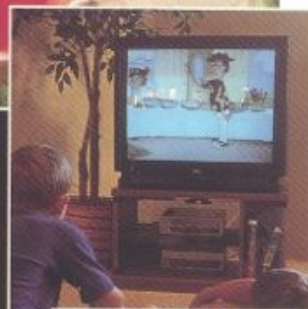




- *A team of knowledgeable specialists provides you with expertise in all phases of glass manufacturing*
- *Lower oxygen production costs, high-efficiency burner and combustion systems, and integrated control systems help reduce your total effective cost*
- *Global R&D efforts and strategic partnerships with glass industry leaders enable us to develop innovative technologies*
- *Extensive testing facilities, three decades of experience, and more than 190 glass installations in 35 countries assure you of proven technology and equipment that performs as promised*
- *With operations in 60 countries, BOC Gases offers you reliable local service and support combined with ready access to glass expertise on a global scale*



Our Glass Technologies Group has expertise in all applications, from float glass and container manufacturing to lighting, fibreglass, tableware, TV and speciality glass.





## ***When you need a gas supplier for your glass-making operations anywhere in the world, the choice is crystal clear ...***

For more than 30 years, BOC Gases has been a leading supplier to the glass industry. We have a long history of developing technologies that help glass manufacturers improve quality, increase production and enhance furnace performance.

Now, with our team of specialists and recent technological breakthroughs, BOC Gases offers the worldwide glass industry the most cost-effective products and systems for glass manufacturing.

### ***Your global partner in glass-making***

A world leader in the manufacture and supply of industrial gases and gas-handling technology, BOC Gases employs more than 27,000 people in 60 countries.

BOC Gases is the industrial gases business of The BOC Group, the worldwide industrial gases, health care, vacuum technologies, and distribution services company with annual sales of approximately \$5 billion.

The BOC Group has operations in more than 60 countries around the world.

### ***BOC Gases: over three decades of glass-making innovation***

#### ***1950s***

BOC Gases begins providing oxygen to glass-makers

#### ***1960s***

BOC Gases supplies the world's first float furnace with a hydrogen-nitrogen atmosphere

BOC Gases enhances glass furnace performance and extends furnace life using innovative oxygen lancing

#### ***1970s***

BOC Gases installs its first oxygen on-site non-cryogenic plant in the glass industry

#### ***1980s***

BOC Gases installs oxy-fuel burners in recuperative and regenerative furnaces

BOC Gases successfully commissions oxy-fuel conversions in the US and UK

#### ***1990s***

BOC Gases introduces Improved Cryogenic Oxygen (ICO) on-site plant and high-efficiency, low NOx Flat Jet burner

BOC Gases, Corning Incorporated, and BH-F (Engineering) Ltd. develop oxy-fuel forehearth to achieve better temperature stability for increased production and less refractory erosion



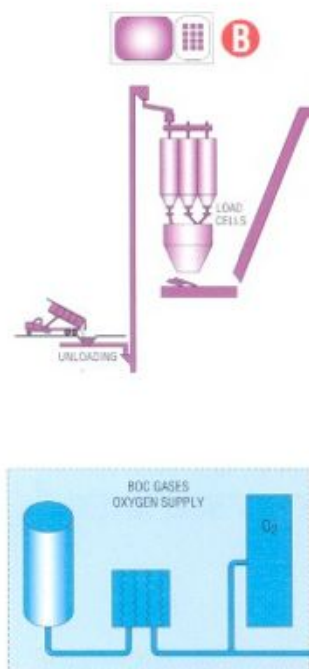


# More than just low NOx

BOC Gases is more than a supplier of industrial gases. We are specialists in all phases of glass manufacturing.

## A Oxygen supply

Low-cost and efficient cryogenic and non-cryogenic on-site plants and delivered liquid oxygen.



## B Process control systems

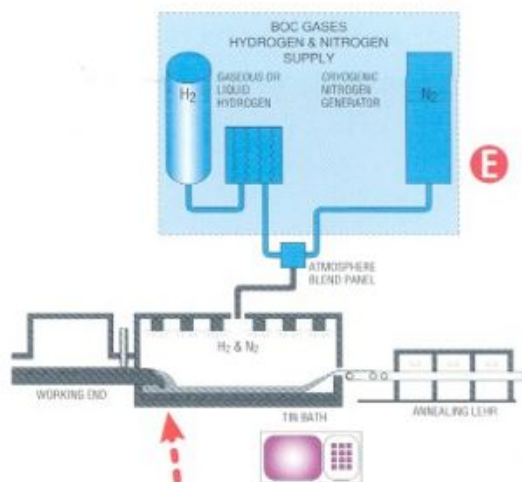
The industry's most advanced control systems including batch, oxy-fuel and air-fuel melter, forehearth, tin bath, and lehr, plus temperature and level measuring equipment.

## C Oxy-fuel burners and combustion systems

BOC Gases' patented Flat Jet burner and lance, burners from Corning Incorporated and Laidlaw Drew, and combustion systems for oxy-fuel melting and boosting.

## D Oxy-fuel melter conversions

Turn-key service including furnace design, computational fluid dynamics (CFD) modelling, burner placement, start-up assistance, and refractory recommendations to optimise melter performance.

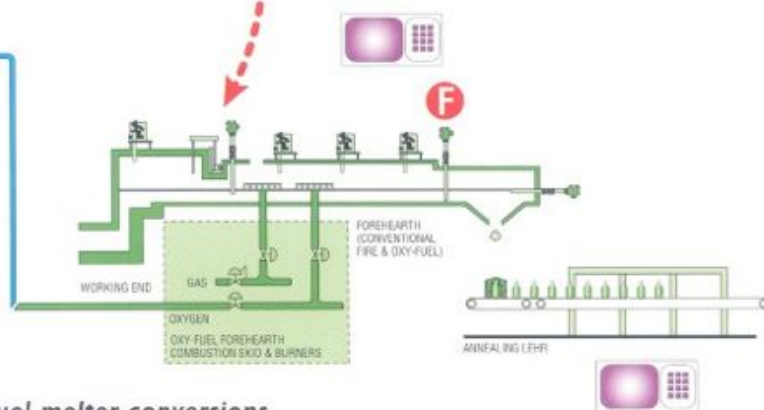


## E Hydrogen and nitrogen supply

Industry-proven nitrogen and hydrogen on-site generators and delivered hydrogen accompanied by applications expertise.

## F Glass conditioning equipment

Forehearts, working ends, and feeder mechanisms from our UK partner, BH-F (Engineering) Ltd.



Another division of The BOC Group, Airco Coating Technology, also services the glass industry with thin film coating technology.

# Six reasons why BOC Gases should be your gas and equipment supplier ...

## 1. Global specialists in a wide range of glass applications

We have assembled a Glass Technologies Group comprising more than 35 specialists dedicated to meeting the needs of our glass industry customers in all phases of glass manufacturing.

Team members include specialists in industrial gas production and application, process control, melting technology, oxy-fuel conversion and combustion, and glass conditioning.

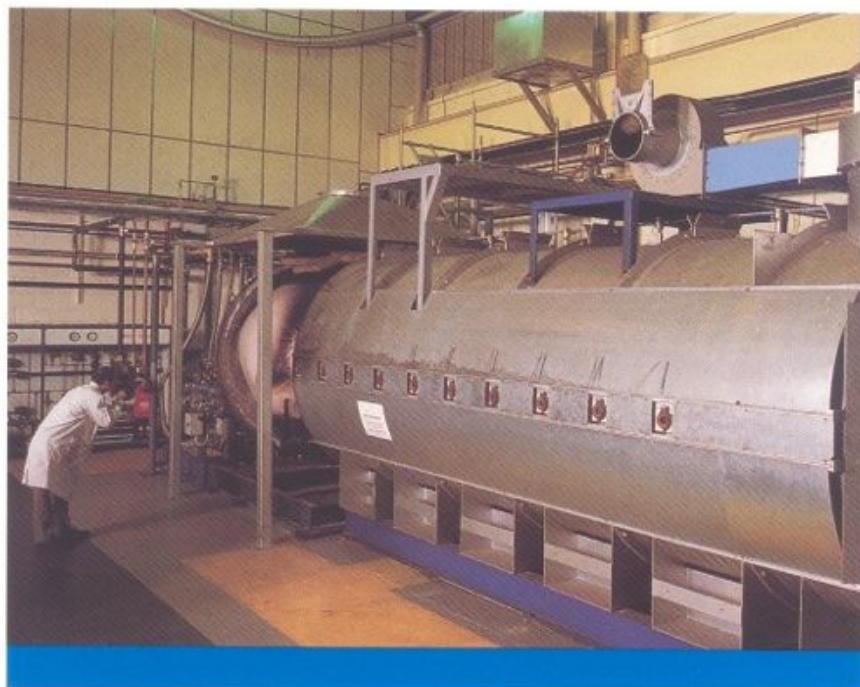
## 2. Cost-effective solutions

BOC Gases focuses on reducing your total effective cost of operations by offering a unique combination of products and services not available from any other industrial gas company. These include

- on-site plants that generate oxygen and nitrogen at low cost
- integrated control systems that improve quality and increase yield
- high-efficiency burners and combustion systems that reduce fuel and oxygen costs.

## 3. An industry innovator

An extensive worldwide technology development programme combined with strategic partnerships in the glass industry enable us to bring our customers innovative technologies for enhancing efficiency and reducing costs. When you need answers, we tap the resources of our global network to find innovative solutions fast.



Our test furnace enables us to assess accurately the performance of new burner designs to maximise heat transfer rates.

## 4. Proven technology

BOC Gases has a century of experience in industrial gases and more than three decades of service to the glass industry. With more than 190 glass installations in 35 countries, and extensive test facilities in the US and UK, no industrial gas company is better positioned to offer you proven technology for glass manufacturing.

## 5. Global presence combined with local support

With operations in 60 countries, BOC Gases gives you access to a global network of glass expertise and technology while assuring you of responsive local sales, supply and support.

## 6. A single-source supplier

Our broad product line and global presence enable us to be your single-source supplier for gases and equipment used in your glass-making operations worldwide. We can provide a turn-key package, taking single-source responsibility for the entire project.

Finding innovative solutions to difficult glass manufacturing applications is a BOC Gases speciality.





## **BOC Gases innovations for the glass industry**

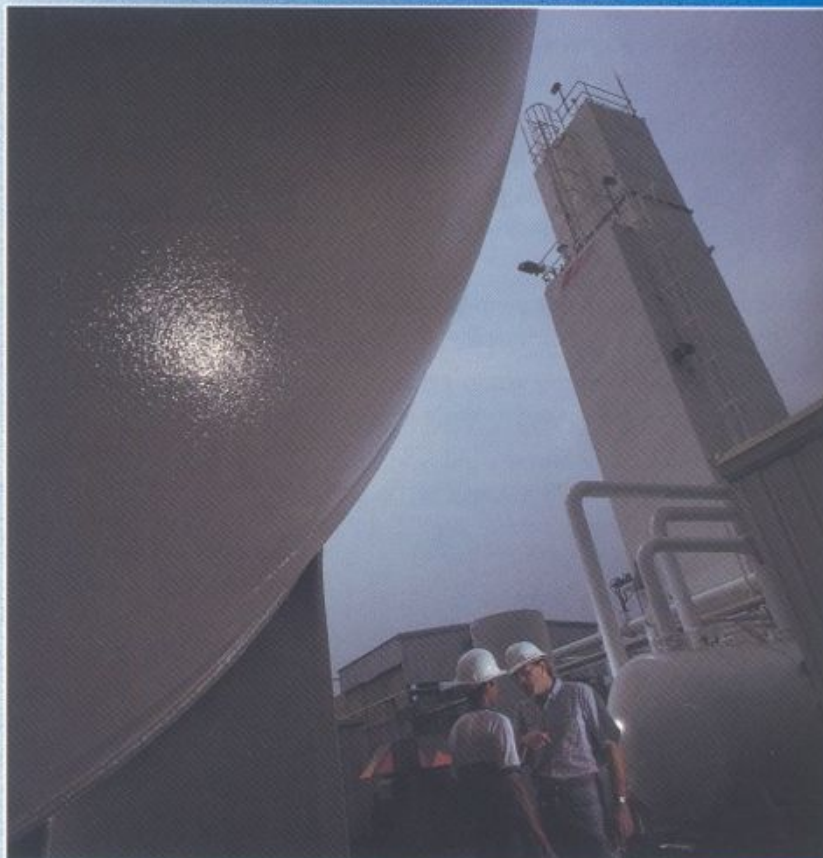
*How we have advanced technology to help our customers make higher quality glass at lower cost*

### **Improved Cryogenic Oxygen (ICO) plant**

ICO is an advanced cryogenic technology that can produce oxygen at costs up to 20 percent less than traditional cryogenic air separation units.

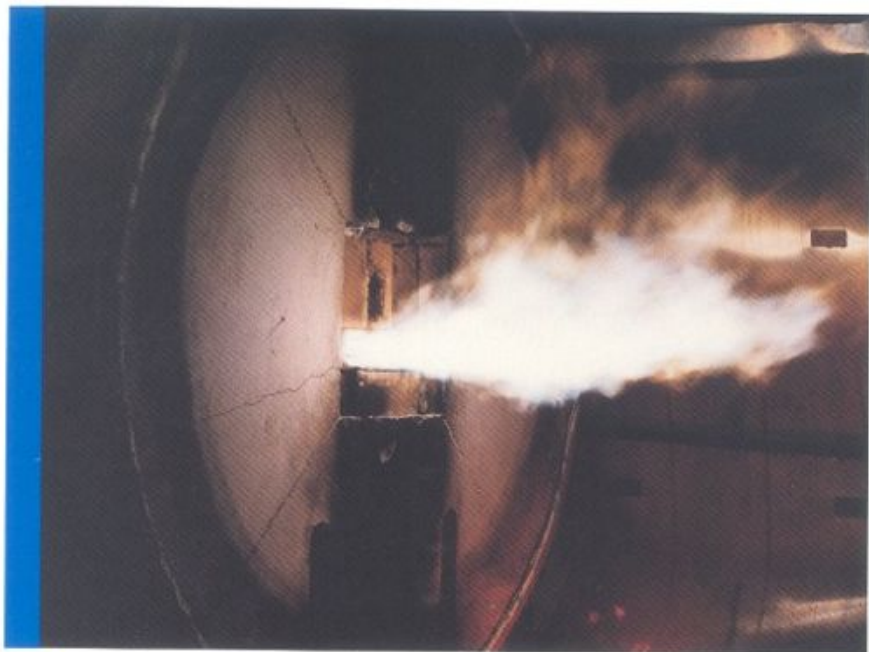
Through an improved cryogenic process, ICO plants generate

- gaseous oxygen for oxy-fuel combustion in purities from 90 to 98 percent (nitrogen content at maximum purity is less than 0.2 percent)
- pressure flexibility to serve the economic ideal 0.7 bar(g) or higher
- dry gaseous nitrogen used for inerting, instrument air or cooling
- compressed dry air for use as plant or instrument air
- liquid oxygen — the ICO plant generates its own backup supply of liquid oxygen to reduce dependence on more expensive delivered liquid oxygen.



BOC Gases' Improved Cryogenic Oxygen (ICO) generator is an industry breakthrough, capable of producing gaseous oxygen and nitrogen as well as liquid oxygen for backup at significantly reduced cost.





Our patented Flat Jet burner has a thin, flat flame that is visibly more luminous and provides more uniform coverage of the melt than conventional oxy-fuel burners.

### Flat Jet Burner

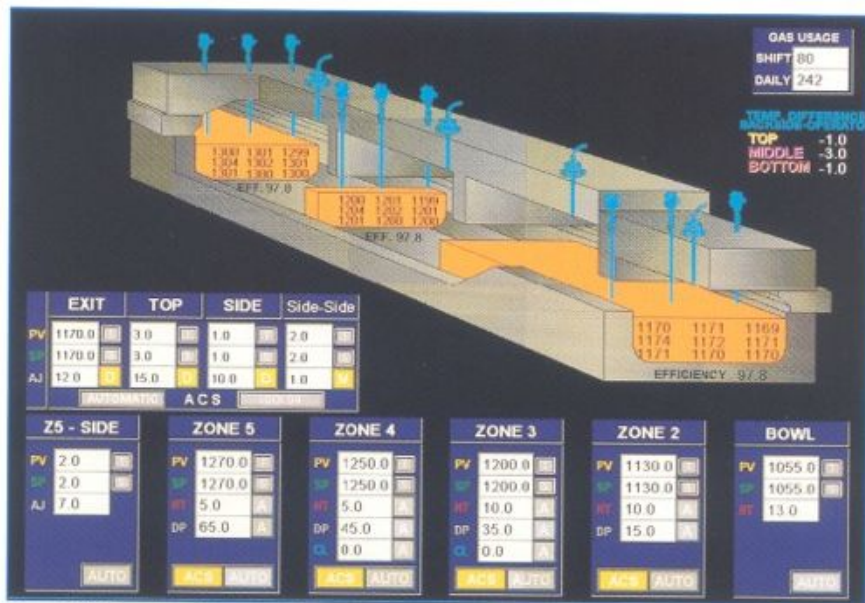
BOC Gases' patented Flat Jet burner produces a wide, flat flame in which fuel is sandwiched between two layers of oxygen and fans out at a range of angles. The innovative burner design provides broader, more uniform flame coverage than tube-in-tube or conical burners with visibly greater flame luminosity.

The Flat Jet burner has been shown to increase heat transfer significantly while reducing NOx emissions. Increased heat transfer maximises glass pull per unit area and reduces fuel consumption.

### Advanced Control Strategy (ACS™) forehearth control system

The ACS forehearth control system is a revolutionary advancement in glass temperature conditioning. The system uses sophisticated feedforward and feedback algorithms for direct control of forming temperatures, enabling the glass-maker to maintain forming temperatures and improve glass thermal homogeneity. Benefits include

- the ability to make thinner, stronger glass
- increased forming speeds
- fewer rejects for increased yield
- quicker start-up and reduced downtime between runs.



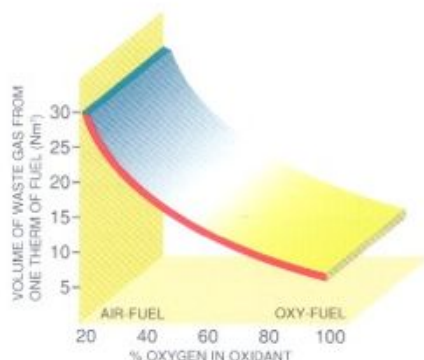
The ACS forehearth control system overview screen provides the operator with temperature control loop data and a visual representation of the forehearth.

### Oxy-fuel forehearth

Jointly developed by BH-F (Engineering) Ltd. and Corning Incorporated, the oxy-fuel forehearth uses oxygen instead of air to increase capacity without physically extending the forehearth.

In the manufacture of soda-lime glass, the oxy-fuel forehearth improves thermal homogeneity of the glass to increase the pull through the forehearth. In making borosilicate glass, the unit improves thermal homogeneity while reducing refractory erosion.

## BOC Gases: your source for oxygen boosting and oxy-fuel conversions



Oxy-fuel conversion can reduce furnace exhaust gas volume by up to 75 percent in regenerative furnaces and by as much as 90 percent in direct-fire furnaces.

Oxygen has been used in the glass industry for many years. In the 1960s, BOC Gases developed high-performance lances for oxygen boosting of glass furnaces, increasing furnace life as well as boosting furnace capacity.

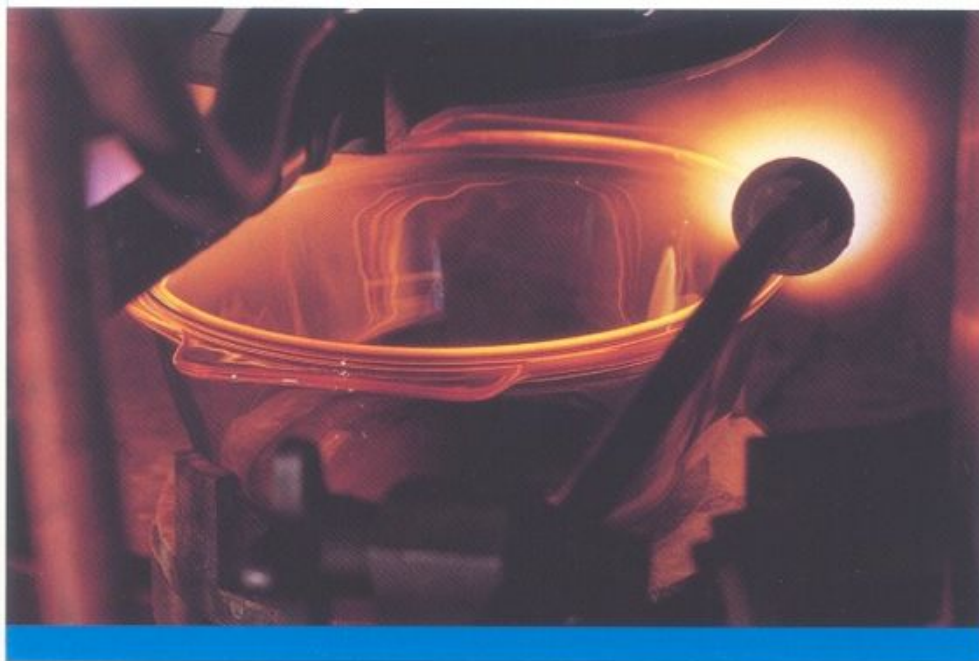
Today we are converting furnaces around the world to 100 percent oxy-fuel firing and continue to use our innovative lances for oxygen boosting. The current demand for oxy-fuel firing of glass furnaces is being driven by two recent developments:

- stricter environmental regulations requiring glass-makers to reduce NOx and particulates
- innovations in on-site oxygen production that have resulted in lower cost oxygen.

In an oxy-fuel conversion, regenerators are eliminated because furnaces use oxy-fuel burners and combustion systems that mix natural gas or oil with oxygen instead of air. An on-site oxygen generator is installed, and the furnace is redesigned and remodelled if necessary to optimise melt efficiency.

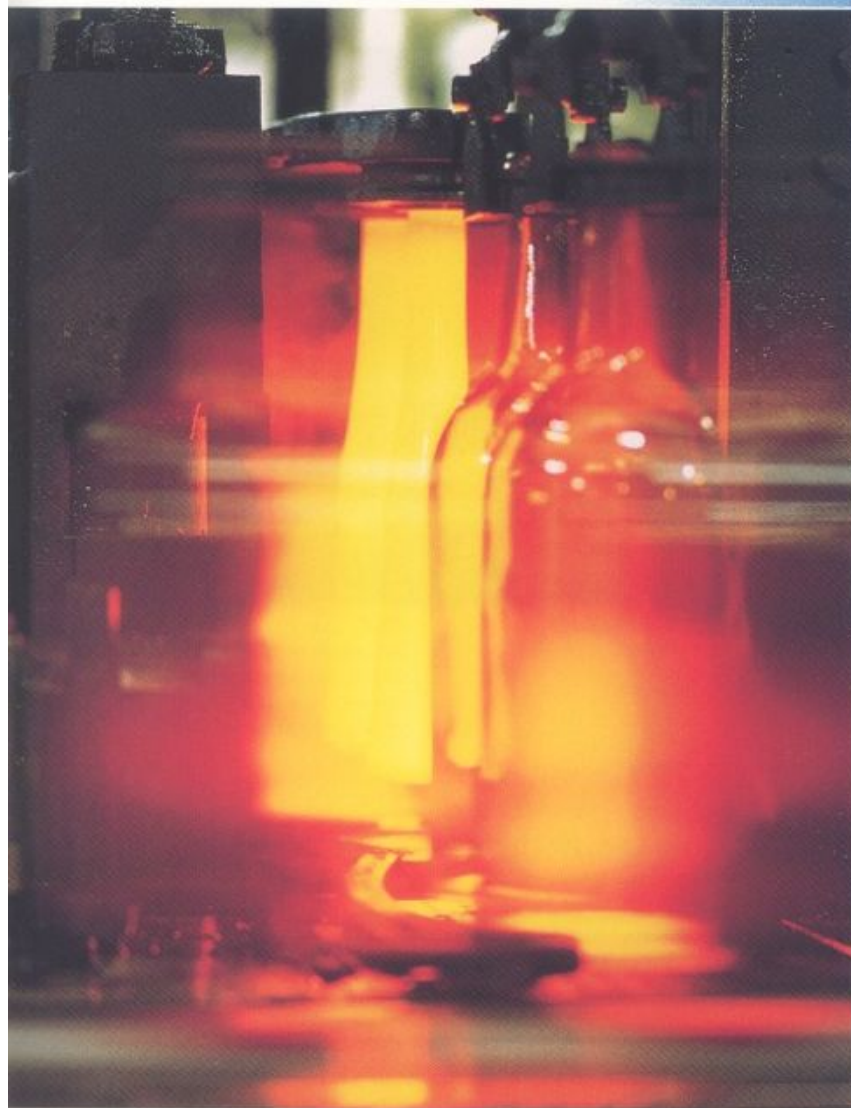
### Benefits of oxy-fuel conversion

- NOx and particulate emissions are reduced at lower cost than with catalytic reduction and other abatement technologies
- Eliminating regenerators reduces capital outlay for new and retrofit installations
- Furnace output is increased up to 20 percent for higher production
- Improved temperature stability of glass melt results in better quality product
- Fuel savings of 10 to 70 percent, depending on type of furnace
- Better work environment results in greater acceptance by furnace operators
- Improved combustion stoichiometry for greater control of the oxygen-to-fuel ratio
- Elimination of regenerators provides for more factory floor space.



BOC Gases was instrumental in the oxy-fuel conversion of Corning's Sunderland, UK facility, where high-quality glass is produced.





### ***A total oxy-fuel conversion service***

When you consider converting to oxy-fuel, tap the resources of BOC Gases. Now in our second century of oxygen production and application, we have more than 50 years of oxy-fuel melting experience.

Is oxygen right for your furnace? BOC Gases can help you decide. Whether it's modelling the furnace for optimum design, analysing the economics with our powerful software package, evaluating oxy-fuel burners for your furnace, or recommending the right refractory to use with oxygen, we are there every step of the way to ensure you get the most from oxy-fuel firing.

In many areas of the world, we are able to utilise our technological relationship with Corning Incorporated. Corning is a global leader in speciality glass manufacture with unmatched experience in operating oxy-fuel glass melting furnaces. The company has successfully completed more than 50 oxy-fuel furnace conversions throughout the world. Through this relationship, we offer a team of glass specialists with unparalleled expertise.



## Cost-effective supply of oxygen

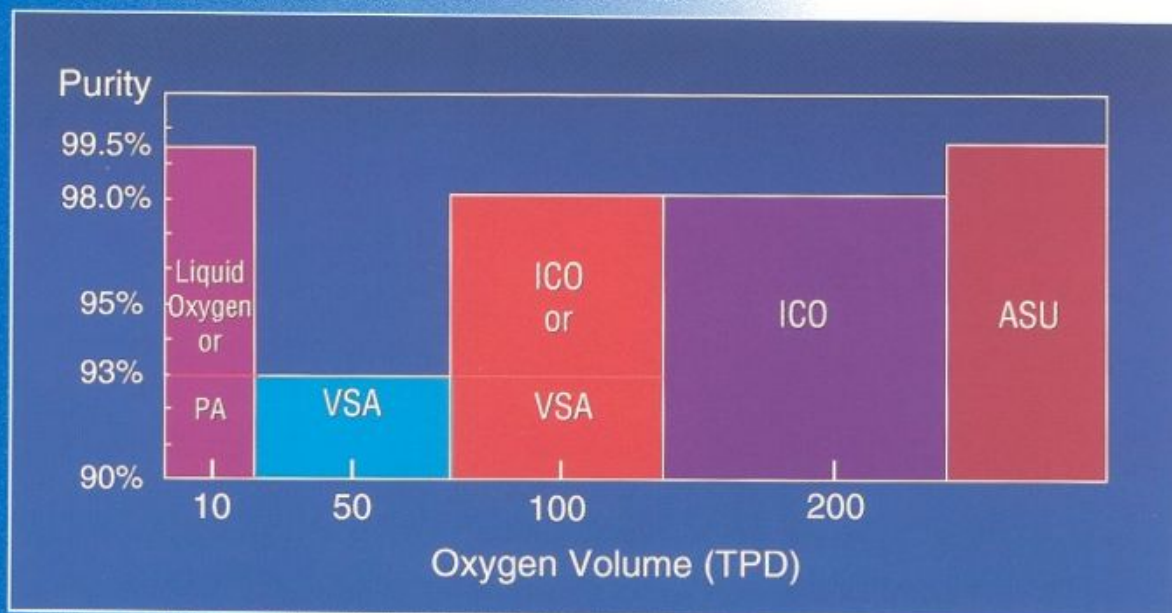
BOC Gases offers the widest range of oxygen supply options in the industry, which means we can tailor a supply mode to your volume, pressure and purity requirements, minimizing your cost. From liquid oxygen and non-cryogenic plants to large air separation units, BOC Gases has the technology and engineering resources to meet your needs.

Our on-site oxygen generators offer you a number of advantages including high reliability, low cost and high efficiency.

Working in partnership with you, BOC Gases provides training, advanced technology, on-line monitoring of oxygen plants, liquid storage tanks and more. Through development of new technology, we continually work to find better ways to supply you with oxygen at lower cost.



BOC Gases' vacuum swing adsorption (VSA) plants are ideal for providing oxygen for small to medium furnaces.



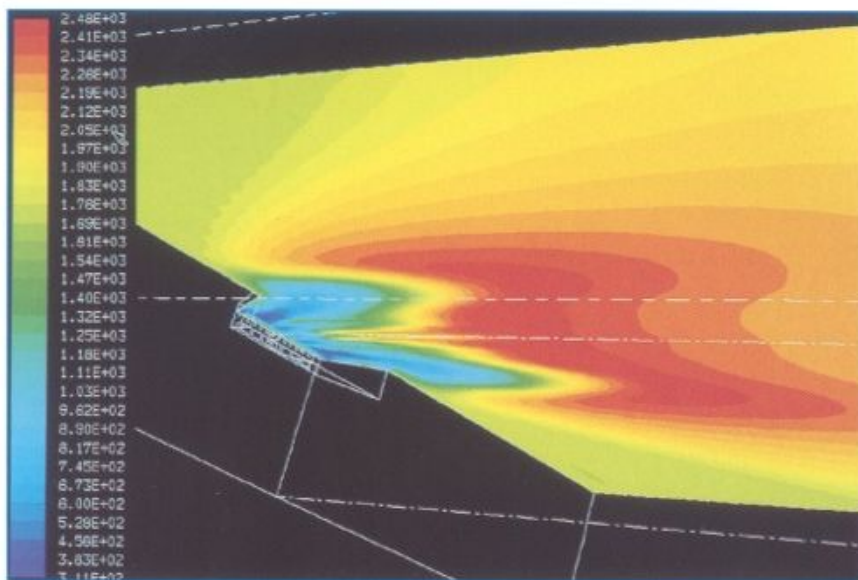
Whatever your volume, pressure and purity requirements, BOC Gases has a cost-effective supply option to meet your needs.



<b>Supply mode</b>	<b>Description</b>
<b>Liquid oxygen</b>	<ul style="list-style-type: none"> <li>• delivered liquid oxygen stored in tanks at customer site</li> <li>• TEL-TANK™ telemetry systems used to monitor product levels in your liquid tanks remotely</li> <li>• used as a backup supply for on-site plants to provide 100 percent oxygen availability</li> <li>• used in oxygen boosting and oxy-fuel conversions of smaller furnaces</li> </ul>
<b>Pressure-atmospheric (PA)</b>	<ul style="list-style-type: none"> <li>• simple design with low capital cost</li> <li>• ideal when electricity cost is low</li> <li>• used in oxygen boosting and oxy-fuel conversions of smaller furnaces</li> </ul>
<b>Vacuum swing adsorption (VSA)</b>	<ul style="list-style-type: none"> <li>• high-efficiency unit results in 40 percent less power consumption than PA</li> <li>• oxygen is produced using a molecular sieve</li> <li>• compact, skid-mounted design reduces space requirements and installation time</li> <li>• used in oxy-fuel conversions of small- to medium-size furnaces</li> </ul>
<b>Improved Cryogenic Oxygen (ICO)</b>	<ul style="list-style-type: none"> <li>• advanced cryogenic technology generates oxygen at up to 20 percent lower cost than alternative cryogenic plants</li> <li>• produces gaseous oxygen, gaseous nitrogen, dry compressed air and liquid oxygen simultaneously</li> <li>• reduces need for tanker delivery of liquid oxygen</li> <li>• safe operation because oxygen compressor is not required</li> <li>• quiet operation</li> <li>• used in oxy-fuel conversions of medium- to large-size furnaces or multiple small furnaces</li> </ul>
<b>Oxy-Float generator</b>	<ul style="list-style-type: none"> <li>• new technology specifically designed for float industry requirements</li> <li>• produces low-purity oxygen for oxy-fuel melting and high-purity nitrogen for the tin bath</li> </ul>
<b>Air separation unit (ASU)</b>	<ul style="list-style-type: none"> <li>• a traditional cryogenic plant producing oxygen and nitrogen tailored to meet your requirements</li> <li>• used in oxy-fuel conversions of large furnaces</li> </ul>



# Burners, combustion systems, furnace modelling



This computer model view of our Flat Jet burner illustrates the broad coverage of the flame over the glass melt.

## Burners

BOC Gases' patented Flat Jet Burner is aerodynamically engineered to enhance flame coverage and heat transfer while reducing thermal NO<sub>x</sub> emissions. The unique flat flame provides superior melting performance to reduce fuel and oxygen costs.

The oxy-oil Flat Jet Burner uses the industry-proven Laidlaw Drew oil atomiser. Our relationships with Corning and Laidlaw Drew allow us to provide you with a broad choice of burner designs and configurations.

## Oxygen lances

BOC Gases' oxygen lances are used to extend the life of aging furnaces and increase the production of newer furnaces.

Our patented Flat Jet Lance injects a thin, fan-shaped jet of oxygen under the flame, where additional heat is transferred directly to the glass melt without adverse effect on the crown. This increases heat transfer rates while eliminating hot spots associated with conventional lancing techniques. Benefits include

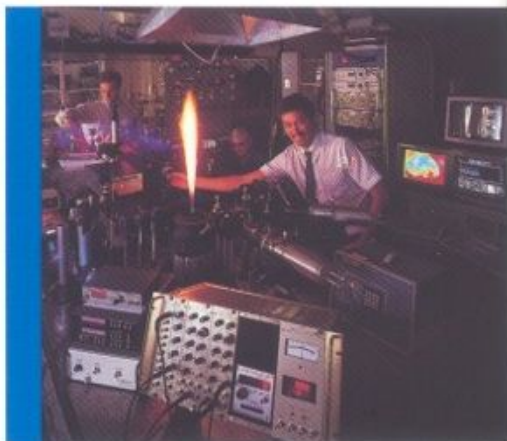
- improved combustion control
- increased output due to higher heat transfer rates
- improved glass surface temperature homogeneity
- reduced structure temperatures.

## Combustion control systems

Our combustion control systems provide accurate control of oxygen and fuel to the burner. The BOC Gases combustion system features a modular design that enables faster and easier installation while reducing operating costs.

## Furnace modelling

From basic research in aerothermochemistry and the use of computational fluid dynamics (CFD) for combustion and furnace modelling, we work to find innovative ideas for increasing your furnace's production. CFD is used to determine furnace output, temperature, burner placement, positioning of exhaust flues, waste gas temperatures and other parameters that optimise your furnace's performance.



Soot formation, a major contributor to luminosity, is measured in an oxy-fuel flame using laser technology at our Group Technical Centre in Murray Hill, NJ (US).



## Process control systems

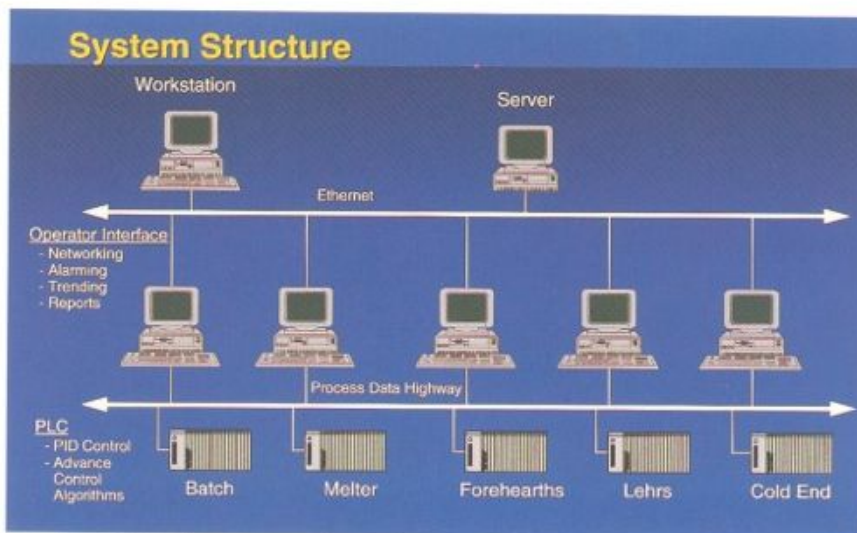
BOC Gases offers a full line of industry-proven control systems for the hot end including batch house, melter, forehearth, tin bath and annealing lehr.

Our control systems, formerly BH-F Systems products, help improve glass quality, reduce rejects, increase yield, boost production and reduce cost. They have been installed in more than 100 glass plants worldwide.

### State-of-the-art technology

Our process control systems offer glass-makers a number of advantages.

- **Flexible control.** Advanced programmable logic controllers are used for more sophisticated and flexible control of process operations.
- **Custom solutions.** Each system is programmed to meet the customer's specific requirements.
- **Advanced control algorithms.** New feedforward and feedback control algorithms enable you to achieve exit glass temperature stability.
- **Easy-to-use interface.** Our Windows-based process control systems are designed for ease of operator use and require little training.



An integrated systems approach: each segment of the glass-making process can be connected to an integrated communications network for viewing on a single screen.

- **Lower costs.** Standard hardware components are used on all systems, minimising spare parts costs.
- **Remote monitoring and control.** We can integrate control systems so your entire operation can be monitored and controlled from any local or remote personal computer or workstation.
- **Data collection, trending and analysis.** Control systems provide long-term data storage for troubleshooting and process control analysis, generating detailed statistical reports.

### A single-source for all your control system requirements

We can provide a turn-key control system for your entire operation or upgrade your system in a step-by-step process. Each of our systems can be installed individually and networked at a later date.

Our team includes experienced glass applications engineers, programmable logic controller specialists, project managers and installation supervisors.



BOC Gases' Glass Technologies Group is a full-service control house offering a total capability ranging from programming, design and manufacture to installation, service and support.



## Float glass atmospheres

BOC Gases supplies nitrogen and hydrogen for the tin bath to prevent oxidation of the tin.

On-site generators produce nitrogen in excess of 99.9995 percent purity. And BOC Gases' newly developed Oxy-Float generator produces high-purity nitrogen for the tin bath as well as low-purity oxygen for oxy-fuel melting. Liquid nitrogen is used as backup to the on-site generator, ensuring 100 percent nitrogen availability.

The capacity of BOC Gases' nitrogen generators ranges from 525 to more than 2,635 m<sup>3</sup>/h. Product quality is monitored through continuous on-line analysis of critical process streams and statistical process control. BOC Gases' nitrogen generators installed worldwide operate at greater than 99 percent on-stream time.

Hydrogen is generated on site or shipped via road. We provide instructions, safety literature, audits and videos to train your personnel in the safe handling of industrial gases.



BOC Gases' nitrogen generators provide reliable on-site supply to your exact specifications.

## Glass conditioning equipment

Through our UK partner, BH-F (Engineering) Ltd., we offer a full line of high-performance glass conditioning equipment.

### 400 Series forehearth

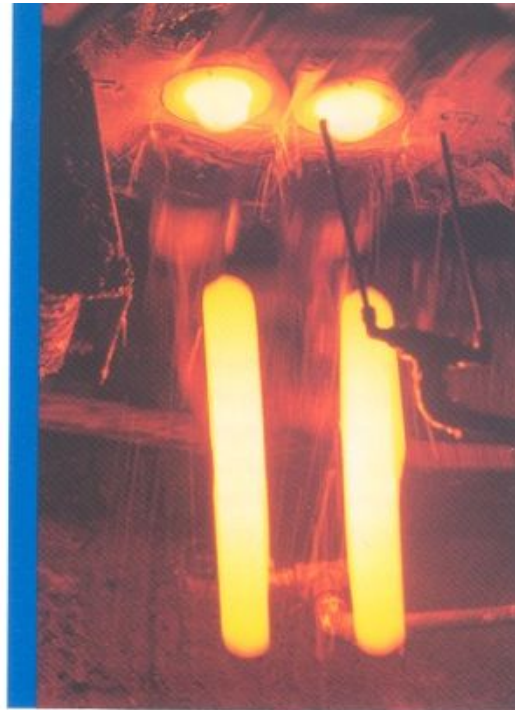
A monobloc roof design, graded insulation, longitudinal cooling, and simplicity of operation and control enable the BH-F 400 Series forehearth to achieve close control of temperature and homogeneity while reducing forehearth fuel consumption by up to 60 percent.

### Type 900 feeder

This modern, high-speed, high-capacity feeder ensures maximum efficiency from the furnace through to gob delivery.

### 400 Series working end

The 400 Series working end serves as a distributor to condition and control glass temperature at the earliest possible moment.



The Type 900 feeder mechanism from BH-F (Engineering) Ltd. operates at container, tableware, stemware and headlamp plants around the world.

**BH-F**

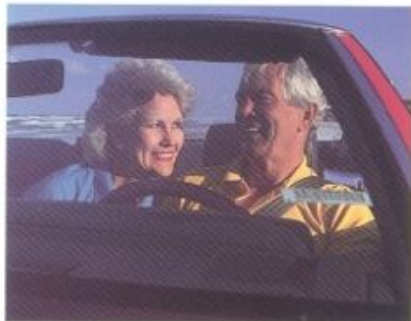
BOC Gases is a representative of BH-F (Engineering) Ltd.



The Fibertemp II pyrometer is part of BOC Gases' full line of temperature- and level-sensing devices for the glass industry.



## **Coatings put a finishing touch on your glass products**



Airco Coating Technology manufactures systems that coat glass surfaces with thin films.

Through another division of The BOC Group, Airco Coating Technology, we offer technology and equipment used to deposit thin metallic and nonmetallic films on flat and curved glass surfaces.

We can provide a wide range of systems for architectural, automotive, electronic displays and optical applications. The coatings produced can have solar reflection, low-emissivity, electrical conductivity, antistatic, antireflection or high-quality mirror properties.

The coating systems are highly reliable, easy to operate and designed for low operating cost. Buildings all over the world use glass coated on Airco Coating Technology equipment.

## **See your way clear to partnering with BOC Gases**

When you need a reliable, cost-effective supplier of quality gases, products and services for all your glass-making operations, the choice is clear: BOC Gases.

The engineers and technologists of BOC Gases' Glass Technologies Group are glass specialists, first and foremost. We are totally dedicated to finding cost-effective solutions to all your glass melting needs.

Let our team of glass specialists help you enhance quality and reduce costs in your glass-making operations. For more information, or to arrange a visit, contact your local BOC Gases office today.





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