

ELECTRIC ARC FURNACE

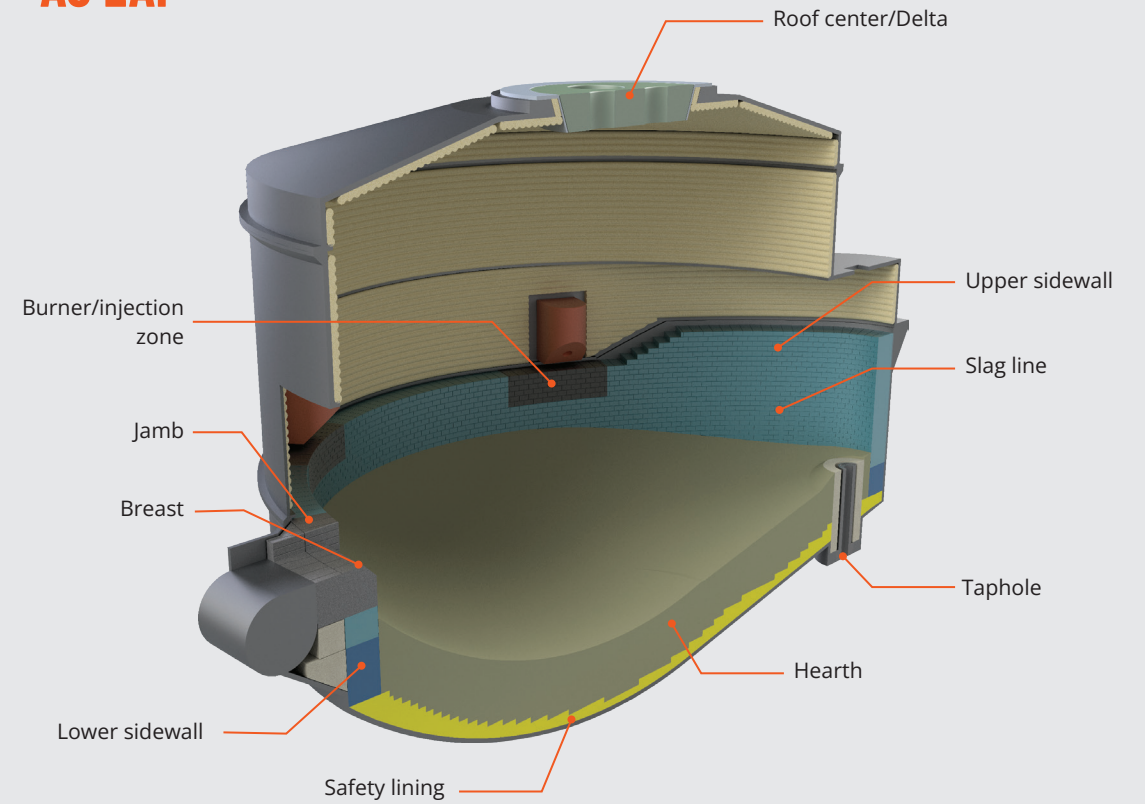
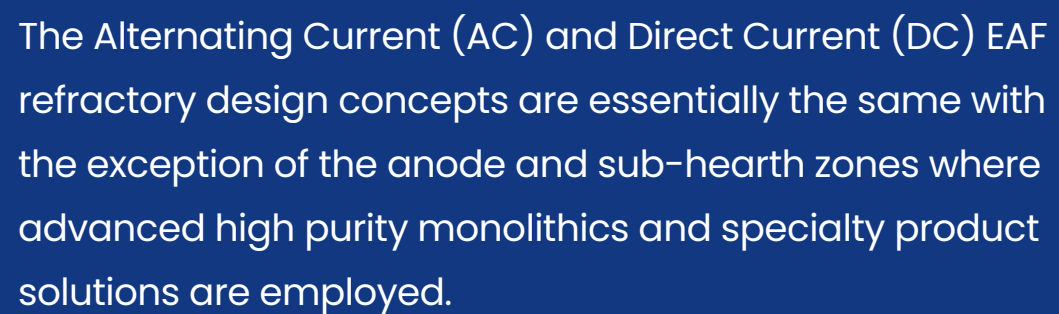
 **HWI**
A MEMBER
OF CALDERYS

**OUR BREAKTHROUGHS
IN ELECTRIC ARC
FURNACES ARE DESIGNED
TO IMPROVE THE INDUSTRY.**

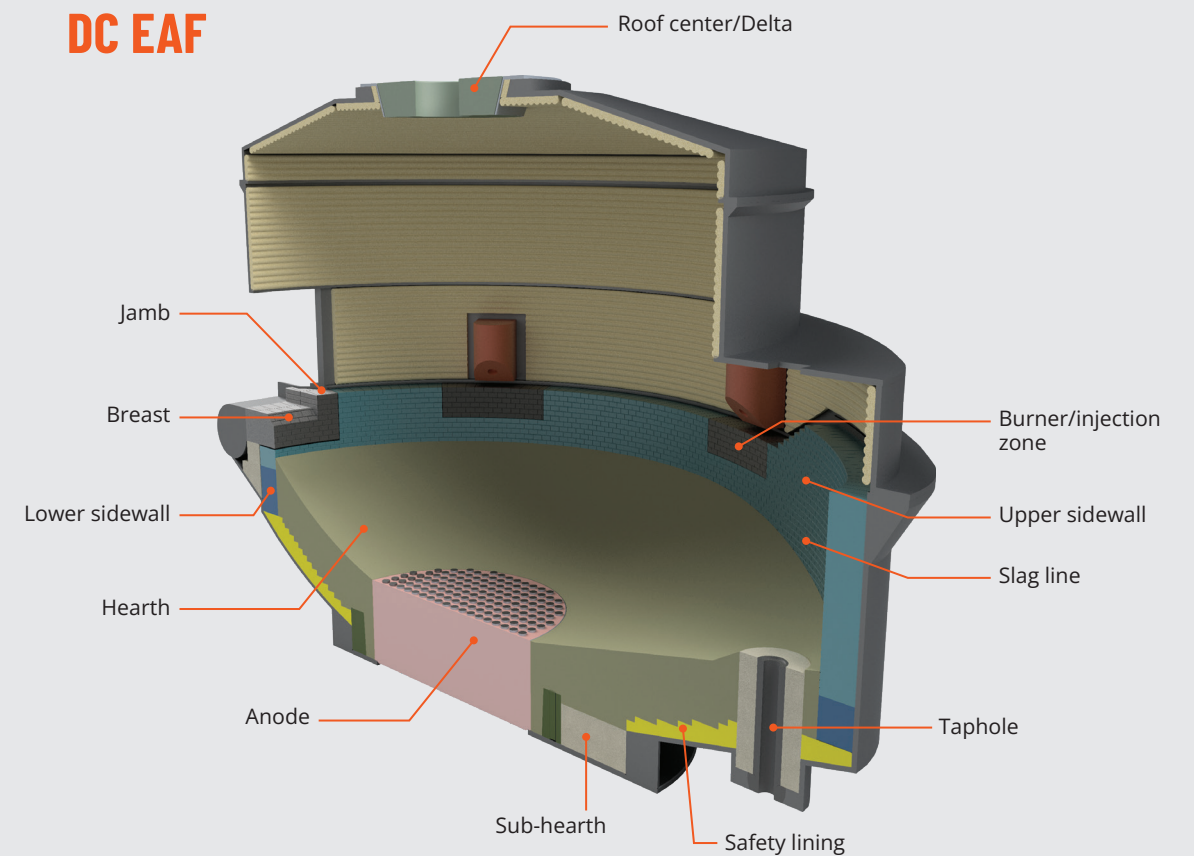
ELECTRIC ARC FURNACE

**The Electric Arc
Furnace (EAF)
is the major
producer of hot
metal in the steel
industry today.**

There are two types of EAFs: Alternating Current (AC) and Direct Current (DC). AC EAFs have three electrodes; DC EAFs have two: a cathode, a single electrode in the roof of the furnace, and an anode in the bottom of the furnace. The electrodes conduct an electrical charge, creating an arc that melts the scrap. Chemical energy is also used in the melting process to enhance melting efficiency. A number of furnace design and operational improvements have been made over time. Furnace design improvements include water-cooled panels, oxygen burners, eccentric bottom tap (EBT) tapholes, and continuous scrap feeding. Operational improvements include foamy slag, slag chemistry, and scrap compositions. These improvements have necessitated a higher degree of customization than was previously required. HarbisonWalker International (HWI) has the ability to zone the furnace with a wide range of quality refractory products to suit individual operations. HWI provides recommendations based on the standard and customized lining configurations that best complement today's steel-making practices.



DC EAF



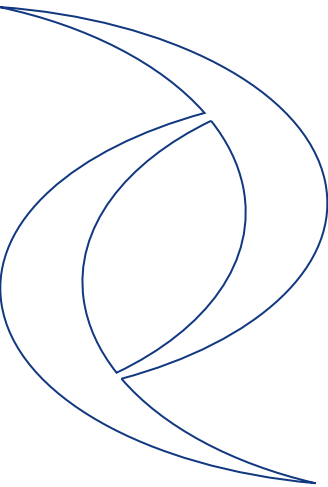
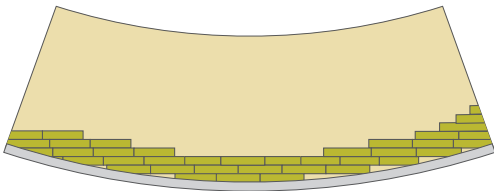
EAF BOTTOM DESIGN

HWI offers a variety of brick, monolithic, and combination bottom designs.

Both brick and monolithic EAF bottoms are used in the refractory industry today. Historically, the most common EAF bottom linings were high quality burned brick. Monolithic bottoms have become more popular in recent years due to cost effectiveness, ease of installation, reduced downtime, and elimination of brick joints.

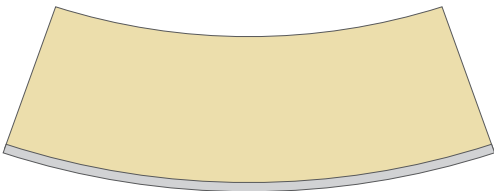
STADIUM

The stadium design is the original bottom design used for EAFs, and consists of brick laid in the design of a stadium. This bottom design takes significant time and brick laying skill to install properly, but provides a certain safety factor to the operation when correctly accomplished. To repair damage to this type of bottom, brick in the damaged area must be removed and then new brick must be installed.



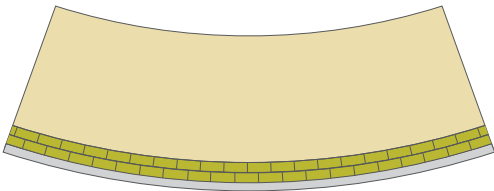
MONOLITHIC

The monolithic bottom design consists entirely of dry vibratable material. It is the easiest to install, can be installed relatively quickly, and requires little bricklaying skill. The dry vibratable material is installed via supersacks and then compacted using vibrating spikes and sleds. Repair of this type of bottom requires only removal of the steel skull and re-installation of the hearth material.



SAFETY LINER AND MONOLITHIC (SHINER)

This design combines the best features of both the stadium and monolithic designs. The brick on the bottom is usually two or three courses of burned brick laid in a horizontal direction directly on the bottom steel shell. The dry vibratable material is then installed directly over this course of brick and vibrated in. This design combines the safety of the stadium brick bottom with the ease of installation and maintenance of the monolithic hearth bottom design.



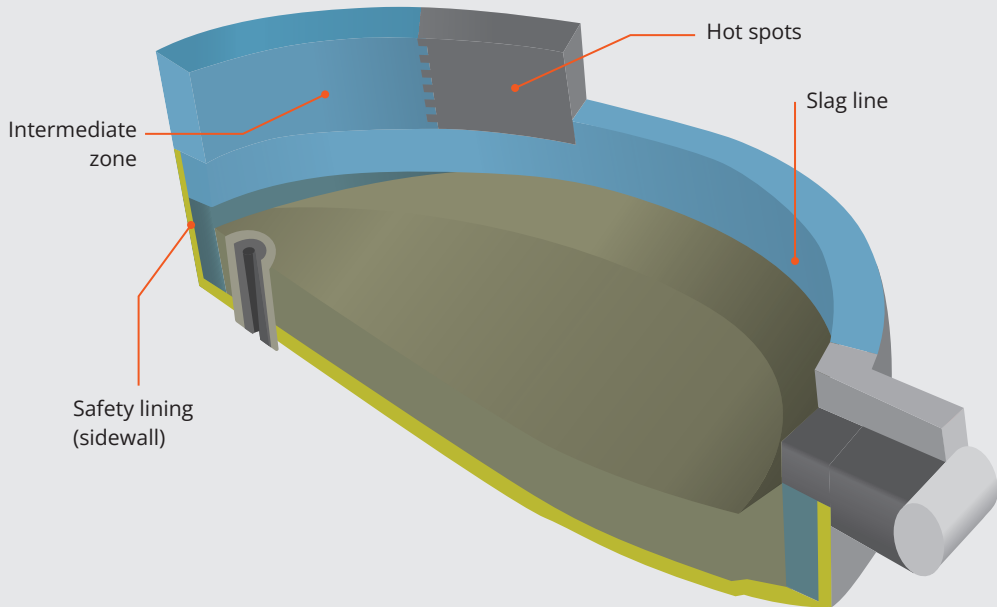
RECOMMENDED HWI EAF BOTTOM PRODUCTS

LOCATION	TYPE	HWI PRODUCT	SPECIFICATION	BENEFIT
Bottom	Brick	NARMAG® HRB	Burned magnesia	- Excellent hydration resistance
		NARTAR® 7	Tar-impregnated burned magnesia	- Excellent hydration resistance - Good slag resistance
	Mono-lithic	AMERICLASE H	High purity magnesia	- High density - Low porosity - Cold installation
		AMERICLASE HSB	High purity magnesia	- Improved angle of repose for steep banks
		AMERICLASE HP	High purity magnesia	- DC anode application - Reduced impurities for controlled sintering

EAF SIDEWALL LINING

Sidewall linings are the refractories directly in contact with molten steel, slag, and atmosphere in the EAF.

They must be able to withstand thermal shock, oxidation, arc damage, localized high operating temperature, slag corrosion, and hydration in the various zones of the furnace. To mitigate the consequences of these conditions, and to optimize refractory performance, HWI zones the furnace with refractories that have been carefully customized based upon magnesia purity, carbon levels, and metal content.



Intermediate Zone	Hot Spots	Slag Line	Safety Lining
Intermediate zones are the areas of the EAF with the lowest temperatures and least amount of chemical activity.	Hot Spots are the areas of the EAF most impacted by the radiant heat of the electrode and/or adjacent to the burners. These areas are subjected to the highest temperatures and the highest levels of oxidation.	The slag line zone requires refractories with high corrosion resistance. The corrosion takes place due to chemical reactions that occur when the metallic oxides contained in the slag come into contact with refractories.	Safety linings are not subjected to the same intense operating conditions as the working lining. They are usually installed as a thermal barrier and as an additional containment measure.

RECOMMENDED HWI EAF SIDEWALL PRODUCTS

LOCATION	TYPE	HWI PRODUCT	SPECIFICATION	BENEFIT
Intermediate zone	Brick	EAF® 200 SERIES	Magnesia-carbon	- Good oxidation resistance - Cost effective
		EAF® 500 SERIES	Magnesia-carbon	- Excellent oxidation resistance
Hot spots	Brick	EAF® 600 SERIES	Magnesia-carbon	- Good temperature and oxidation resistance
		EAF® 800 SERIES	Magnesia-carbon	- Excellent temperature and oxidation resistance
		EAF® BB SERIES	Magnesia-carbon	- Outstanding temperature, oxidation and thermal shock resistance
Slag line	Brick	EAF® 500 SERIES	Magnesia-carbon	- Good corrosion resistance
		EAF® 600 SERIES	Magnesia-carbon	- Good corrosion and temperature resistance
		EAF® 800 SERIES	Magnesia-carbon	- Excellent corrosion and temperature resistance
		EAF® BB SERIES	Magnesia-carbon	- Outstanding corrosion, temperature and thermal shock resistance
Safety lining	Brick	NARMAG® HRB	Burned magnesia	- Excellent hydration resistance
		NARTAR® 7	Tar-impregnated burned magnesia	- Excellent hydration resistance - Good slag resistance

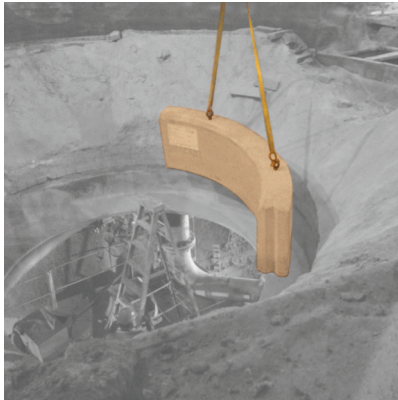
PRECAST COMPONENTS

Precast components reduce the physical stresses associated with manual brick installation. These shapes can reduce turnaround time, allow for more dimensional design configurations and zoning for localized refractory wear.



ANODE RINGS

Historically this area of the EAF was bricked for lining stability. The precast ring achieves the same purpose and can be installed in minutes.



Anode coming up through bottom

RUNNERS

A runner is a spout attached to the rear of the furnace into which a conventional taphole empties molten steel for tapping. Runners are exposed to steel erosion, slag corrosion, extreme thermal shock, and mechanical abuse. HWI's innovative runner designs and high-technology castables provide durable, cost-effective refractory solutions.



ROOF CENTER/DELTA

The delta is a refractory insert in the EAF roof through which the energized electrodes enter the furnace. Its primary function is to protect the roof from the electrode arc generated during the melting operation. The delta is exposed to arc flare, thermal shock, oxidation, chemical corrosion, post combustion, and high temperatures. HWI offers a range of refractory products and custom-fitted designs to cost effectively extend the life of the delta.



RECOMMENDED HWI DELTA & RUNNER PRODUCTS

LOCATION	TYPE	HWI PRODUCT	SPECIFICATION	BENEFIT
Roof center/delta	Castable	UNACAST® 1005X	80% alumina	- Good thermal shock resistance - Cost effective
		D-CAST® 85 GOLD CASTABLE	Ultra-low cement, high alumina	- Excellent wear resistance
		HP-CAST® 94MA-C	Ultra-low cement, spinel containing, coarse grain	- Outstanding wear resistance
		HP-CAST® 93Z3	Ultra-low cement, alumina spinel forming with zirconia	- Excellent thermal shock resistance - Outstanding wear resistance
Furnace runner	Castable	D-CAST® 85 GOLD CASTABLE	Ultra-low cement, high alumina	- Excellent wear resistance
		UNACAST® NCM	Cement free spinel forming	- Outstanding wear resistance
Anode ring	Castable	VERSAFLOW® 70C	Low cement, alumina-mullite based	- Excellent thermal shock resistance - Good mechanical strength

EAF BRICK ASSEMBLIES

Brick assemblies reduce the physical stresses associated with manual brick installation. Assemblies reduce reline turnaround time for improved equipment uptime.

PRE ASSEMBLED TAPHOLE PRODUCTS

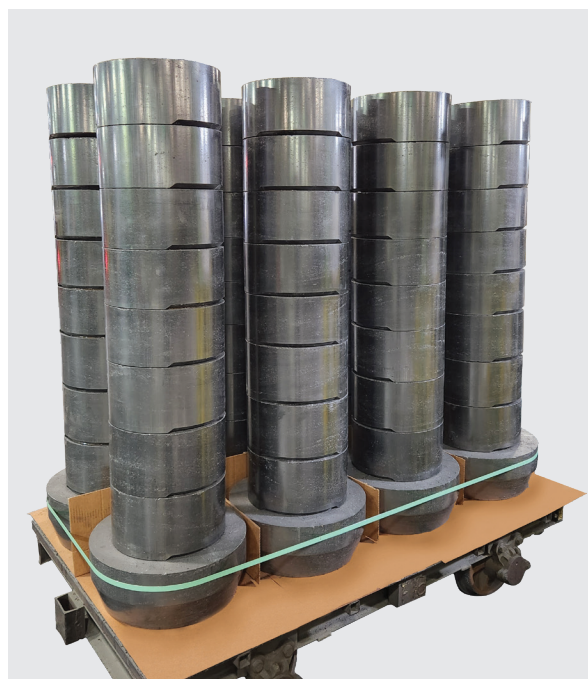
BLOCK

Customized design for side tapping runner furnaces.

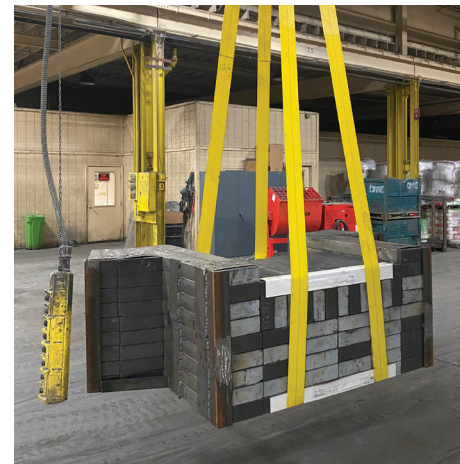


SLEEVES

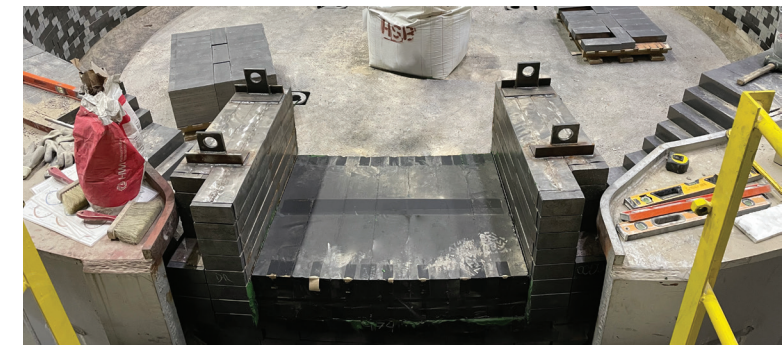
Ergonomic solution for EBT tapping systems.



EAF BREAST AND JAMB ASSEMBLIES

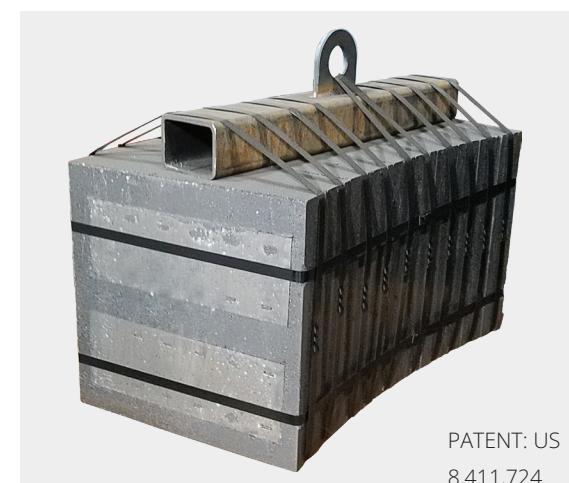
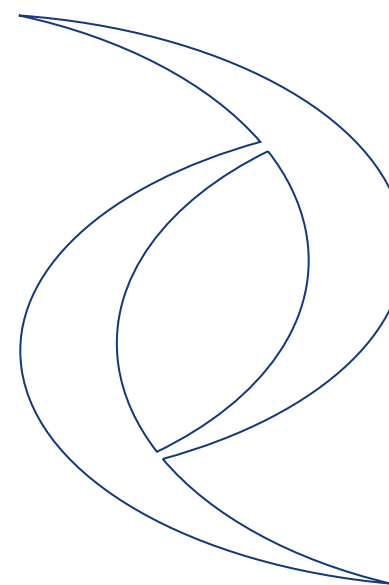


Cased and welded assemblies improve mechanical strength by replacing loose brick construction with a one piece installation. This increases the lining stability and reduces installation time.



BANDED ARCH/WEDGE DESIGN

For modular construction and reduced horizontal joints



PATENT: US
8,411,724

DOOR JAMB

The door jamb area of the EAF is typically lined with individual brick that is often damaged or lost during a campaign. Welded assemblies can replace individual brick in the door jamb area to address the problems of mechanical abuse. These single-unit refractory assemblies are more durable than individual bricks, and therefore are able to withstand the impact of mobile equipment.



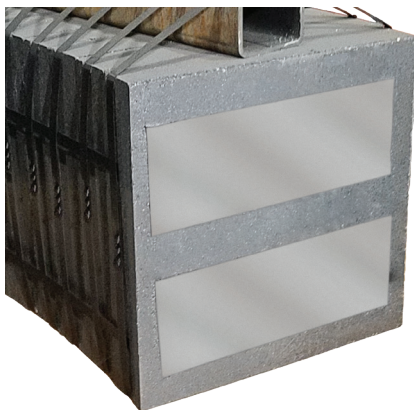
BREAST BLOCKS

The breast block lines the area between the door jambs of the furnace extending to the exterior of the slag door. The block assemblies support the working lining and are designed to resist mechanical abuse, slag corrosion and oxidation. HWI breast block refractories can be preassembled epoxied brick, a precast shape or a combination of both.



CO-MOLDED

HWI's patented co-molded brick technology allows individual brick to fuse together making sill assemblies equivalent to one unit, providing exceptional strength and support.



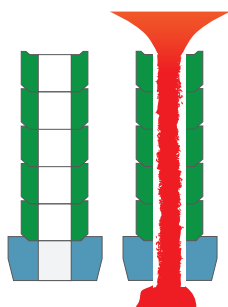
RECOMMENDED HWI JAMB AND BREAST ASSEMBLY PRODUCTS

LOCATION	TYPE	HWI PRODUCT	SPECIFICATION	BENEFIT
Welded assemblies and door jambs	Brick	EAF® 200 SERIES CO-MOLDED and CASED	Magnesia-carbon, two-sided metal casing	- Good mechanical wear resistance
		EAF® 600 SERIES CO-MOLDED and CASED	Magnesia-carbon, two-sided metal casing	- Excellent slag resistance - Excellent mechanical wear resistance
		EAF® 800 SERIES CO-MOLDED and CASED	Magnesia-carbon, two-sided metal casing	- Outstanding slag resistance - Outstanding mechanical wear resistance
Breast block and banded assemblies	Brick	EAF® 600 SERIES CO-MOLDED	Magnesia-carbon	- Excellent slag resistance - Excellent mechanical wear resistance
		EAF® BB SERIES CO-MOLDED	Magnesia-carbon	- Outstanding slag resistance - Excellent mechanical wear resistance

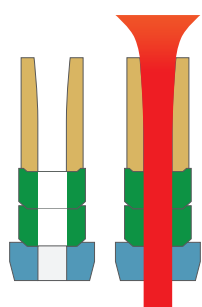
TAPHOLE

The taphole system is the mechanism for tapping the molten steel from the EAF.

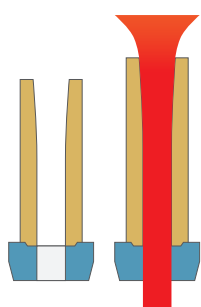
There are taphole systems designed for an EBT (eccentric bottom tap) and for the conventional runner tap system. The taphole system for the EBT usually consists of an isostatically-pressed sleeve, segmented sleeves, or a combination of both; an end block; and a surround block. The taphole for a conventional sidewall tapping system can be a pressed segment, a pre-drilled brick assembly, or a pre-drilled brick assembly with an isopressed sleeve. All taphole systems are subject to steel erosion, slag corrosion, high temperatures, and thermal shock. HWI delivers high-purity magnesia-graphite taphole products with very high hot strength and slag corrosion resistance.



Segmented
The conventional EBT taphole



Combotap
Combines the flexibility of segmented sleeve with the operating advantages of the ISOTAP technology



Isopressed
The dominant type used in BOF, now popular in EAF Market



EBT SURROUND BLOCK

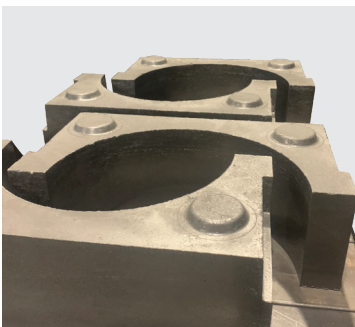
PRECAST

Precast surround blocks offer flexibility in dimensional design and ease of installation. They are typically made with high purity magnesia castables for corrosion resistance but in some cases high alumina castables are employed for better strengths.

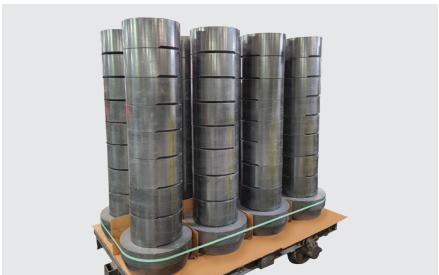


PRESSED

Pressed shapes are utilized for the modular construction of the surround block. They have higher density, lower porosity versus castables and employ magnesia carbon technology for increased refractoriness.



EBT TAPHOLE SLEEVES

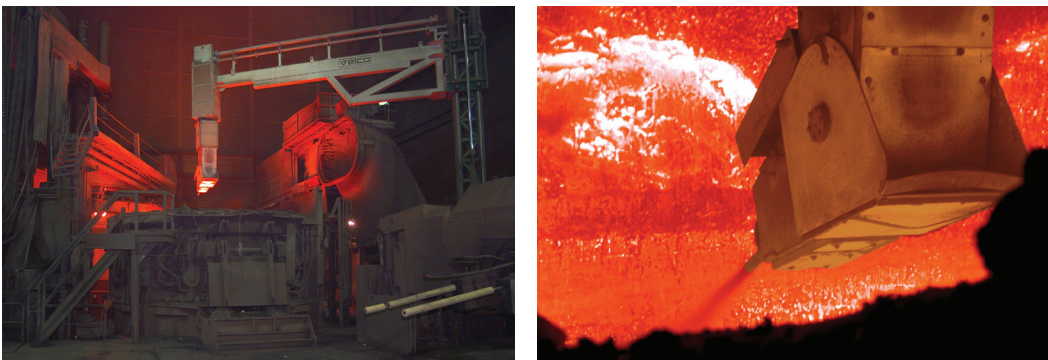


RECOMMENDED HWI EAF TAPHOLE PRODUCTS

LOCATION	TYPE	HWI PRODUCT	SPECIFICATION	BENEFIT
EBT	Isopressed sleeve	ISOTAP® SERIES	Magnesia-carbon	- Excellent slag and oxidation resistance - Optional elliptical taper - Less slag carryover - Reduced nitrogen pickup - Faster tapping speed
	Segmented sleeve	TAP 300 SERIES	Magnesia-carbon	- Excellent slag and oxidation resistance - Ease of installation
	End block	TAP 400 SERIES	Magnesia-carbon	- Excellent slag and oxidation resistance - Ease of installation
	Surround block	NARMAG® 95 CASTABLE	Basic castable	- Excellent wear resistance
Sidewall tap	Brick	TAP 300 SERIES	Magnesia-carbon	- Excellent slag and oxidation resistance

GUNNING MATERIAL

Gunning material is a spray-on refractory used to repair an EAF lining. Refractory damage can occur from slag corrosion, oxidation, thermal shock, arc flare, and mechanical abuse.



HWI gunning material offers a high degree of gunnability, consistent flow through the gunning machine, excellent adhesion, low rebound and the capability to withstand the highly corrosive atmosphere of the furnace. HWI gunning material products are available for both hot and cold installation.

RECOMMENDED HWI GUNNING MATERIAL

LOCATION	TYPE	HWI PRODUCT	SPECIFICATION	BENEFIT
Sidewall	Gun mix	BASIC 187 GM-60	Magnesia-dolomite	- General purpose
		BASIC 187 GM-88	Magnesia	- General purpose
		AMERICLASE 94	High purity magnesia-dolomite	- High performance - General purpose
		BASIC 187 GM-93	High purity magnesia	- High performance
Tap hole	Gun mix	BASIC 187 GM-95	High purity magnesia	- High performance
		AMERICLASE 98 S	Highest purity magnesia	- Outstanding for taphole repair

FETTLING MATERIAL

Fettling material is a dry monolithic used for “hot repair” of the EAF hearth and banks.



The chemical composition of the material allows for quick sintering fast repair of the monolithic lining. HWI fettling products are designed to withstand the highly corrosive atmosphere of the furnace.

RECOMMENDED HWI FETTLING MATERIAL PRODUCTS

LOCATION	TYPE	HWI PRODUCT	SPECIFICATION	BENEFIT
Bank/ Bottom	Monolithic	HOT BANK 53	Magnesia-dolomite	- General purpose
		HOT BANK 19	Magnesia-dolomite	- General purpose
		AMERICLASE HC	High purity magnesia-dolomite	- HOT & COLD installation - General purpose
		AMERICLASE HSB	High purity magnesia-dolomite	- HOT & COLD installation - General purpose - Improved angle of repose

INSTALLATION EQUIPMENT

For the installation of monolithic materials, this equipment is designed for ease of movement and use during relines and repairs.

VELCO GUNNING EQUIPMENT

Automates the demanding job of manually gunning the EAF and improves the placement accuracy and speed.

TANK GUN



HYTOP



PNEUTOP



MOBIGUN



SPREADER

HWI provides a full line of crane-held spreaders. The lifting mechanism allows for safe and easy movement and installation without excessive or unsafe rigging.

- Available in 6, 10 and 20 NT capacity.

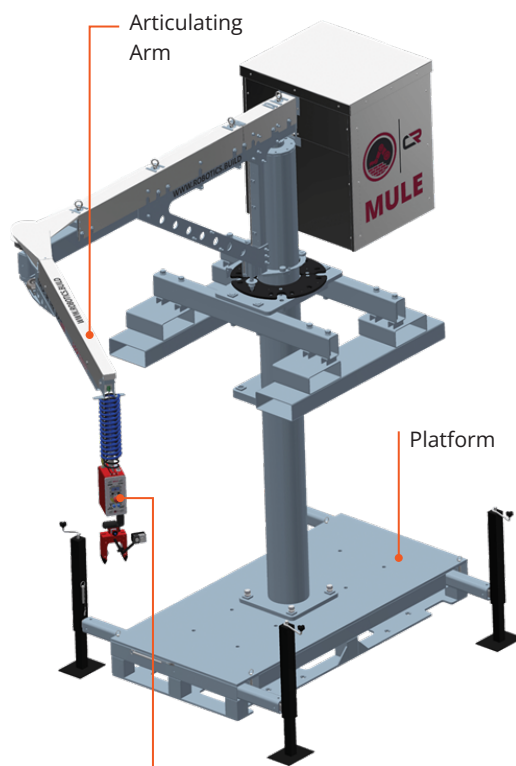
EAF BANK VIBRATOR

Accomplishes the critical de-aeration process in minutes, eliminating the need for manual de-aeration which can be physically demanding and take hours to complete.



MULE-R

Reduce or eliminate injuries resulting from placing thousands of brick over time.



MULE-R

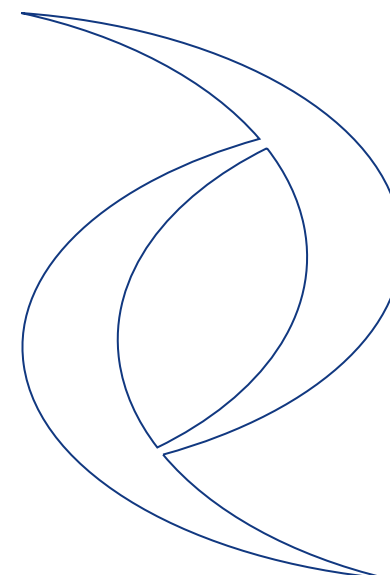
The MULE-R from HWI is a lift-assist device that is designed to reduce fatigue and injuries related to the repetitive motion of on-site construction.

The technology of the MULE-R allows the worker to directly interact with the product they are lifting, making heavy objects (up to 135lbs) feel weightless.

- Customizable to unique plant needs
- Vacuum gripper heads
- Potential for custom gripper head solutions
- Multiple bases allow for the equipment to be deployed in a variety of environments.



MULE-R has the capability to lift up to three bricks at a time, to make the job almost effortless.



BENEFITS

- Ergonomic—Reduces Strain
- Increases Productivity
- Flexible Deployment
- Reduce Installation Cost
- Work Flow Improvement
- Expands The Labor Force



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