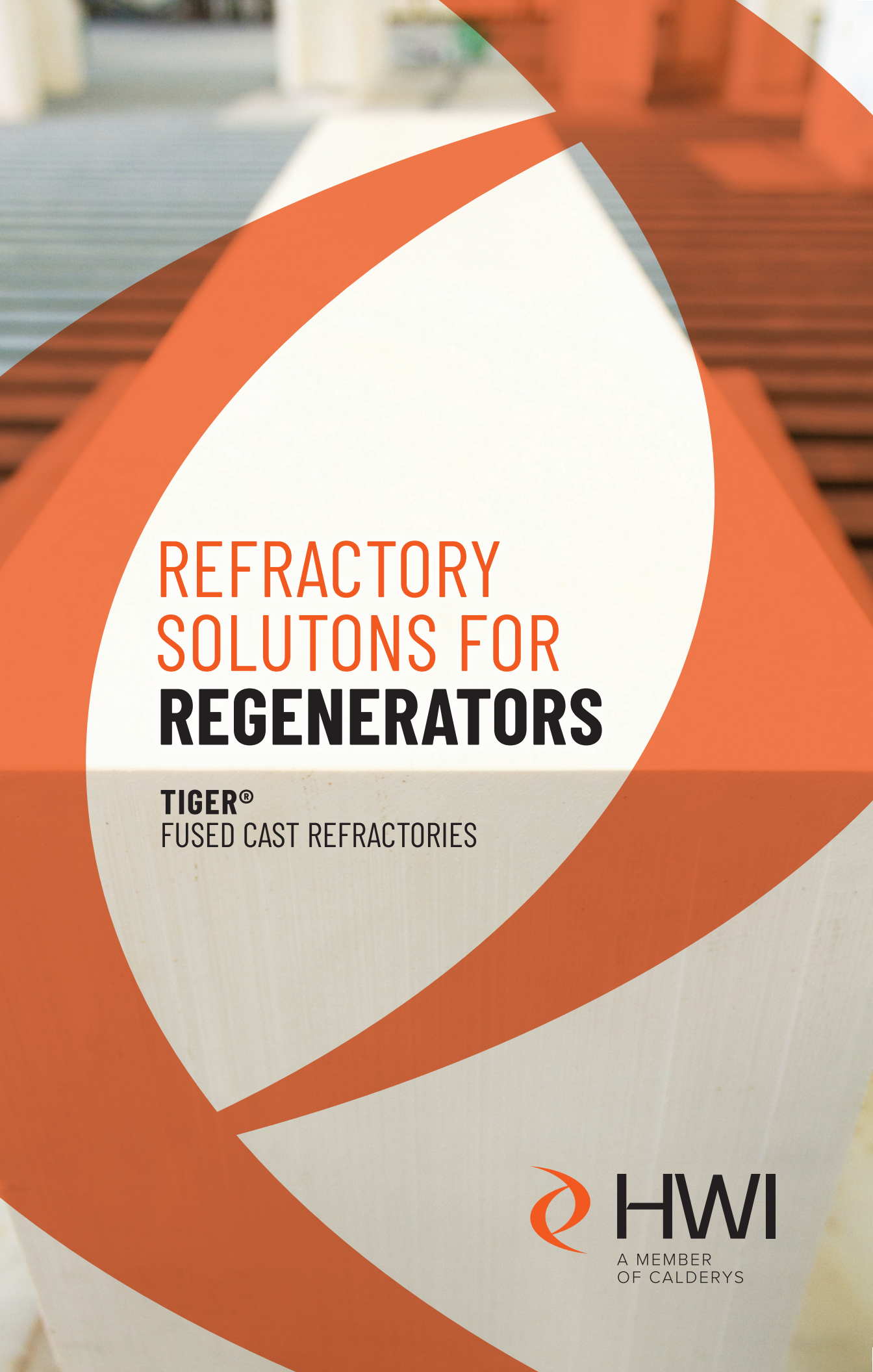


REFRACTORY SOLUTONS FOR **REGENERATORS**

TIGER®
FUSED CAST REFRACTORIES

HWI
A MEMBER OF CALDERYS

A CLEAR **COMPETITIVE EDGE.** FOR ALMOST 100 YEARS, WE'VE PIONEERED REFRACTORY GLASS SOLUTIONS THAT CONTINUE TO SHATTER INDUSTRY EXPECTATIONS.

HarbisonWalker International (HWI) provides the largest refractory manufacturing capacity to the glass industry in North America.

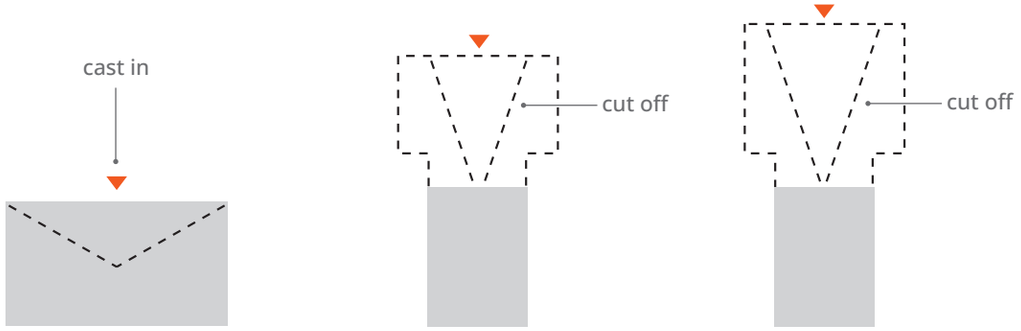
Over 85 years of research and development in the glass market have enabled us to pioneer innovative glass solutions.

Today, our products are in furnaces all over the world, including our Tiger® line of fused cast products, engineered for some of the most intense environments.

Since 2005, HarbisonWalker International has been in a joint collaboration with Luoyang Dayang High-Performance Material Co., Ltd. (DY), a leading Chinese technology company, to produce the Tiger® line of fused cast alumina-zirconia-silica (AZS), α-β alumina (M), and high zirconia (Z95). These blocks have excellent corrosion resistance and are manufactured for easy assembly in the field.

CASTING TECHNIQUES

Fused cast refractories are manufactured by melting oxide minerals in an electric arc furnace and casting into molds while in the liquid state. During the cooling and solidifying stage, a shrinkage cavity forms.



RC

REGULAR CAST

Cavity is located under the casting scar.

EVF

ESSENTIALLY VOID-FREE

Similar to VF, the cavity is almost sawed off.

VF

VOID-FREE

The zone where the cavity is located is sawed off.

85 YRS.

OF R&D OF REFRACTORY SOLUTIONS FOR THE GLASS INDUSTRY

TIGER® AZS 33

Excellent corrosion resistance combined with multiple production options make TIGER® AZS 33 the most versatile of HWI's fused cast AZS products. Available in Regular Cast, Essentially Void-Free, and Void-Free qualities, TIGER® AZS 33 is designed for use in a wide range of applications including melter paving, sidewalls, and superstructure.

TYPICAL CHEMICAL COMPOSITION, %	
ZrO_2	33.0
SiO_2	15.0
Al_2O_3	50.5
$TiO_2 + Fe_2O_3$	0.3
CaO + MgO	<0.04

Physical Characteristics	TYPICAL
Bulk Density	3.80 g/cm³ (237 lb/ft³)
Apparent Porosity	1.0%
Al_2O_3	260 MPa (37,734 lb/in²)
$TiO_2 + Fe2O_3$	>1700°C (0.2 MPa)
CaO + MgO	<0.04

TIGER® AZS 36

TIGER® AZS 36 has improved corrosion resistance compared to the 33% composition. Available in three different qualities—void-free, essentially void-free, and regular cast—TIGER® AZS 36 is recommended in high-wear applications and areas where batch contact is possible, such as ports, doghouses, and sidewall electrode blocks.

TYPICAL CHEMICAL COMPOSITION, %	
ZrO_2	36.0
SiO_2	14.0
Al_2O_3	47.4
Na_2O	1.4
$TiO_2 + Fe_2O_3$	0.3

Physical Characteristics	TYPICAL
Bulk Density	3.88 g/cm³ (242 lb/ft³)
Apparent Porosity	1.0%
Cold Crushing Strength	260 MPa (37,734 lb/in²)
Refractoriness Under Load	>1700°C (0.2 MPa)

TIGER® AZS 41

TIGER® AZS 41 has excellent resistance to corrosion in molten glass. Available in void-free and essentially void-free qualities, TIGER® AZS 41 is recommended for use in the highest-demand applications, including throats, electrode blocks, and bubbler blocks.

TYPICAL CHEMICAL COMPOSITION, %	
ZrO_2	41.0
SiO_2	12.0
Al_2O_3	45.8
Na_2O	1.0
$TiO_2 + Fe_2O_3$	0.3
CaO + MgO	>0.04

Physical Characteristics	TYPICAL
Bulk Density	3.97 g/cm³ (248 lb/ft³)
Apparent Porosity	1.0%
Cold Crushing Strength	280 MPa (40,636 lb/in²)
Refractoriness Under Load	>1700°C (0.2 MPa)

TIGER® M

TIGER® M is composed of 44% alpha alumina, 55% beta alumina, and only 1% vitreous glass phase. This material has excellent resistance to corrosion in molten glass. It's low defect potential makes it an ideal material for use in the working end of soda-lime glass furnaces, including refiner paving and sidewalls as well as feeder channels.

TYPICAL CHEMICAL COMPOSITION, %	
Al_2O_3	94.0%
SiO_2	0.9%
Na_2O	4.2%

MINERAL COMPOSITION	
α-Alumina	34-45%
β-Alumina	45-58%
Glassy Phase	<2.0%

Physical Characteristics	TYPICAL
Bulk Density	3.52 g/cm³ (220 lb/ft³)
Apparent Porosity	0.7%
Cold Crushing Strength	300 MPa (43,540 lb/in²)

TIGER® Z95

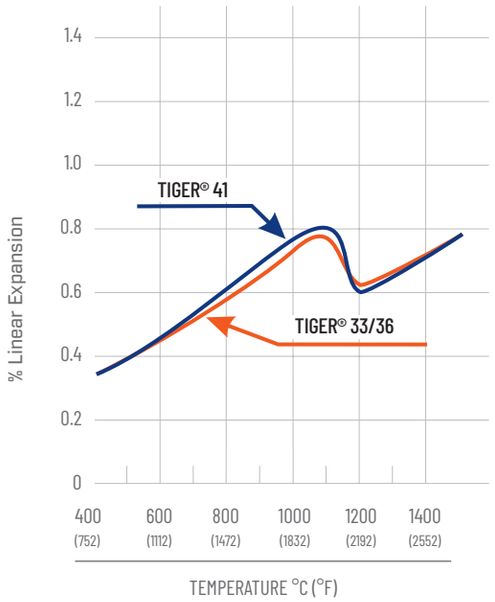
TIGER® Z95 is a 95% zirconia, fused cast brick. The characteristics of the product are excellent corrosion resistance and very low blister and stoning potential.

CHEMICAL COMPOSITION, %	
ZrO_2	≥93.6
SiO_2	≤5.3
Al_2O_3	≤1.0
Na_2O	≤0.05

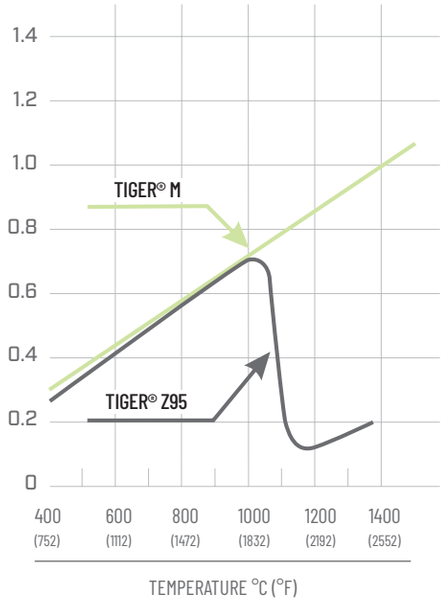
Physical Characteristics	TYPICAL	
Bulk Density	5.30 g/cm³ (331 lb/ft³)	
Cold Crushing Strength	260 MPa (58,015 lb/in²)	
Linear Thermal Expansion	1000°C	0.7
	1500°C	0.3
Electrical Resistivity	36 (Ω·cm)	

LINEAR EXPANSION

THERMAL EXPANSION



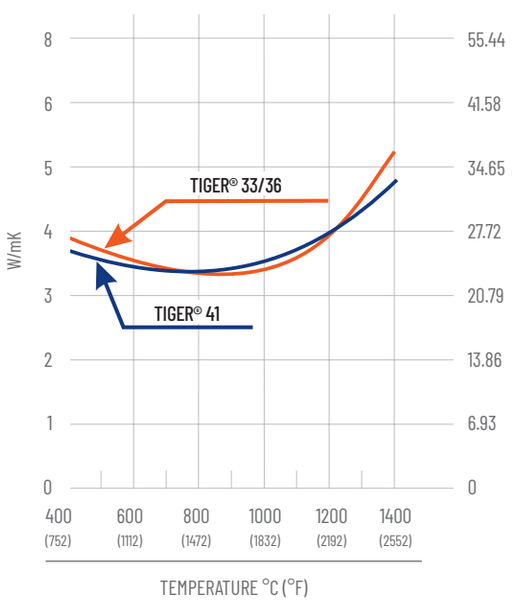
THERMAL EXPANSION



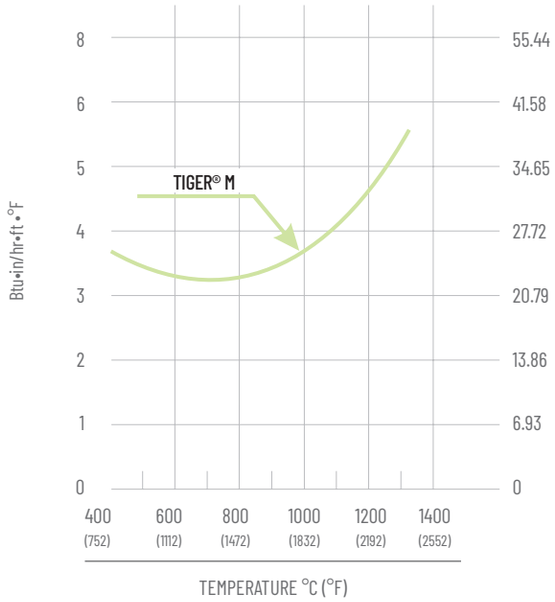
TEMP. °C	TIGER® AZS 33	TIGER® AZS 36	TIGER® AZS 41	TIGER® M	TIGER® Z95
600	0.43	0.43	0.43	0.43	0.40
800	0.55	0.55	0.57	0.58	0.55
1000	0.73	0.73	0.75	0.73	0.70
1200	0.63	0.63	0.60	0.88	0.10
1400	0.70	0.70	0.69	1.03	0.16

THERMAL CONDUCTIVITY

THERMAL CONDUCTIVITY



THERMAL CONDUCTIVITY



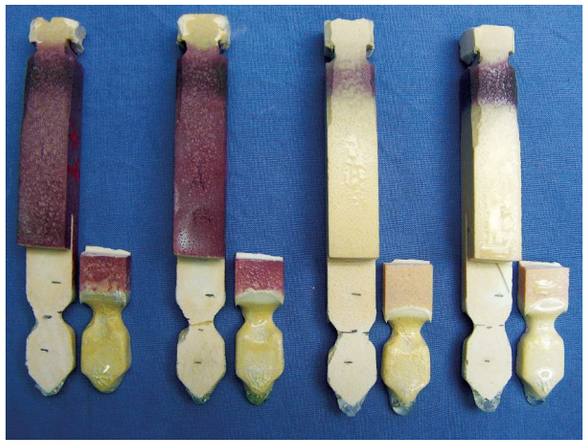
TEMP. °C	TIGER® AZS 33	TIGER® AZS 36	TIGER® AZS 41	TIGER® M
600	3.50	3.50	3.45	3.33
800	3.35	3.35	3.40	3.30
1000	3.40	3.40	3.48	3.65
1200	3.85	3.85	3.85	4.40

PERFORMANCE

GLASS CORROSION RESISTANCE

In laboratory corrosion tests all compositions of TIGER® AZS performed well when evaluated against competitive materials.

Soda-Lime Glass Corrosion Test 1350°C (2642°F), 5 Days



Competitive Sample | TIGER® AZS 33 RC | Competitive Sample | Competitive Sample

Glass Exudation – 1500°C, 4 Hours

TIGER® AZS 33	TIGER® AZS 36	TIGER® AZS 41
<3.0%	2.0%	<2.0%

Blister Potential, 1300°C, 10 Hours, Number of Seeds Formed

TIGER® AZS 33	TIGER® AZS 36	TIGER® AZS 41
2.0%	1.5%	1.0%

PRODUCT APPLICATIONS

Products	RC	EVF	VF
TIGER® AZS 33	Working Ends Feeder Channels Melter Superstructure Melter Crowns	Melter Sidewalls	Melter Sidewalls Paving Doghouse Arches Crowns
TIGER® AZS 36	–	Melter Sidewalls	Sidewalls Port Walls and Crowns Doghouse Walls and Corners Doghouse Superstructure
TIGER® AZS 41	–	Melter Sidewalls	Sidewalls Throats Bubbler Blocks Electrode Blocks
TIGER® M	Feeder Channels Channel Lips Refiner and Feeder Paving Working End Melter Superstructure Crowns	–	Feeder Channels Channel Lips Refiner and Feeder Paving Working End Melter Superstructure Crowns
TIGER® Z95	–	–	Melter Sidewalls Electrode Blocks Extremely High Wear Applications

EVERY DETAIL MATTERS

Every block is crafted with precision, starting with the raw materials. DY purchases their zircon exclusively from Tronox and ILUKA, Australia. To meet the demanding requirements of the glass industry, TIGER® AZS and alumina-based products are all quality inspected, assembled, and matchmarked for easy assembly in the field. The accuracy of the dimensions and quality of the joints are assured through precision grinding and pre-assembly on a specially designed assembly floor. Sophisticated PLC control systems enable machining accuracy up to 0.2 mm.

THE BOTTOM LINE ON TOP PERFORMANCE

At HWI, we work with intensity every day to ensure that the quality of our products stands strong. TIGER® blocks are tested rigorously from the moment raw material is received to the final inspection of the assembly. DY follows HWI pre-assembly specifications for the glass industry on all orders supplied by HWI.

The following tests are performed on-site during manufacturing:

- Chemistry
- Bulk density
- Static corrosion
- Glass exudation
- Cold crushing strength
- Radar testing

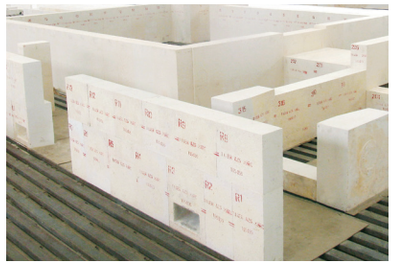
Further meticulous attention to quality control happens at the HWI Advanced Technology and Research Center. Additional testing includes:

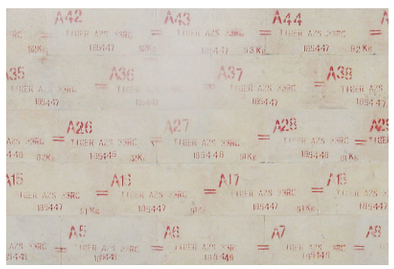
- Bulk density
- Apparent porosity
- Chemical analysis
- Refractoriness under load
- Linear expansion
- Exudation
- Corrosion
- Raw material radioactivity

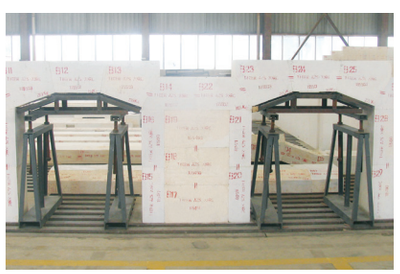
HWI also performs an on-site inspection of the products and the pre-assemblies in addition to the customer inspection. The HWI Quality Assurance Team reviews and approves inspection reports and Certificate of Analysis.

HWI has the capability to offer final inspections in either Luoyang, China or in South Shore, KY, depending on the customer's preference. South Shore, also has state-of-the-art finishing and grinding equipment in order to meet the pre-assembly specifications.

The DY manufacturing facility is ISO 14001:2004, ISO 9001:2008, and OHSAS 18001:2007 certified.







PUT OUR INTENSITY TO WORK FOR YOU

The competitive edge you're looking for starts with us—and with your dedicated HWI glass application specialist. They're experts who will understand every inch of your process and who will work intensely to optimize your refractory performance.

Every day at HWI, we design solutions that help improve efficiencies, make installations easier, extend campaign lives, and save our customers millions of dollars. To learn more, contact a HWI representative at **800-887-5555** or visit **thinkhwi.com.**

HWI A MEMBER OF CALDERYS

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