Rolling Glare Shield for Steelmaking Applications

Hazards are ever-present in the steel plant environment, and a heightened awareness and emphasis on safety is a necessary priority for our industry. This monthly column, coordinated by members of the AIST Safety & Health Technology Committee, focuses on procedures and practices to promote a safe working environment for everyone.

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Comments are welcome. If you have questions about this topic or other safety issues, please contact safetyfirst@aist.org. Please include your full name, company name, mailing address and email in all correspondence.

In 2016, MacPherson and Company, a manufacturer of specialty safety glass for extreme heat and impact in the molten metal industries, developed the rolling glare shield as an added layer of safety designed to cut the radiant light hazard in molten metal applications. This article explains how the rolling glare shield works plus its relationship to other layers of safety glass. The shield is another safety layer behind the infrared-reflecting glass for blocking radiant heat energy and the impact safety glass for stopping debris in molten metal reactions (Fig. 1).

Knowledge of steelmaking combined with understanding the properties and strengths of different glasses is critical in engineering windows for the steel industry. Most people commonly view glass as glass; however, the design of window systems for critical steelmaking areas requires the proper selection of glass with varied properties and strengths. Durability, serviceability, comfort, and the operator's safety and health are important considerations for designing industrial window systems. It is best to rely on an expert to determine the best options, as a sizable percentage of people associated with, operating behind, ordering and/or buying industrial glass do not have a basic knowledge of the different properties of glass. Therefore it is important to review properties of different safety glass in steel manufacturing environments.

The most dangerous phase of steelmaking is during the charging phase. The second-most dangerous is when the molten metal is in motion. Steelmaking has two threats: severe radiant energy that is present from the melting through the casting operation and the occasional reactions with water that causes explosions while in the molten phase.

The term "safety glass" refers to any type of glass designed for safety, but generally it falls into just two types. The first, monolithic glass, breaks into tiny pieces as opposed to sharp shards when broken (Fig. 2). In order for glass to break in a dice pattern, the glass needs to be tempered. The process of tempering glass is similar to the tempering process in steel in that it rearranges the molecules to achieve a specific strength and flexibility. Tempering glass is a way to dramatically change the microstructure and strengthen the glass. Quenching allows the outside surface glass to cool rapidly and at the same time allows for the

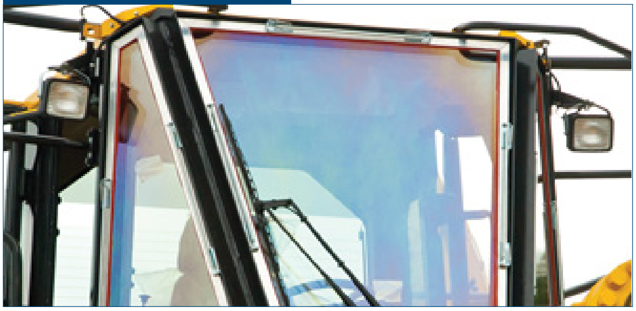
Figure 1

Safety layers between the operator and molten metal applications.

Figure 2

Break patterns in tempered versus annealed glass.

Figure 3



Example of iridescent IRR coating on glass.

interior of the glass to cool slowly. This puts the outer surfaces into compression and the middle into tension.

The second recognized safety glass is laminated glass, which is a composite of glass and laminate material. This glass remains in one piece after being fractured. The laminated glass can vary in strength by using a variety of thicknesses of glass and laminating material. For steelmaking operations, it is a good choice to use glass featuring infrared-reflective (IRR) coatings for the heat-side glass for elevated radiant energy environments. IRR coating is birefringent, which gives an iridescent reflection on the glass (Fig. 3).

There are three varieties of glass that are ideal for molten metal applications as the outer heat shield on the heat side of the operator's enclosure: tempered IRR, tempered borosilicate with IRR and glass ceramic.

Tempered Infrared-Reflecting Glass — This soda lime glass will dice into small pieces when broken. It has a pyrolytic coating to reduce radiant energy and is serviceable up to 400°F at the surface area. This is a useful product for most applications in areas with minimal thermal shock. This is the most commonly used glass in steelmaking applications.

Tempered Borosilicate With IRR (BPS Heat Shield) — This also has a pyrolytic coating to reduce the radiant energy transfer through the glass. BPS has low thermal expansion. Tempered BPS heat shield will outperform tempered soda lime IRR glass in extreme thermal shock environments, but is not a safety glass since it does not dice when broken. It has a maximum operating temperature of approximately 550°F at the surface area. It is desirable in applications less than 50 feet from molten steel, especially with the possibility of thermal shock.

Glass Ceramic — This is not a safety glass because it has a near-zero expansion coefficient and cannot be tempered. This glass will sustain 1,100°F at surface area and performs well against thermal shock. This glass is available in clear or with an IRR coating. Glass ceramic is normally used less than 15 feet from molten steel.

One can tell the difference between common (soda lime) glass and the other glass products when looking at the edge. (Fig. 4) The edge of soda lime glass will appear as a green color and the edge of borosilicate and glass ceramic will appear clear.

Note that this discussion is only about the outer 0.25-inch glass for operator enclosures in hot applications. Laminated safety glass is popular in many mill settings because the local glass installer can cut and install the same day as needed. The 0.25-inch-thick laminated glass is annealed and not tempered, therefore it can be cut on-site. The downside to 0.25-inch laminated glass is it will crack at a much lower thermal stress and more frequently, making it a costlier product over a short period of time. In addition, 0.25-inch laminated glass does not have IRR coating. A comparison property chart (Table 1) reflects the varieties of outer heat-side glass that would be appropriate for hot metal applications.

After reducing the radiant energy entering the cab, the next layer of safety recommended is an industrial

Figure 4

Edge comparison between glass types.

Table 1

Comparison of Properties Chart

	Tempered infrared reflecting	BPS® tempered heat shield	RADIANT® heat shield clear ceramic
Type of tempered glass	Soda lime	Borosilicate	Crystallized
Industrial use	For minimal radiant energy	For short radiant energy blast	For long-sleeve radiant energy
Nominal thickness	0.25 inch	0.22 inch	0.25 inch
Coefficient of thermal expansion 0° –300°C x 10^{-7}	93.5	32.5	3
Transmission % of infrared radiation from 2,800°F source	28	30	30
Withstands thermal shock (scale 1–10)	4	6	10
Maximum sustained temperature (°F)	400	550	1,100
Mechanical strength flex and impact (scale 1–10)	9	6	3
Light transmission (%)	81	85	80

Figure 5

The rolling glare shield.

impact/explosion-resistant composite safety glass like either the SAFE-SHIELD® or HOOGOVENS® impact safety glass. These products are designed to stop the concussion and impacts from hot metal reactions found in steelmaking. SAFE-SHIELD offers high-temperature inner layers with an additional IRR coating and is tested to resist penetration at least 3,000 ft-lbs. HOOGOVENS offers maximum protection and tested repeatedly to resist penetration with at least 4,000 ft-lbs. HOOGOVENS has high-temperature inner layers but does not feature IRR coating.

Lexan is a type of safety glass that is not recommended in hot metal or steelmaking applications. Lexan is a polycarbonate that offers the highest impact strength of any transparent product with over 250 times the impact strength of glass in equal sheet thickness. The Vicat softening temperature using method B120 is 145°C (295°F), and deformation begins around 49°C (120°F). Most steelmaking applications' ambient temperature often is above that temperature. Therefore, Lexan is not ideal for hot metal glass even for the explosion-resistance safety layer.

After ensuring both radiant heat and extreme impact threats are addressed, focus can turn toward the reduction of blinding white light for operators in the crane cabs and pulpits during the manufacturing of steel. The rolling glare shield was designed as an added safety layer to block the damaging radiant light associated with steelmaking and molten metals.

Over the years, there have been many improvised methods of achieving this goal. Duct taping a green or blue glass to the inner pane of glass in the EAF was the first solution encountered. This glass was not easily removed and proved to be inconvenient when maintenance needed to use the pulpit. Polymer film shade is a commercially available product for automobiles. When used on steelmaking windows, it quickly bubbles then cracks and becomes difficult to scrape off the glass; it eventually renders the glass unusable. Another solution is personal protection equipment (PPE) flip-down shades that attaches to all operators' helmets. Some minor drawbacks for flip-down shades is those working in the pulpits tend not to wear a hard hat inside and people temporarily in the area will not have the flip-downs. Another issue with PPE flip-down shades is the continual cost because these are regularly lost and need to be replaced frequently. Finally, another common solution used is pull-down shades. These are a workable solution but tend to have issues after only a short time of use.

The rolling glare shield can be paired up with PPE flip-down shades and pull-down shades. The rolling glare shield, together with flip-down or pull-down shades, mediates the blinding light that interrupts the operator's clear viewing.

The rolling glare shield was developed out of the need in the industry for a better solution for radiant white light defusing. The purpose is to protect the operator from the damaging bright white light in the steelmaking process without losing its strength and properties as it filters the difference between molten steel and slag. The system allows the rolling glare shield to roll quickly in place for charging, pouring or other blinding applications. When the work is completed, the rolling glare shield can easily be moved out of the way. It is positioned inside of the window system, shielding from the heat and impact. Since it is made of industrial-grade material, it is able to take the heavy use seen in steel mills.

The shield reduces the strain on the eyes, improves workers' productivity and reduces accidents by protecting operator's eyes during radiant light events and eliminating distracting and harmful light transmissions. The rolling glare shield, when used in a crane cab, increases the ability for the operator's eyes to adjust and better see the environment below on either side of the ladle, as it diffuses light while traveling down the aisle. The shield also reduces the double-image issue in the glass created by light bouncing off the double heat-reflecting glass. The rolling track system maximizes ease of use and serviceability.

References

1. The Corning Museum of Glass, Corning, N.Y., USA.
2. Schott Glass Specification Sheet 2005.
3. Lexan Specification Sheet 2015.

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