



Refractories for Continuous Casting

SHINAGAWA REFRACTORIES is the top refractories manufacturer supporting key industries.

Since being established in 1875, Shinagawa Refractories Co., Ltd. has contributed to the development of key industries, including the steel, non-ferrous metal, electricity, gas, cement, glass and ceramic industries by providing them with refractories.

Today, Shinagawa Refractories manufactures a variety of refractories and delivers our products and technologies across the world. As a world leading company of refractory engineering, we strive to contribute to the development of new refractory technologies.

As soon as continuous casting technology was invented, Shinagawa Refractories started the development of our refractories for continuous casting. Since then, we have developed various products for our customers such as slide gate valve systems, submerged entry nozzles, tundish linings and mold powders.

Our products supported by our expertise and outstanding technologies are well-received not only with the domestic continuous casting industries but also around the world industries through exports and contributing to the manufacturing activities of these industries.

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Note: All quality characteristics values described in this brochure show the standard.
Values to be assured at the time of delivery are to be determined upon consultation
before receiving orders.

P2: Photo by Joe Nishizawa

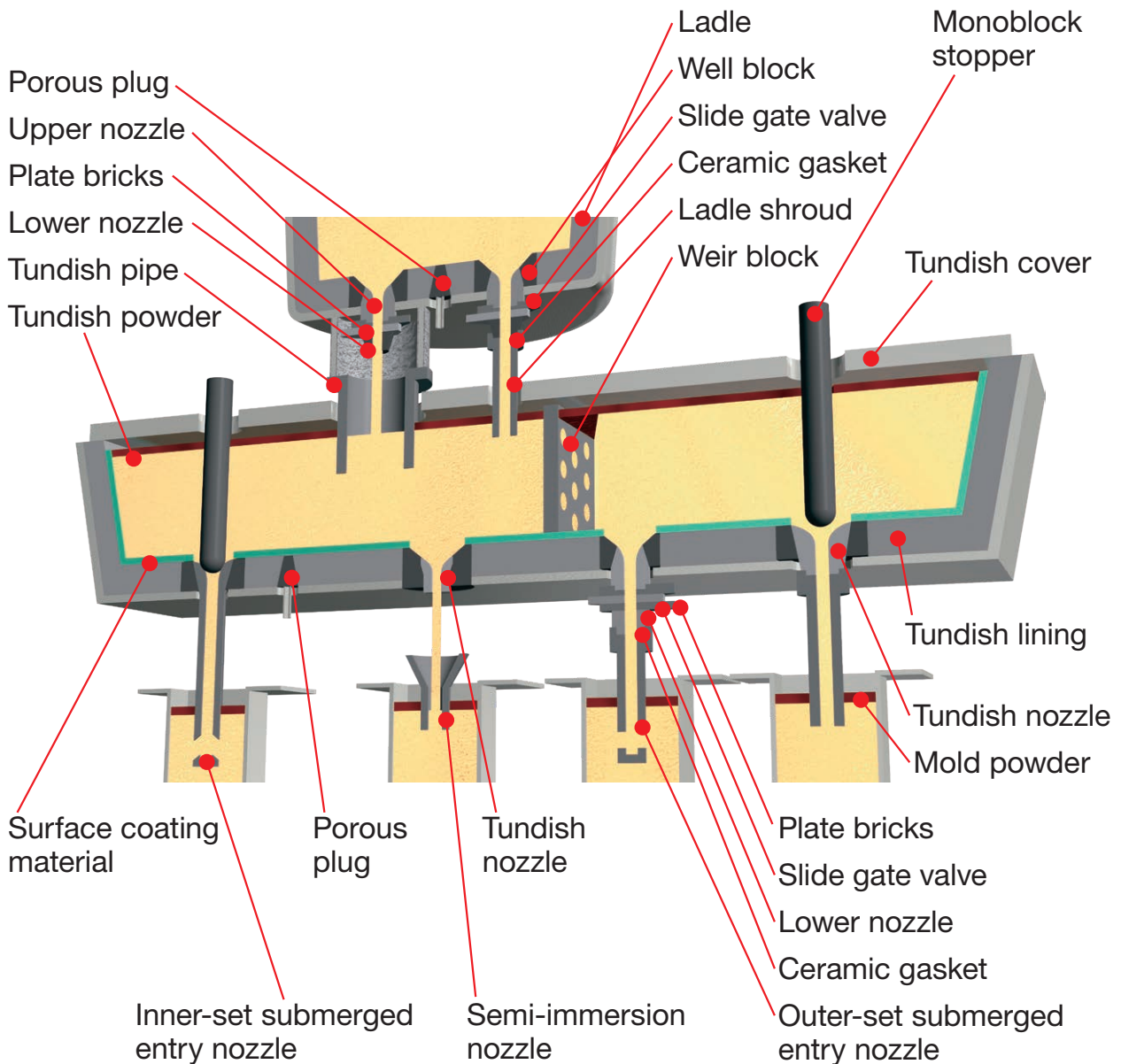
Refractories for Continuous Casting

Recently, most of crude steel is manufactured by continuous casting process. And the technology of continuous casting has increasingly been necessitating the development of high-speed casting, multi-sequence continuous casting and the improvement of steel quality. Shinagawa Refractories has been dealing with development and design of refractories for continuous casting in order to meet these needs and has been developing and providing various refractories from ladle to mold such as slide valve flow rate control system, refractories for tundish, ladle shroud and submerged entry nozzle etc. and mold powders. These refractories for continuous casting produced using Shinagawa Refractories' abundant experience and advanced refractories technologies are utilized under various operational conditions and parameters for casting of billets, blooms, slabs as well as thin slabs, all of which have acquired a good reputation.



Does your supplier meet your needs for continuous casting refractories?

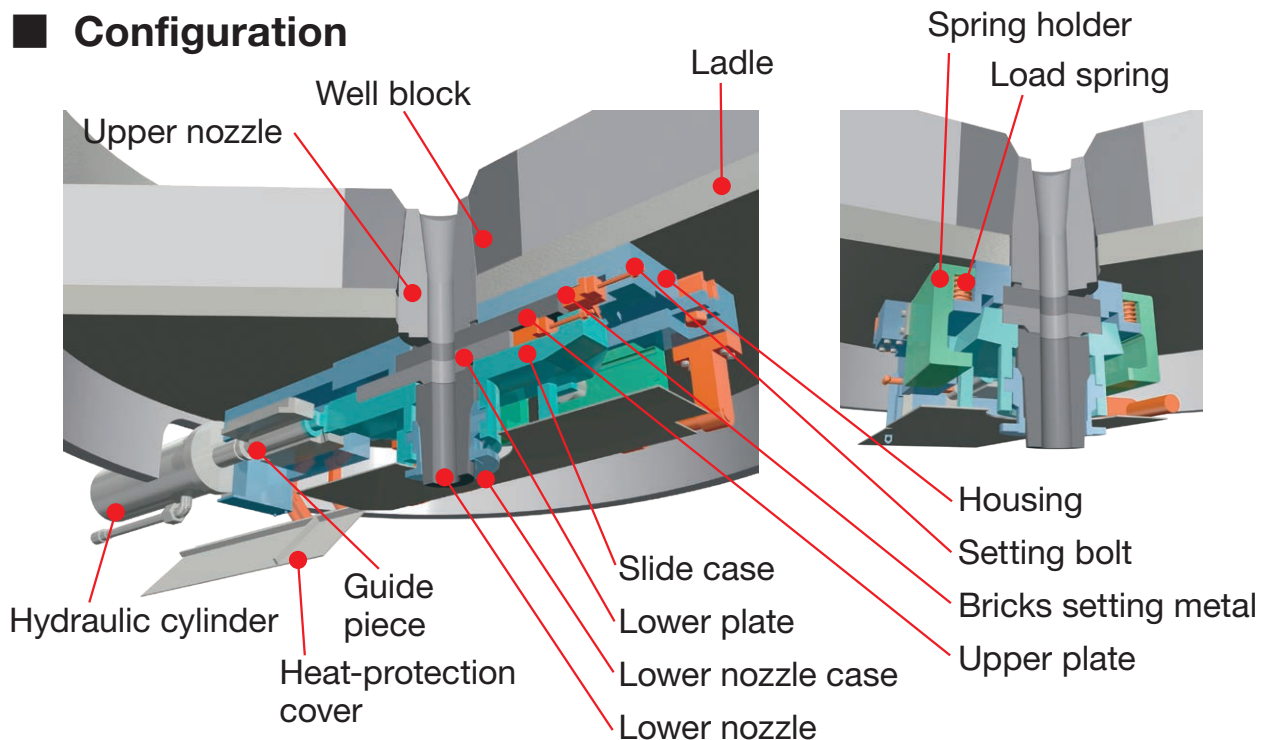
Refractories and equipment of Shinagawa Refractories for continuous casting are surely capable of meeting your needs for the improvement of continuous casting operations and quality of cast products.



Slide Gate Valve Equipment for Ladle

Slide Gate Valve Equipment for Ladle (SST)

■ Configuration



■ Features

1. Refractories cost saving and high security

- The weight of plate brick is reduced due to optimizing plate design based on the stress analysis and the plate life is extended because cracks in bricks are reduced remarkably by adopting unique plate fixation structure.

2. Maintenance cost saving

- Total number of component parts is reduced by approximately 50% (conventional ratio) and convenient replacement of consumable parts.
- Extension of spring life using a unique cooling system for load spring.
- Simple, convenient and stable contact pressure application structure and high rigidity of equipment.

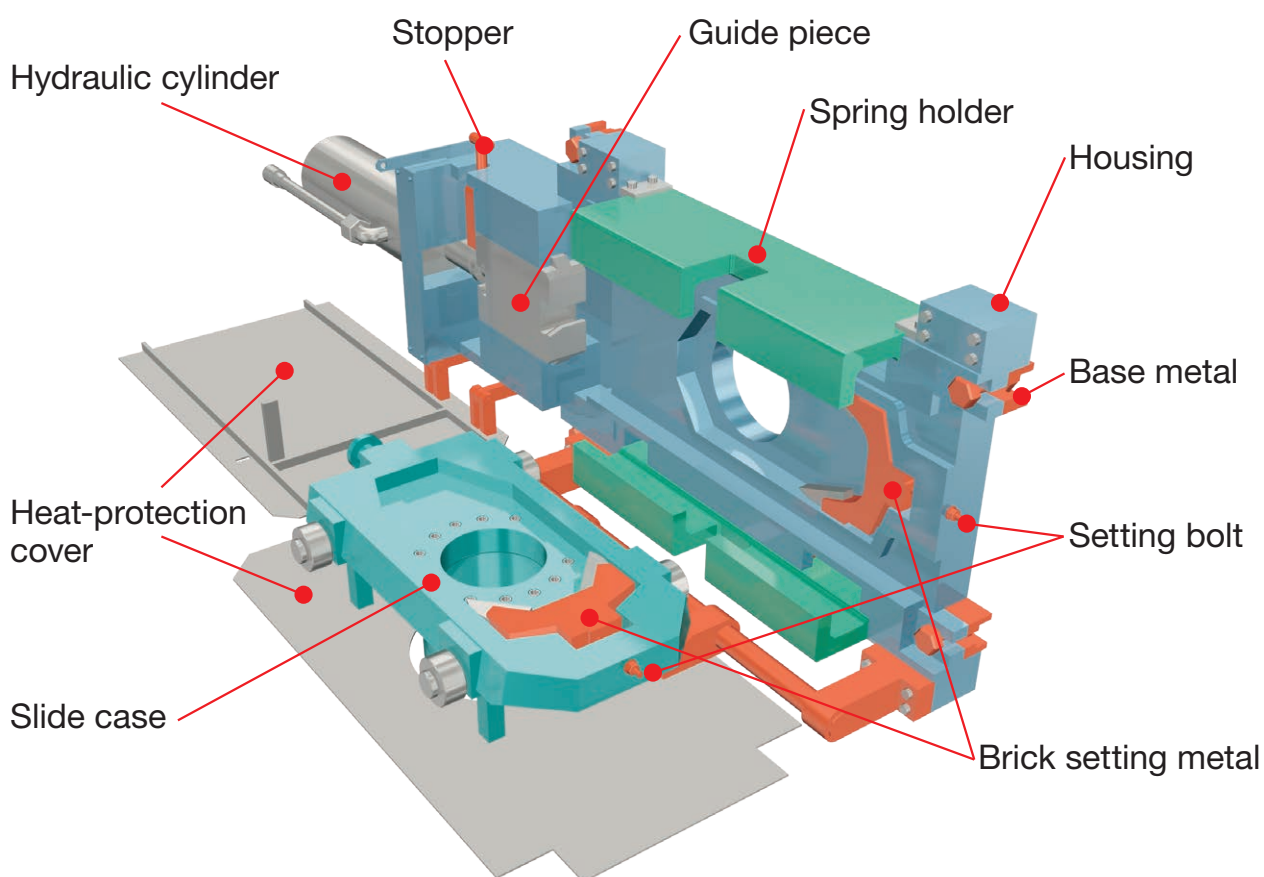
3. Excellent working efficiency

- Short operation times made possible with a simple and convenient refractories change system.

■ Standard specification

Item	Model name	SST		
		50	70	80
Plate brick composition		2 or 3-plate pattern		
Standard nozzle diameter (mm)		50	70	80
Sliding stroke (mm)		150	175	210
Loading Mechanism		Automatic Loading Mechanism		
Weight (kg) (including cylinder)		600	800	1000

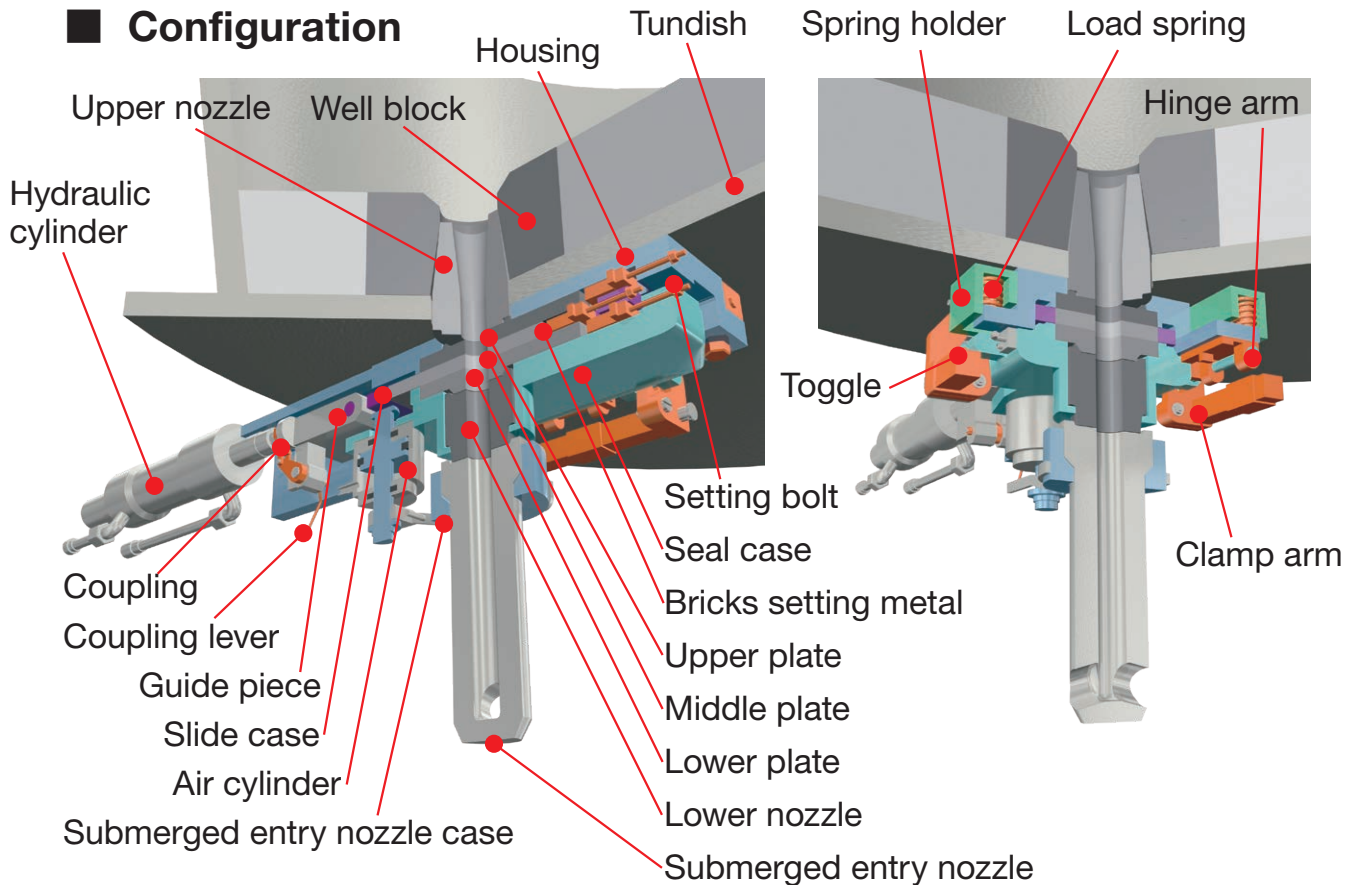
■ Automatic loading mechanism



Slide Gate Valve Equipment for Tundish

Slide Gate Valve Equipment for Tundish

■ Configuration



■ Features

1. Submerged entry nozzle mount with an excellent sealing performance

- The submerged entry nozzle mounting device is equipped with an air cylinder which improves the sealing performance of the engagement parts. At the same time, this simplifies the process for replacing submerged entry nozzles.

2. Clogging preventive configuration

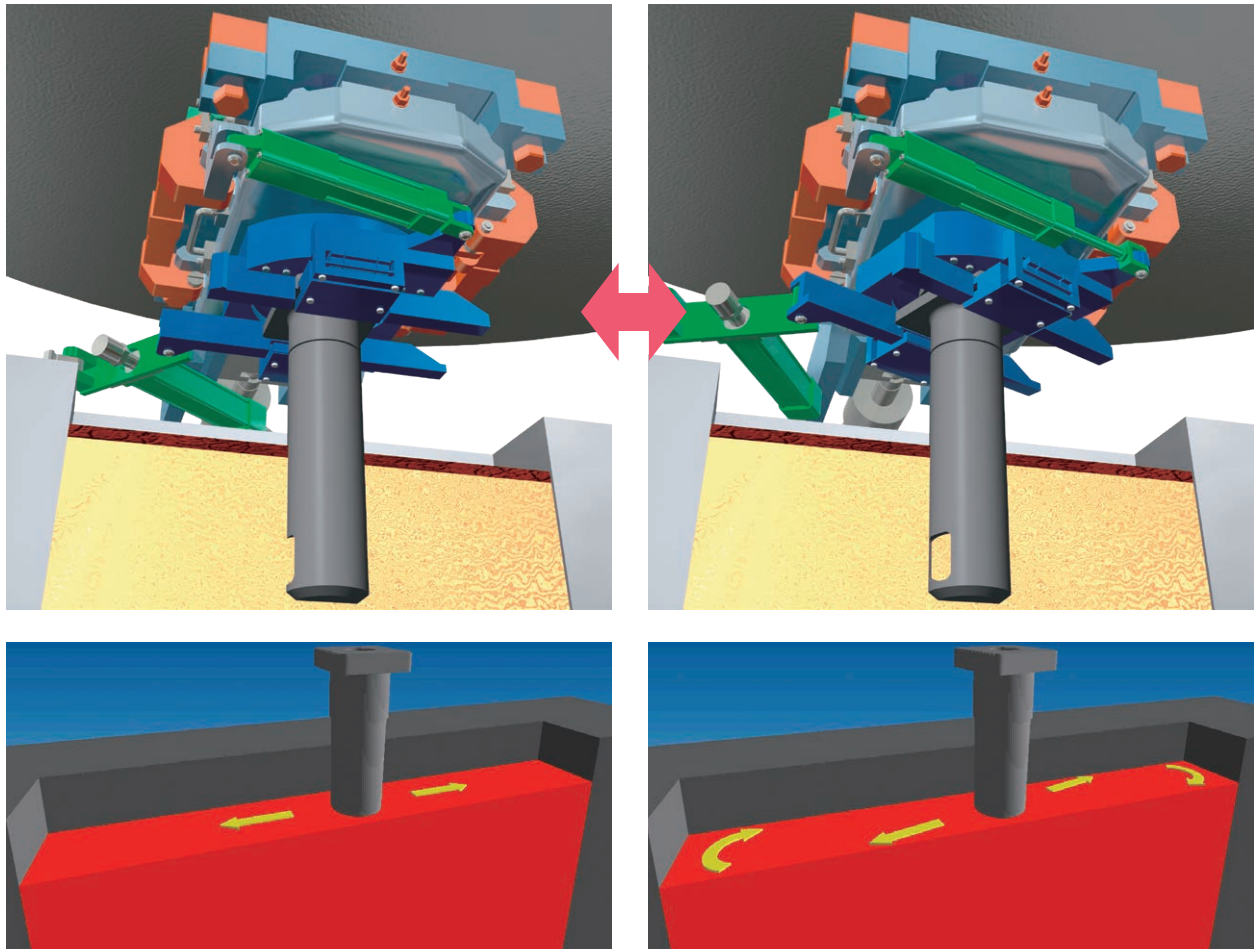
- This configuration includes a function to inject inert gasses from upper nozzles, lower plates, lower nozzles and submerged entry nozzles and prevents deposits of alumina which causes clogging.

3. Complete gas sealing configuration

- This is a configuration which injects inert gasses to the area around the engagement and prevents the absorption of air.

Advanced SEN Quick Change System (SGT)

■ Configuration



■ Features

1. Improvement of steel quality

- Improvement of steel quality by generating swirling flow in the mold without Electro Magnetic Stirrer.

2. Cost-saving

- Resolving issues of slab joint scraps.
- Saving costs of refractories by increasing the sequence.

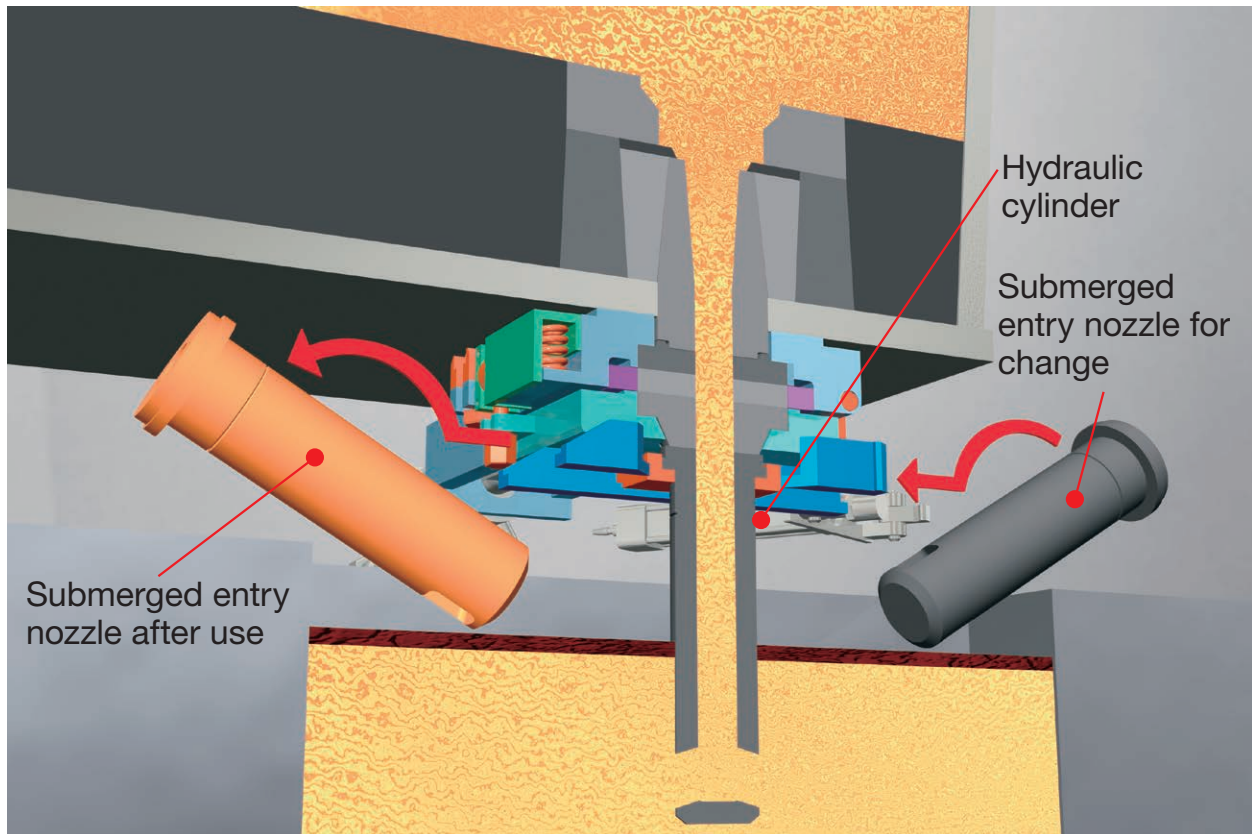
3. Productivity enhancement

- A submerged entry nozzle can be replaced without stopping casting.
- Time needed for submerged entry nozzle change can be minimized.

Slide Gate Valve Equipment for Tundish

Submerged Entry Nozzle Quick Change System (QTC)

■ Configuration and Image of changing operation



■ Features

1. Productivity enhancement

- A submerged entry nozzle can be replaced without stopping casting.
- Time needed for submerged entry nozzle change can be minimized.

2. Cost-saving

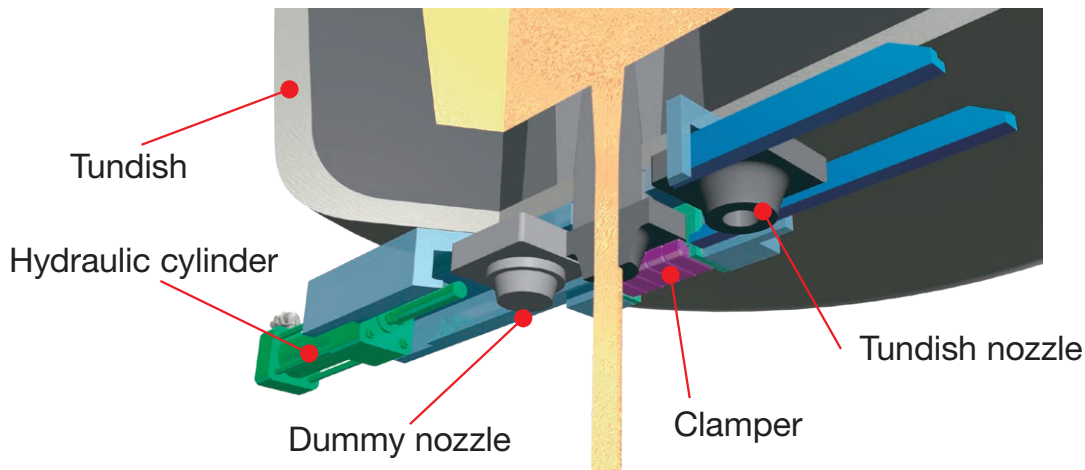
- Resolving issues of slab joint scraps.
- Saving costs of refractories by increasing the sequence.

3. Excellent sealing performance

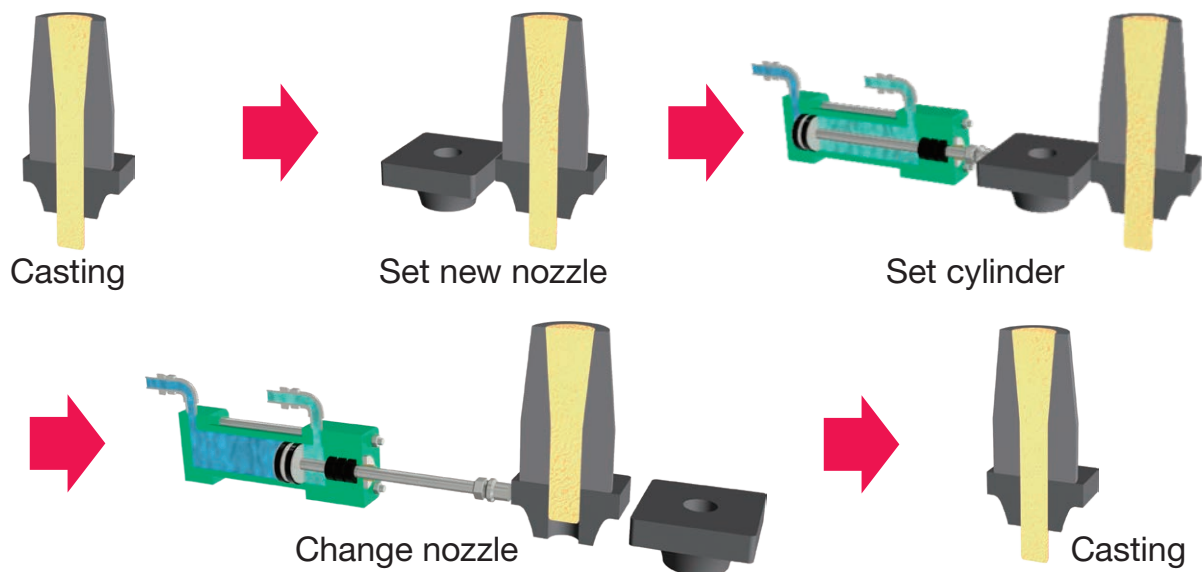
- The application of new sealing material has an extremely good sealing performance of engagement parts.

Tundish Nozzle Quick Change System (NQC)

■ Configuration



■ Flow of change



■ Features

1. Productivity enhancement

- A tundish nozzle can be replaced without stopping casting.

2. Cost-saving

- Saving costs of refractories by increasing the sequence.

3. Enhancement of stability and safety

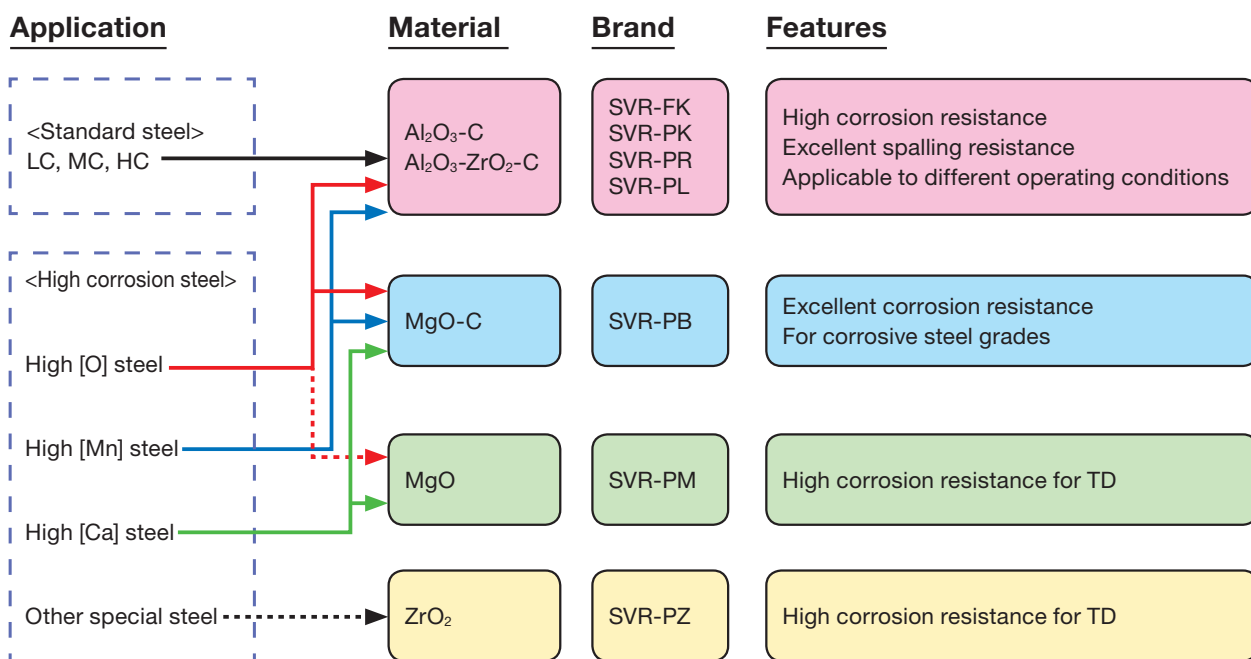
- Dangerous operations, such as plugging after casting stopped, can be removed.

Refractories for Slide Gate Valve

The function of a slide gate valve, which consists of upper nozzles, plate bricks and lower nozzles, is to control the flow rate of steel from ladle and tundish. These refractories are required to have an excellent resistance to corrosion, abrasion and spalling while maintaining configuration and quality control for stable operations. We have been developing, supplying and improving slide gate valve refractories in order to cope with advances of continuous casting technologies. Utilizing these technologies, as well as the computer-controlled plant dedicated to the manufacturing of slide gate valve refractories, our products have realized excellent and stable performance.



Plate Bricks



The plate bricks are the most important refractories that influence the functions and performance of the slide gate valves. As the plate bricks, it is important to select optimum materials and configuration for the conditions and environment of usage.

<Quality for regular steel>

	Oxidation resistance	Spalling resistance	Corrosion resistance	Surface damage resistance
SVR-FK3	Good	Good	Good	Excellent
SVR-PK73	Good	Good	Good	Good
SVR-PK87	Excellent	Good	Good	Excellent
SVR-PR57	Good	Excellent	Fair	Good
SVR-PL1	Excellent	Fair	Excellent	Excellent

<Quality for special steel>

	Oxidation resistance	Spalling resistance	Corrosion resistance	
			High [Ca] steel	High [O] steel
SVR-PL1	Good	Good	Good	Excellent
SVR-PB50	Good	Fair	Excellent	Excellent
SVR-PM5	Excellent	Fair	Excellent	Excellent
SVR-PZ32	Excellent	Good	Excellent	Fair

Refractories for Slide Gate Valve

■ Properties

Brand	SVR-FK3	SVR-PK73	SVR-PK87	SVR-PR57	SVR-PL1	SVR-PB50	SVR-PM5	SVR-PZ32
Quality	Al ₂ O ₃ -C	Al ₂ O ₃ -C	Al ₂ O ₃ -C	Al ₂ O ₃ -C	Al ₂ O ₃ -C	MgO-C	MgO-Spinel	ZrO ₂
Apparent porosity (%)	9.0	8.0	8.8	11.6	9.0	10.0	14.2	15.6
Bulk density	3.30	3.27	3.35	3.23	3.21	3.00	3.07	4.53
Crushing strength (MPa)	165	150	185	110	130	80	100	150
Thermal expansion at 1000 (%)	0.7	0.7	0.7	0.7	0.7	1.2	1.2	0.7
Chemical composition (%)								
Al ₂ O ₃	77	83	75	80	84	—	6	—
SiO ₂	1	1.5	3	4	—	—	—	—
MgO	—	—	—	—	—	92	90	—
ZrO ₂	10	6	10	9	3	—	—	94
C	6	6	5	5	5	4	—	—
Application	Ladle & TD	Ladle & TD	Ladle & TD	Ladle & TD	Ladle & TD	Ladle & TD	TD	TD
	Regular steel	Regular steel	Regular steel	Regular steel	Regular steel	Special steel	Special steel	Special steel

Nozzle bricks

There are two types of nozzles for slide gate valves, upper (insert) nozzles and lower (chute) nozzles. Nozzles are required to have properties of resistance to corrosion, spalling and abrasion. In general, lower nozzles are normally exposed to severe heat cycle, so spalling resistance is emphasized for them and corrosion resistance is emphasized for upper nozzles.

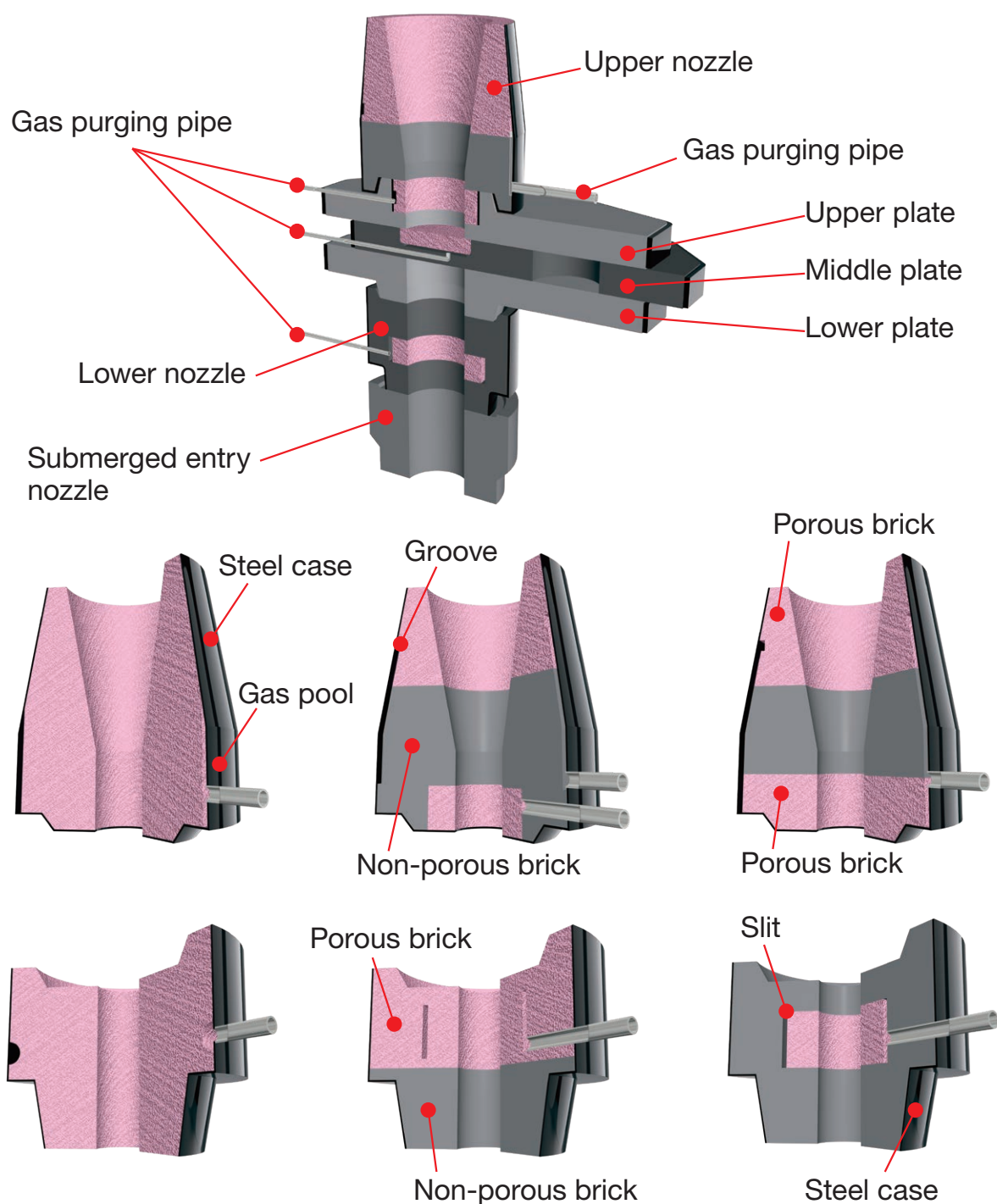
We have a variety of nozzle materials to meet various needs of our customers.

■ Properties

Brand	SVR-NU40	SVR-NU60	SVR-NA5	SVR-NU28	SVR-NU30	SVR-NZ7	ZCN-N-1	ZCN-ZR90
Quality	Al ₂ O ₃ -C	Al ₂ O ₃ -C	Al ₂ O ₃	Al ₂ O ₃ -C	Al ₂ O ₃ -C	Zircon-FS	ZrO ₂	ZrO ₂
Apparent porosity (%)	8.0	9.0	17.0	11.0	7.5	15.0	14.0	13.1
Bulk density	3.20	3.22	3.05	2.75	2.93	3.02	4.83	4.88
Crushing strength (MPa)	100	100	85	80	110	70	195	115
Thermal expansion at 1000 (%)	0.7	0.7	0.7	0.5	0.5	0.3	0.8	0.8
Chemical composition (%)								
Al ₂ O ₃	92	92	92	73	66	—	—	—
SiO ₂	—	—	7	18	17	50	—	—
ZrO ₂	—	—	—	—	8	44	95	95
C	5	3	—	6	6	—	—	—
Application	Upper Nozzle	Upper Nozzle	Upper Nozzle	Lower Nozzle	Lower Nozzle	Lower Nozzle	TD Nozzle	TD Nozzle

Gas blowing configuration of Slide Gate Valve

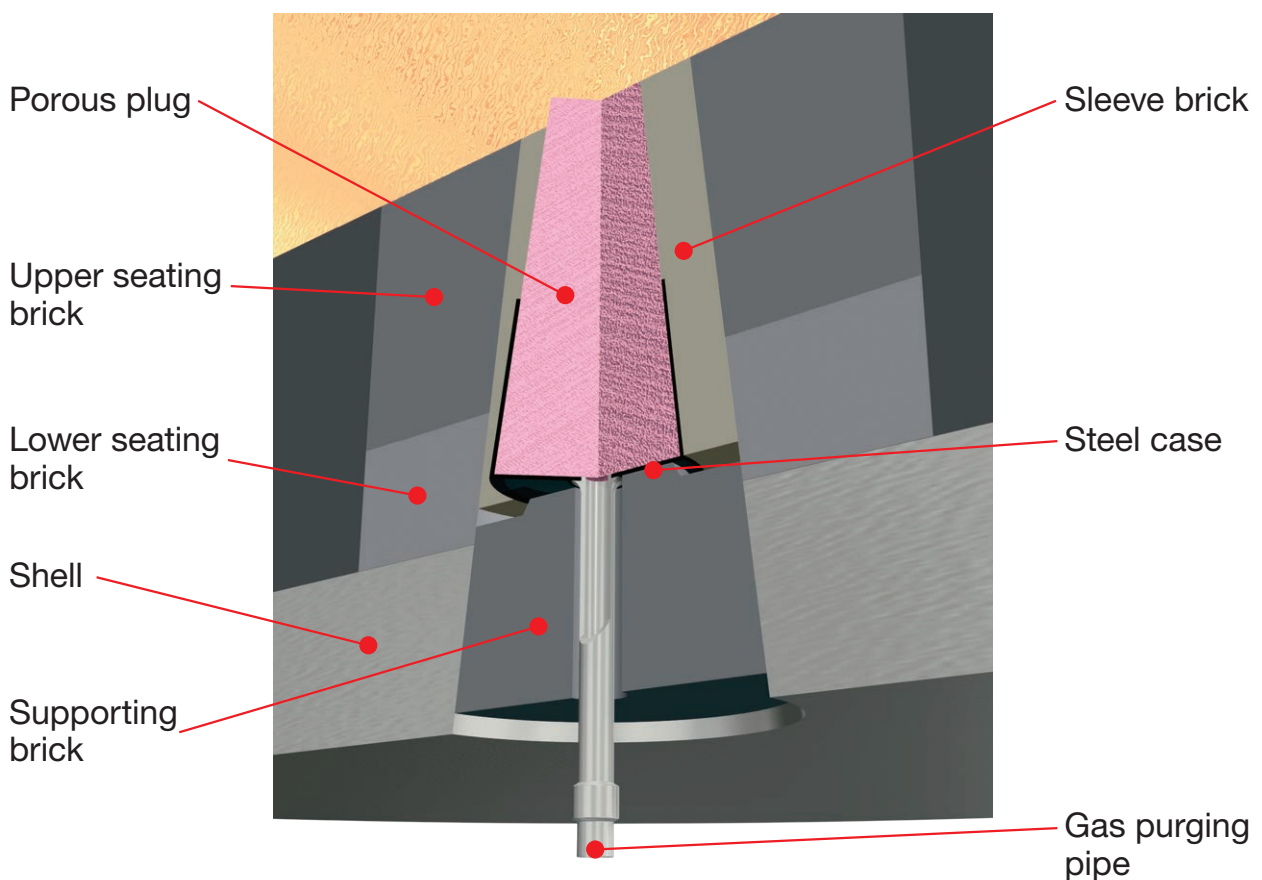
We have developed various methods of gas blowing from upper / lower nozzles and plates. Porous type or direct pore type and configuration can be selected for any purpose or usage conditions.



Purging Plug for Ladle

Purging plug is applied to the stirring of molten steel in ladle. We have developed some gas blowing methods, materials and configurations for any purpose and stable effects of gas blowing can be expected by choosing gas blowing method for usage conditions.

■ Configuration



■ Gas blowing methods

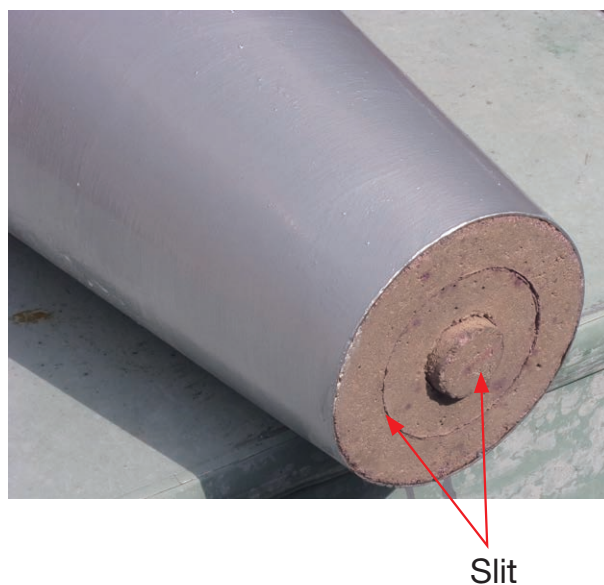
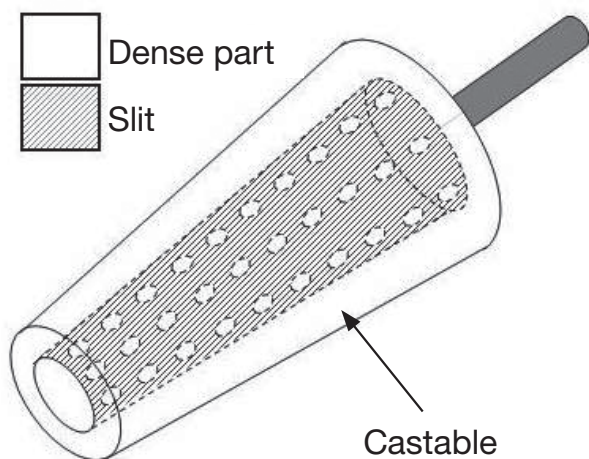
- Porous brick method

Different gas flow rate can be set by determining size of pores and porosity.

- Slit method

Anti-corrosive performance and gas flow rate can be controlled by selecting materials and slit width. This has the characteristics that generated bubbles are rather big.

Slit Plug



Properties

Properties \ Bland	ALP-A14	ALP-A21	HSP20	HSP203	HSP209
Apparent porosity (%)	26.3	27.4	24.0	23.4	22.5
Bulk density	2.47	2.56	2.80	2.83	2.89
Cold crushing strength (MPa)	36	48	54	86	89
Medium pore diameter (μm)	104	102	120	149	113
Chemical composition (%)					
Al ₂ O ₃	79	80	89	86	86
SiO ₂	19	15	7	7	6
ZrO ₂	—	3	—	3	3
Cr ₂ O ₃	1	1	2	2	4
Remarks			Normal	High flow rate	High durability

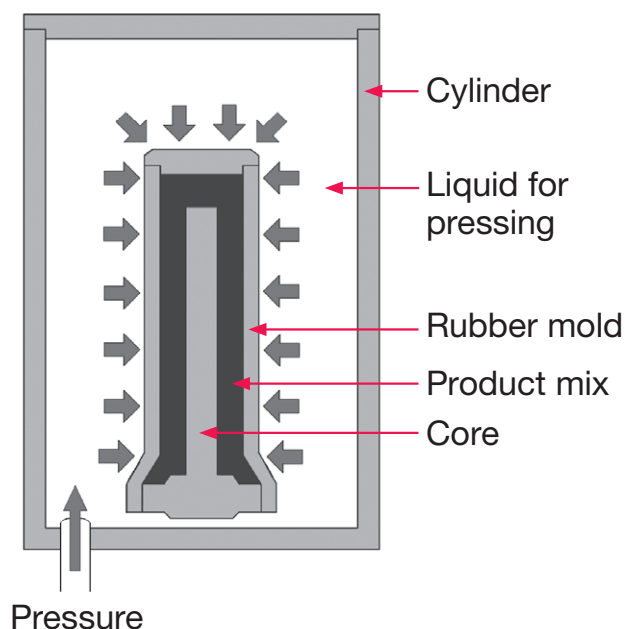
Ladle Shroud, Tundish Pipe, Monoblock Stopper

The functional refractories including ladle shrouds and submerged entry nozzles (SENs) are used in the final stage of steelmaking, thus they are extremely important for a stable operation and steel quality.

From 1968, we started the development and manufacturing of functional refractories and these are widely used for the continuous casting machines around the world.

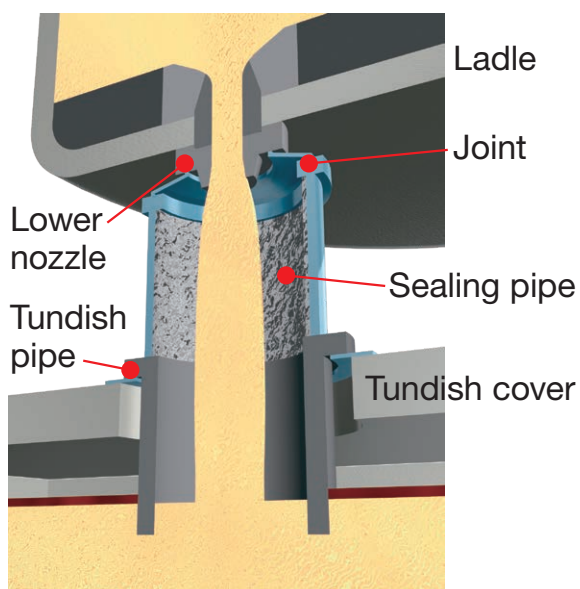
■ Typical production facility of Ladle Shroud and SEN

Ladle shrouds and SENs are manufactured using homogeneous materials with a CIP (Cold Isostatic Press) through high pressure forming, and fired in reduction firing furnace.



Tundish Pipe

As with ladle shrouds, tundish pipes are located between ladle and tundish. These are used in order to prevent air suction.



Properties

Area of application	Main body Submerged region	Submerged region
Brand	G32D series	G2M series
Apparent porosity (%)	15.0	16.0
Bulk density	2.30	2.50
Modulus of rupture (MPa)	7.5	8.0
Thermal expansion at 1000°C (%)	0.30	0.46
Chemical composition (%)		
Al ₂ O ₃	45	11
SiO ₂	18	—
MgO	—	57
C+SiC	33	27+3
Remarks	Al ₂ O ₃ -C	MgO-C



Monoblock Stopper

The resistance of stopper head to abrasion and corrosion greatly impacts on flow control, so we prepare various materials to meet the operational conditions.

Properties

Area of application	Main body	Head		
Brand	G23H series	G20H series	G1M series	G3M series
Apparent porosity (%)	14.5	15.5	15.5	16.5
Bulk density	2.75	2.75	2.60	2.55
Modulus of rupture (MPa)	21.5	15.0	15.0	7.5
Thermal expansion at 1000°C (%)	0.42	0.42	0.50	0.63
Chemical composition (%)				
Al ₂ O ₃	73	74	58	7
MgO	—	—	18	64
C+SiC	21+4	19+4	16+4	23+3
Remarks	Al ₂ O ₃ -C	Al ₂ O ₃ -C	Spinel-C	MgO-C

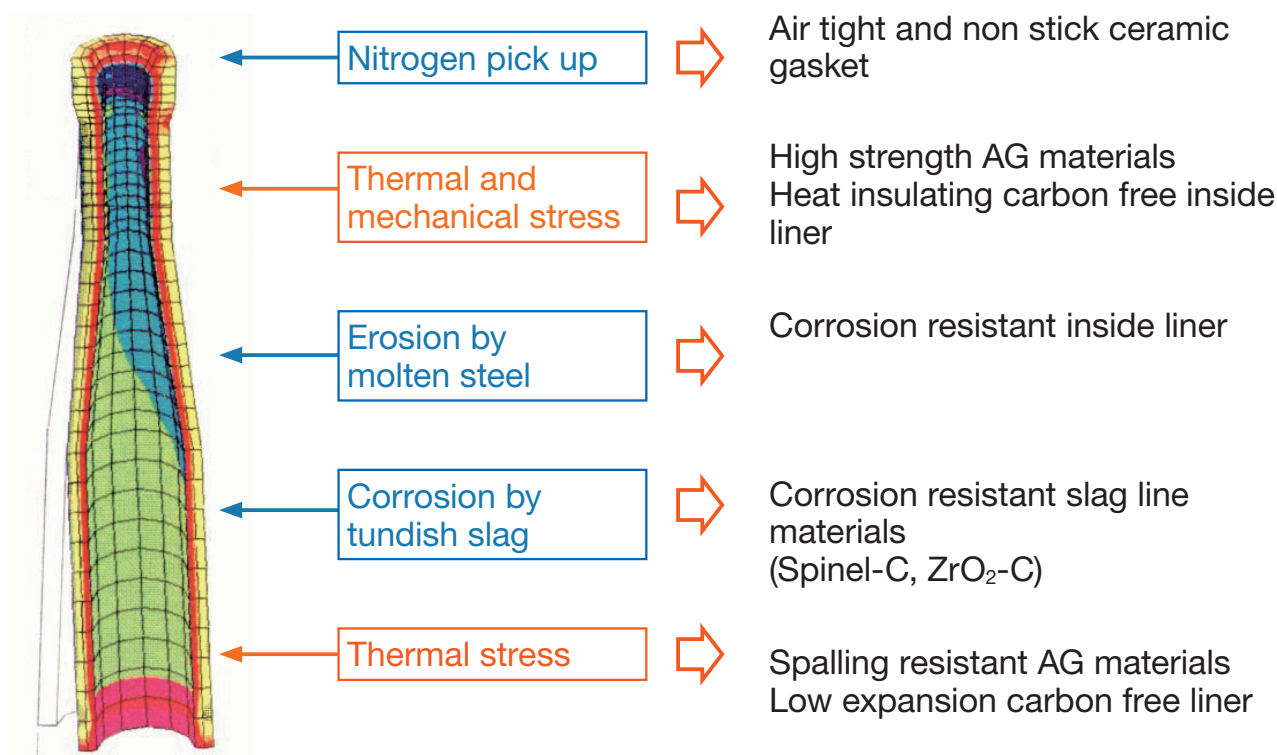
Ladle Shroud, Tundish Pipe, Monoblock Stopper

Ladle Shroud

Ladle shrouds are installed between ladle and tundish.

These are used to prevent air suction and slag withdrawal into molten steel.

Typical problems and countermeasures



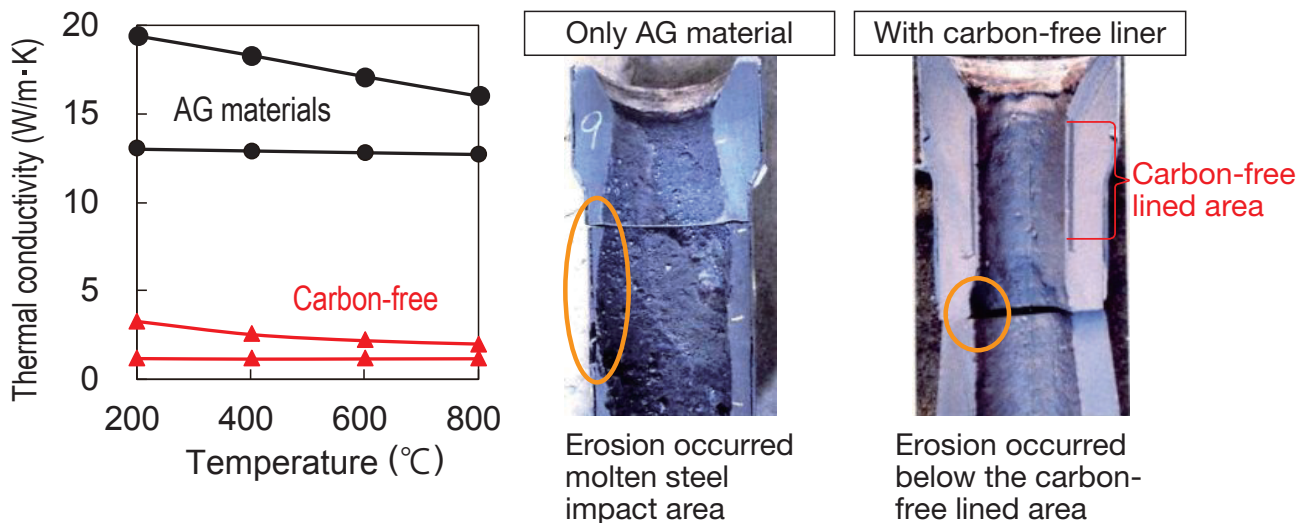
Properties

Area of application	Seat		Main body				Submerged body		
Purpose	All purposes	Oxidation resistance	Cold start	All purpose	High durability	High strength	All purposes	High durability	Corrosion resistance
Brand	G21B Series	G15B Series	G32D Series	G25A Series	G23A Series	G27A Series	G30C Series	G34H Series	G3Z Series
Apparent porosity (%)	13.5	12.0	14.0	14.5	14.0	13.0	14.0	13.5	14.5
Bulk density	2.45	2.45	2.35	2.45	2.35	2.40	2.55	2.55	3.60
Modulus of rupture (MPa)	11.0	13.0	8.0	9.5	10.0	11.0	9.5	11.0	9.5
Thermal expansion at 1000°C (%)	0.32	0.35	0.32	0.33	0.28	0.30	0.42	0.42	0.45
Chemical composition (%)									
Al ₂ O ₃	50	46	52	58	54	47	60	63	—
SiO ₂	18	19	14	14	23	20	3	—	—
ZrO ₂	—	—	—	—	—	—	—	—	70
C+SiC	24+4	23+9	33	27	22	30+2	30+5	34+2	23
Remarks		High strength					SiO ₂ less	Non SiO ₂	ZrO ₂ -C

Ladle Shroud with carbon-free inside liner

■ Features

- Reduced thermal shock in order to prevent cracking
- Improved erosion resistance at molten steel impact area



Ceramic Gasket for Nozzle

It is extremely important to assure sealing properties of the joints between nozzles in order to maintain steel quality and to avoid damages to refractories. We have a wide variety of ceramic gaskets based on unique ceramic materials.

■ Features

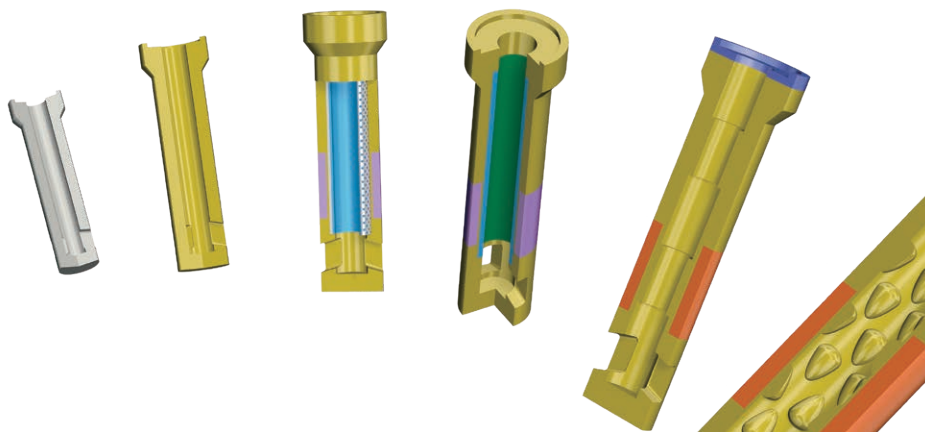
- The gasket is hard at room temperature but becomes flexible by heat.
- The gasket becomes thin by loading pressure to improve air tightness.
- The gasket is coated by carbon that enables easy removal and keeps clean connecting surface resulting in air suction prevention.



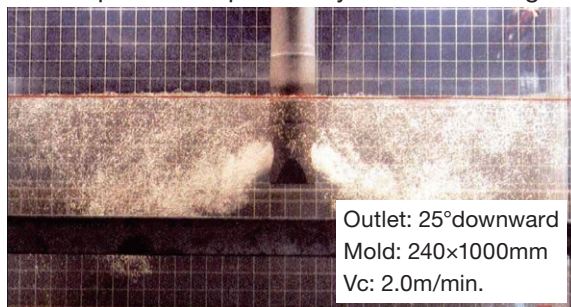
Submerged Entry Nozzle (SEN)

Advanced SENs with unique configuration

Submerged entry nozzles (SEN) are extremely important refractories for stable continuous casting operation and steel quality as they prevent air suction into molten steel between tundish and mold, prevent mold powder withdrawal and control molten steel flow.



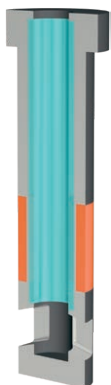
< Example of flow pattern by water modeling >



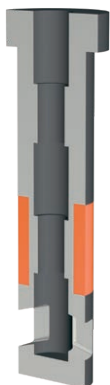
Design of SENs is important because it affects on the molten steel flow in the mold. We design the shapes of SENs that meet various casting conditions by 1 to 1 scale water modeling device or Computational Fluid Dynamics.

Examples of SEN configuration against alumina-clogging or biased molten steel flow in the mold

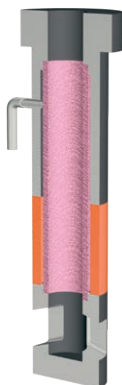
A Anti-clogging material



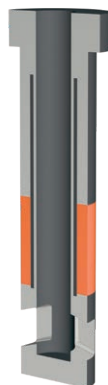
B Step type



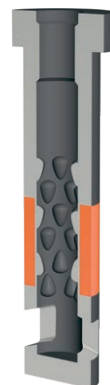
C Gas blowing structure



D Heat insulating slit



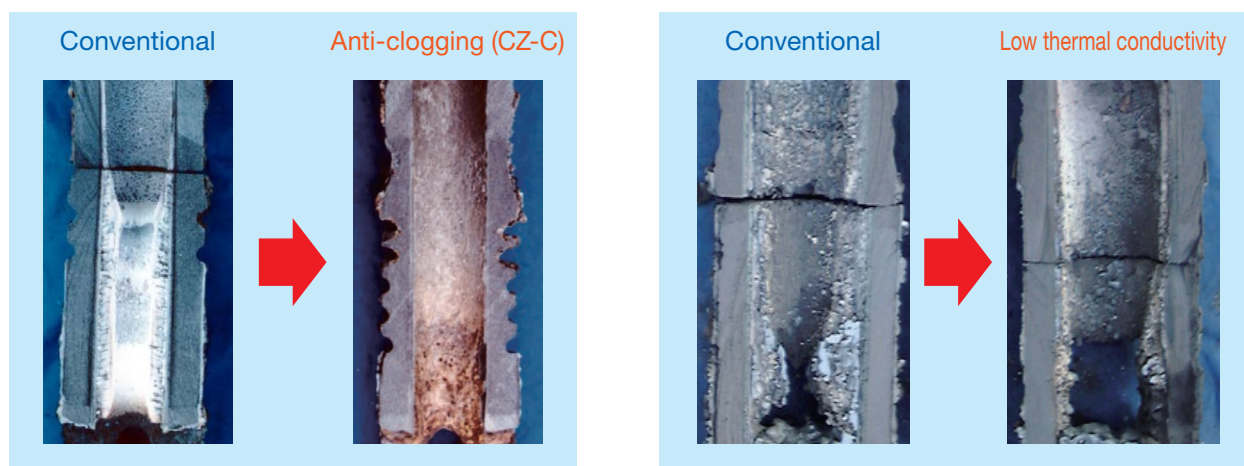
E Mogul



F Slope annular-step



Examples of clogging prevention by special materials



■ Properties

Items	Main body			Slag line			Cold start without preheat	
	All purpose	Stainless steel	High oxygen steel	All purpose	High density type	High ZrO ₂ type	Main body	Slag line
Application								
Brand	G31D series	G30H series	G1M series	G6Z series	G7Z series	G8Z series	G30A series	G3Z series
Apparent porosity (%)	15.0	16.5	15.5	15.0	12.5	12.5	14.5	14.5
Bulk density	2.25	2.55	2.50	3.70	3.95	4.10	2.30	3.60
Modulus of rupture (MPa)	7.5	9.0	6.5	8.5	9.5	10.5	7.5	9.5
Thermal expansion at 1000°C (%)	0.26	0.44	0.52	0.48	0.49	0.51	0.28	0.45
Chemical composition (%)								
Al ₂ O ₃	38	64	58	—	—	—	47	—
SiO ₂	27	—	—	—	—	—	22	—
MgO	—	—	18	—	—	—	—	—
ZrO ₂	—	—	—	77	81	84	—	70
C+SiC	31	30+5	16+4	19	15	12	30	23
Remarks		Non-SiO ₂	Spinel-C		High corrosion resistance	High corrosion resistance	Low expansion	

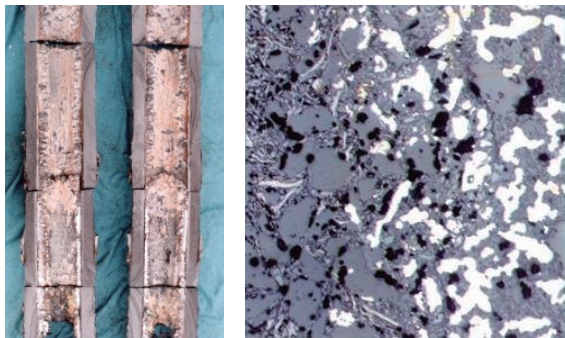
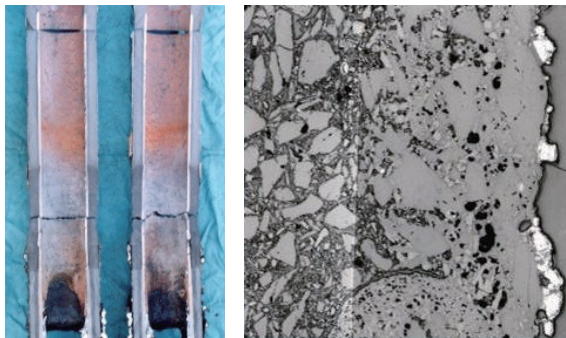
Submerged Entry Nozzle (SEN)

Carbon-free inside liner for SEN

(Example of various countermeasures against clogging)

■ Features

- Reduced alumina build up of SEN (or reduced Argon flow rate)
- Reduced carbon pick up of molten steel
- Reduced inclusion defects in the steel products

Conventional AG material	Carbon-free inside liner
	
Alumina build-up was developed on the decarbonized AG hot face.	The sintered carbon-free material prevented alumina build-up .

■ Properties

Area of application	Inner		
	0X series		
Type	Al ₂ O ₃	Al ₂ O ₃ -SiO ₂	Spinel
Apparent porosity (%)	23.0	22.5	21.5
Bulk density	2.90	2.40	2.70
Modulus of rupture (MPa)	1.5	2.0	3.0
Thermal expansion at 1000°C (%)	0.80	0.48	0.65
Chemical composition (%)			
Al ₂ O ₃	96	66	70
SiO ₂	—	27	—
MgO	—	—	26

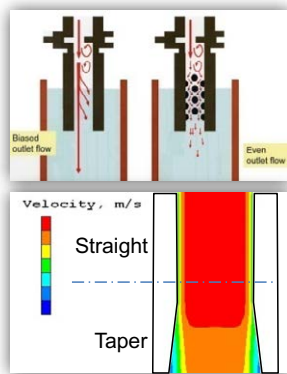
Trumpet (Single port with Mogul and reverse-taper) SEN

In actual casting, the direction of the outlet flow from single port does not become perpendicular.

Biased and deep-penetrated flow cause uneven solidified shell growth and inhibited inclusions floatation.

■ Features

- Mogul geometry solves biased flow.
- Reverse-taper port decreases outlet flow speed.



“Trumpet” SEN can generate straight and shallow flow.



Standard SEN

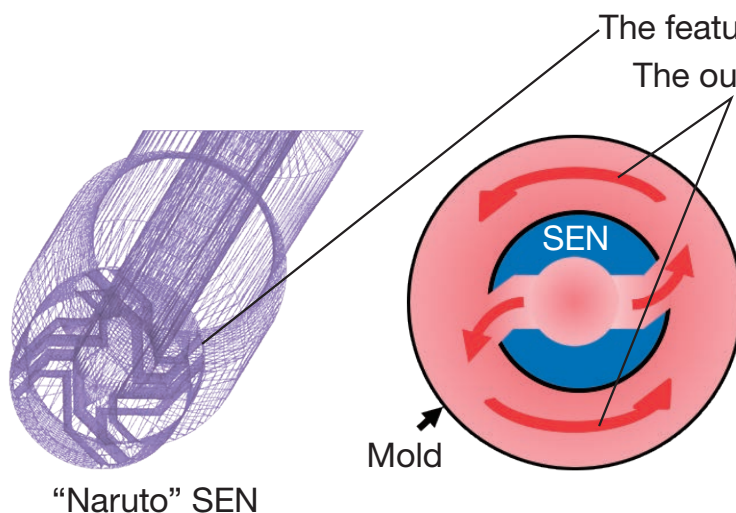


Trumpet SEN

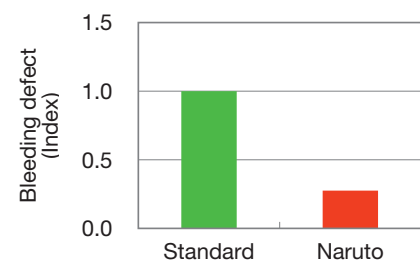
“Trumpet” SEN produces ideal flow pattern in bloom and billet caster.

⇒ Decreasing defects

Naruto (Lateral bend ports) SEN



The feature of “Naruto” is “bend ports”.
The outlet flow has turning movement.

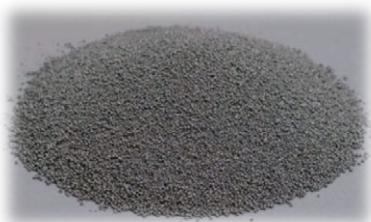
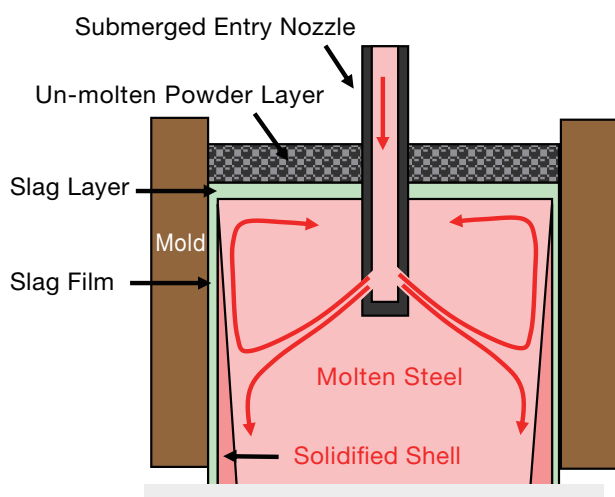


The ratio of bleeding defects decreased to 1/3 by using “Naruto” SEN

Mold Powder

Mold powders are widely used for continuous casting process and the roles are extremely important. We have been developing, manufacturing and selling mold powders and they get a favorable reception from customers. For the development of better and more excellent products, we continue our research and development activities daily and our expert staffs are supporting the operation in our customers' factories.

■ Roles of Mold Powder



	Chemistry (%)
SiO ₂	28-40
Al ₂ O ₃	2-10
CaO	28-44
R ₂ O	0-20
(Na ₂ O+Li ₂ O+K ₂ O)	
F	2-12
T.C	2-15
CaO/SiO ₂	0.7-1.5

- Insulation

Un-molten mold powder layer and molten powder slag provide thermal insulation of the surface of meniscus to prevent freezing of molten steel and to help inclusions floatation.

- Prevention of Re-oxidation

Powder slag layer prevents re-oxidation of molten steel by protecting from the air.

- Absorption of Inclusions

Powder slag absorbs and removes out non-metallic inclusions and gas bubbles from molten steel to prevent defects.

- Lubrication

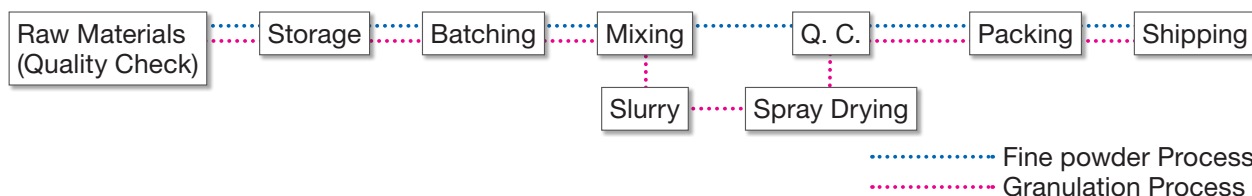
Powder slag flows into gaps between mold wall and solidified steel shell, and it provides lubrication.

- Heat Removal Control

Powder slag film reduces heat removal between mold and solidified steel shell to prevent strand surface cracking.

■ Mold Powder Production Flow

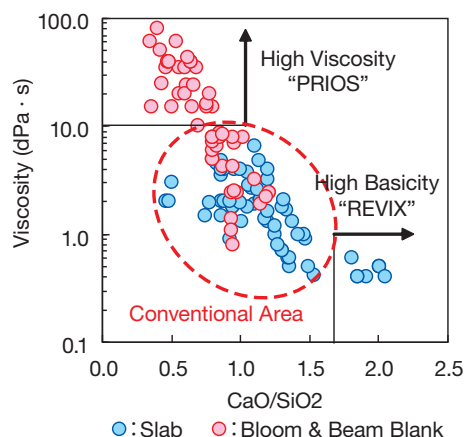
Shinagawa is committed to providing our customers with mold powders of the highest quality and constancy.



■ Our Proposals

The grades of mold powder should be determined after careful study on the steel type, casting conditions, parameters and tasks. We are pleased to support our customers by providing advanced technologies in conjunction with accumulated data and/or our abundant experiences.

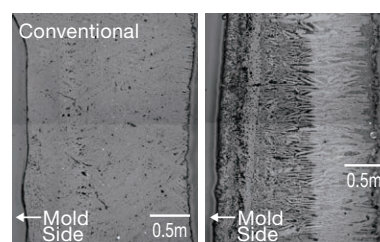
We have a lot of unique mold powder technologies that could improve your casting issues.



High Basicity Mold Powder "REVIX"

Application: Peritectic/Medium Carbon Grades

- High crystallization speed in the slag film
- Providing softer heat removal from initial solidified stage in the mold
- Prevention of strand surface cracking

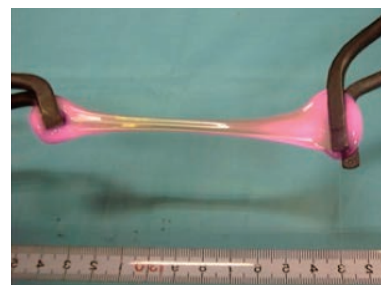


Comparison of Actual Slag Film

Fluorine Less Ultra-High Viscosity Powder "PRIOS"

Application: Billet, Bloom and Beam Blank casting

- Available on lower powder consumption
- Improving surface quality
- No sticking
- Reduction of casting machine corrosion
- Extended SEN life by decrease of erosion rate



High Viscosity Slag

Exothermic Type Mold Powder

Application: Starter and Running Powder

- Gaining exothermicity by metal oxidation in the mold powder
- Reduction of gas and inclusion defects
- Stable operation at casting start
- Reduction of oscillation mark depth
- Prevention of carbon pick-up by less carbon



Conventional High Viscosity PRIOS
Comparison of SEN Erosion



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