INSTEEL®
SERIES OF MULTICOMPONENT MODIFIERS FOR EXTRA-FURNACE STEEL PROCESSING

Our company produces **INSTEEL®** multicomponent modifiers used for extra-furnace steel processing. They contain such chemically active components as **Ca, Sr, Ba, Ti, Zr, Ce, La**, etc. Their combination and quantitative content in particular grades depend on the specific conditions of their application and challenges faced by a particular foundry plant working to meet quality requirements.

INSTEEL® modifiers are produced by using a proprietary technology called "chips process". The modifiers produced by using this technology have characteristically dense, highly dispersed structures and low gas saturation.

All INSTEEL® multicomponent modifiers significantly increase steel fluidity. High fluidity ensures good castability and thus proper feeding of thin-section castings, They also make it possible to lower pouring temperatures and solve the problem of shrinkage defects.

Besides, each **INSTEEL®** series **modifier** additional particular properties.

1. INSTEEL®1.3, INSTEEL®1.5 and INSTEEL®6.1 modifiers

are the grades of modifiers used predominantly to solve problems caused by the significant contamination of carbon, low- and medium-alloy steels by non-metallic inclusions resulting in low fluidity of steel and structural defects of castings.

They contain such chemically active components as **Ca** and **Ba** in various proportions, have different degrees of efficiency, which makes it possible to vary their use depending on the degree of initial contamination of the melt and possible limitations on silicon in it. **Calcium** contained in these modifiers has low solubility in iron, reacts actively with oxygen, sulfur, hydrogen and other elements, purifies the boundaries of grains of carbonitrides, sulfides that make steels brittle. Calcium promotes modification of the products of aluminum deoxidization leading to the formation of readily removable globular NMI.As a result, **the pliability and impact strength of steels increases**. Calcium vapors are highly resilient, which significantly decreases its recovery in steel in the absence of barium.

Barium (Ba) does not easily dissolve in iron but, unlike calcium, it has a low pressure of vapors in the zone where its modifier dissolves (5.2 kPa at 1,600C).As the melting point of barium is relatively low (710C), it reacts earlier and more efficiently with oxygen and sulfur, and its high surface tension (wettability) promotes rapid and complete removal of reaction products.

The presence in one modifier (alloy) of calcium and barium which are fully reciprocally soluble, when liquid, lowers the elasticity of their vapors in steel. Due to a slower rate of evaporation of the elements the period of reaction of calcium with the melt increases. As a result, its purification of oxygen and sulfur progresses more efficiently and the degree of calcium recovery increases due to the modification of a larger amount of NMI.

2. INSTEEL®11 modifier contains zirconium **Zr** in addition to its main components **Ca** and **Ba**. **Zirconium** is a multi-functional element as it acts as a deoxidizer, desulfurizer and denitrizer. It prevents other elements (vanadium and boron) from interacting with oxygen and nitrogen. Additions of zirconium as well as titanium to the melt result in the formation of carbosulfides.

Zirconium also combines with other elements to form Zr(N,C), ZrSx or Zr4S2C2.Due to its significant affinity to nitrogen, zirconium can force nitrogen out of aluminum nitrides. Interaction of ZrN with (Zr,Mn)S results in the formation of inclusions having the shape of angular crystals. Zirconium carbonitrides also form as thin layers around sulfides.

Zirconium is used as a microalloying element to increase the strength, toughness, wear- and corrosion resistance, hardenability, weldability and workability of steels.

The INSTEEL®11 modifier has shown high efficiency when used for producing heavy-duty cast products utilized for the manufacturing of rolling stock for the Russian Railways (railway carriage frames and beams). It increased the impact strength of steels at low temperatures (KCV-60).

3. INSTEEL®3.2, INSTEEL®3.3 and INSTEEL ®10.1 modifiers, besides such main elements as **Ca** and **Ba,** also contain REM, predominantly **cerium (Ce)** and/or **lanthanum (La)** in various concentrations.

The effects of REM on steels are diverse. Their use not only results in efficient globularization of non-metallic inclusions but also makes it possible to change conditions under which castings solidify.

Formation of REM hydrides **promotes high corrosion resistance of steels.** REM, in their turn, are capable of forming high-melting and hard intermetallic compounds (intermetallics) with non-ferrous metals, which eliminates intercrystalline low- and high-temperature brittleness thus increasing the plastic properties of steels.

REM significantly influence conditions under which steels solidify modifying the macro- and microstructure of ingots and castings. REM oxides, sulfides and nitrides as well as intermetallics **produce a modification effect on the structure of steels,** contributing to their strength. Additions of REM decrease the segregation of liquating elements (carbon, sulfur and phosphorus), reduce the value of the columnar zone, the size of equiaxed crystals and the distance between dendritic branches. This deeper impact on the structure of steels **significantly improves the crack resistance of ingots undergoing subsequent forging.**

4. The INSTEEL®5.1 and INSTEEL®5.2 modifiers also contain **Ca, Ba and RE,** but higher concentrations thereof, which significantly increases their efficiency when solving special problems. For example, ladle treatment of steels used for underground and underwater pipelines, which are continuously exposed to factors causing corrosion, makes it possible to significantly increase their service life. These modifiers are also quite efficient for ladle treatment of steels used for manufacturing **corrosion resistant shut-off valves.**

5. The INSTEEL®4.4 and INSTEEL®7 modifiers, in addition to **Ca, Ba and RE**, contain **titanium (Ti).** **Titanium** is a strong deoxidizer. It efficiently impacts the phase composition and morphology of non-metallic inclusions by additionally deoxidizing steel, increases the solubility of hydrogen in steel thus preventing pinholes from appearing in castings.

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Depending on its concentration in steels and their chemical composition, titanium form carbides (TiC), sulfides (TiS), carbosulfides (Ti4C2S2) and nitrides (TiN).Carbides increase the hardness of steels to a greater degree. Titanium injected into molten steel forms TiNs forms nitrides as early as during the pre-crystallization and crystallization periods. By binding sulfur and nitrogen and forming infusible particles, titanium not only produces a modifying influence on the process of crystallization but also performs a barrier function as a refiner of austenite grains during processes of heat treatment.

Titanium is used to prevent intercrystalline corrosion **when manufacturing corrosion-resistant ferritic and austenitic steels.**

Injection of microadditions of titanium into steel promotes fine-grained structure and reduces the tendency of steel towards the formation of hot cracks.

Titanium increases the wear resistance of steels as they resist increasingly the development of plastic deformation at its initial stage and their hardness increases. It also impacts their mechanical properties by not only refining austenite grains but also by reinforcing them and strengthening intergranular bonds.

6. The INSTEEL®9.3 and INSTEEL®9.4 modifiers, in addition to **Ca, Ba,** also contain **Sr.** Strontium and other AEM contained in multicomponent alloys enhances the impact of calcium and barium on the various properties of steels: their flowability and mechanical properties.

The use of this modifier makes it possible to obtain a high degree of calcium recovery and highest impact strengths at temperatures below freezing.

Based on the obtained results with regard to modification, it is safe to assume that strontium, as compared to barium, more efficiently protects calcium from oxidization and transforms it into a microalloying element, making the dendrite structure of steel castings more refined and improving steel properties.

7. INSTEEL® modifiers can be manufactured to have such chemical compositions as to meet individual customers' requirements. They may also contain boron and vanadium.