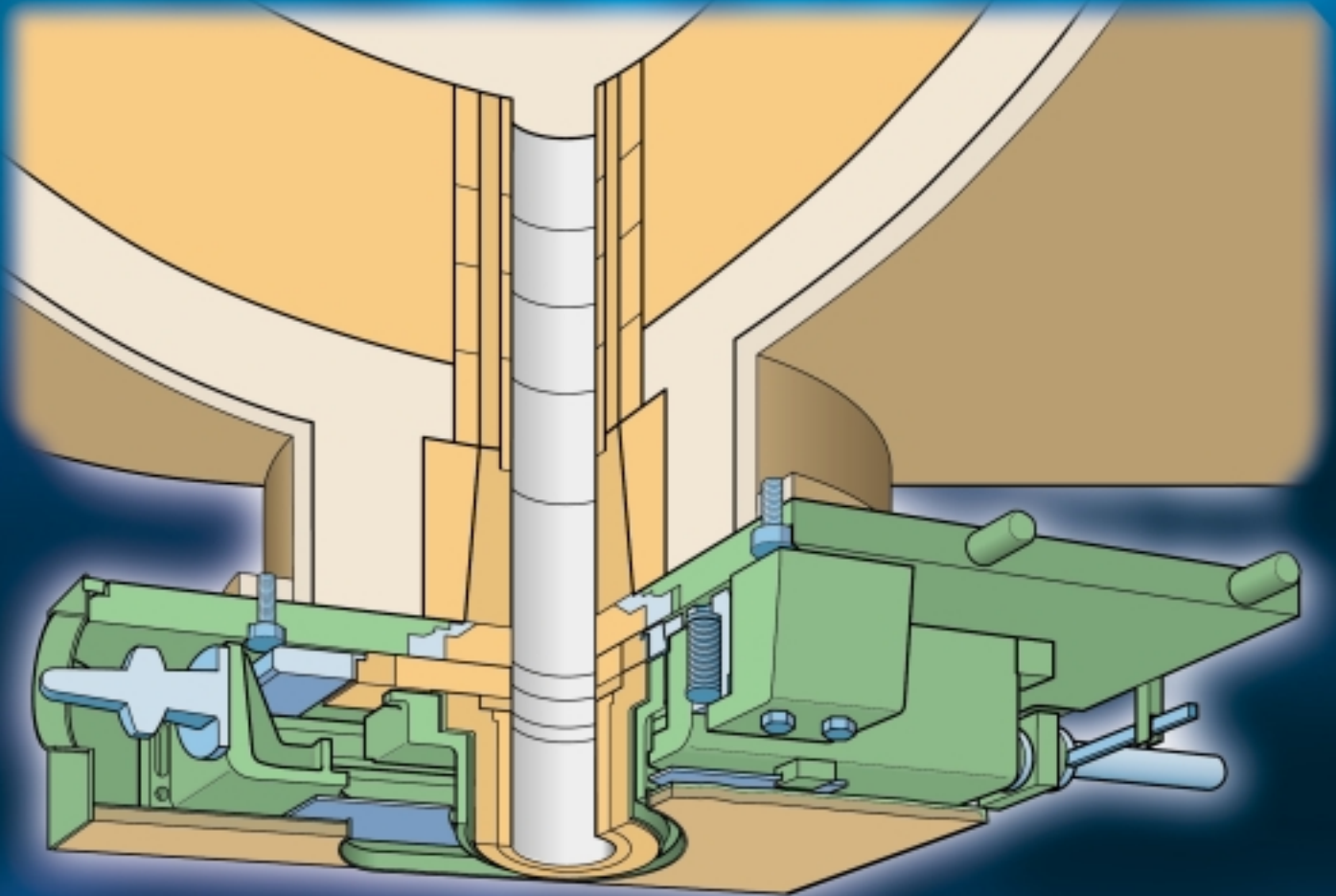


# Slag Free Tapping with the INTERSTOP Tap Hole Gate Type TAP 120



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## Abstract

Slag free tapping is the key to the clean steel technology, to improve steel quality and to reduce production costs.

BOF converters require special applications of slag retaining systems, such as floating stopper, pneumatic stopper, quick retilting of the converter, float balls etc. However, there is no system which has fully met the requirements so far. This leads to the consideration for a special BOF designed slide gate and handling system.

Salzgitter AG, Salzgitter, Germany worked together with Stopinc AG – the world-wide leader in Flow Control Technology – and Didier Werke AG for the refractories, to develop a reliable and well performing tapping system for an improved slag free tapping for their 210 ton BOF-vessels by means of the new INTERSTOP Tap Hole Gate Type TAP 120.

The handling of a slide gate system on a BOF i.e. the tools to replace mechanical and refractory parts within a very short period of time was one of the major preconditions for the successful introduction of this Tap Hole Gate.

The combination of a Tap Hole Gate with a slag detection system was the logical consequence for an automatized operation, resulting in the production of ultra clean steel grades for highest quality levels.

With this paper we are pleased to present results regarding the metallurgical quality and economical advantages reached so far with the industrial experience over more than 7'500 taps with the INTERSTOP Tap Hole Gate Type TAP 120 (Figure 1).



Figure 1:  
Tap Hole Gate on BOF-Vessel

### 1. Presentation of Project

Salzgitter AG produces flat products at the Salzgitter plant, e.g. high standard sheets for the automotive industry, plate grades up to 690 N/mm<sup>2</sup> of tensile stress as well as HIC resistant pipe line grades. The installations in the liquid steel area at the Salzgitter plant are consisting of:

- 3 BOF's of 210 tons each
- 4 Ladle treatment stations
- 2 VD degassing stands
- 2 Twin LF's
- 2 Slab CCM's

The annual capacity of 4'400'000 tons is achieved with 60-70 heats/day.

The BOF vessels are equipped with the Iso-Jet Tap Hole System (Veitsch). This Iso-Jet System is the key for handling and positioning the Tap Hole Gate at the channel end (Figure 2). The tap hole channels are rebricked with the LAG (Veitsch) setting and removal machine (Figure 3), which grants also the precise centering of the link to the Tap Hole Gate. The coil of the early slag detection system (Amepe) is integrated in the safety lining of the tap hole.

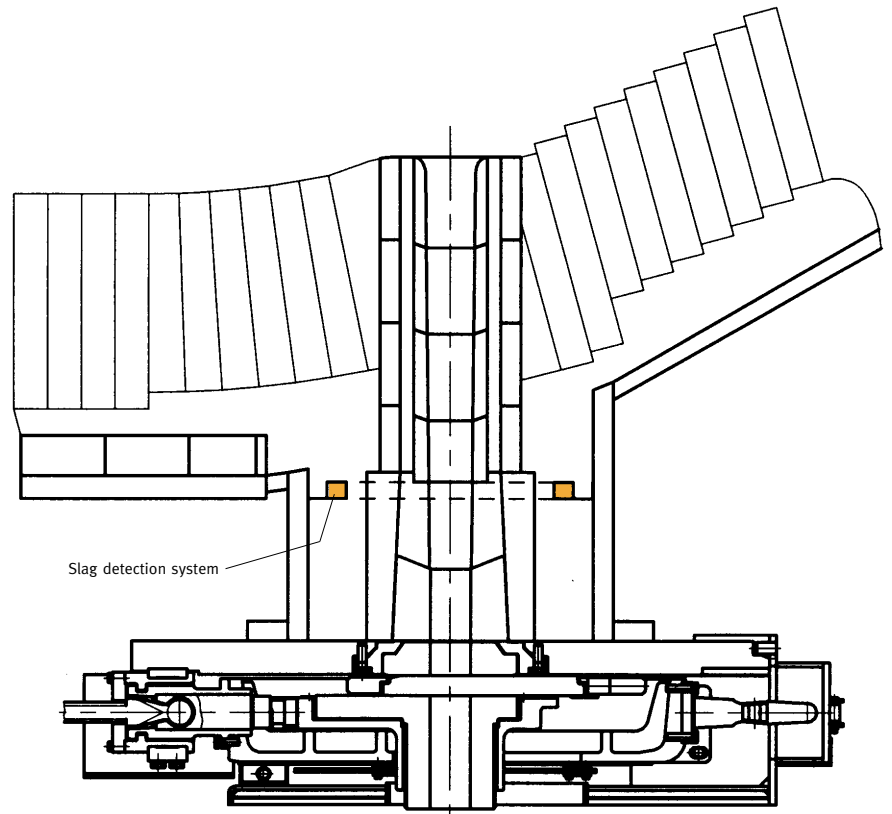


Figure 2:  
Section of tap hole with Tap Hole Gate

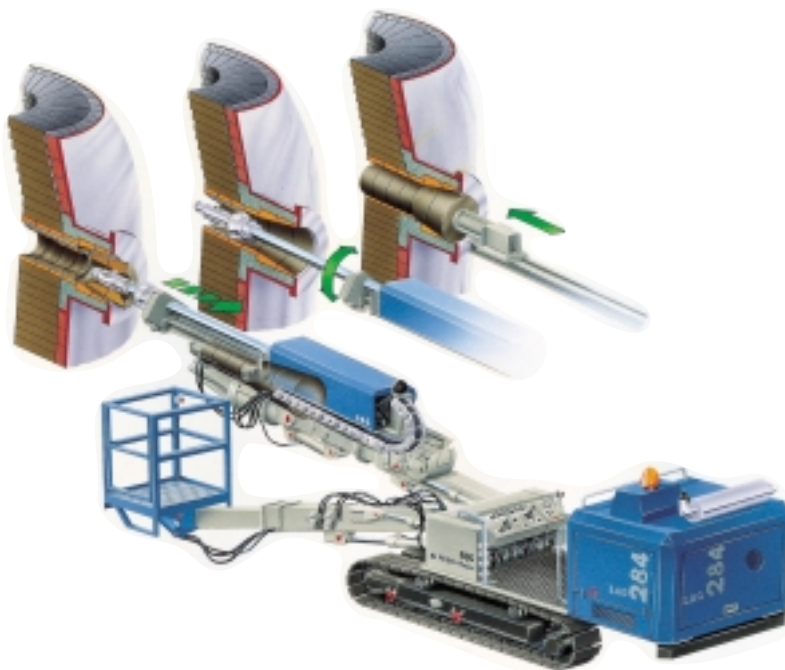


Figure 3:  
LAG tap hole setting and removal machine

It was decided to go with the slide gate system after the preliminary tests, because neither of the used slag hammer stopper nor other conventional shut-off systems were able to give a clean, safe and splashfree closure of the tapping channel.

The solution Tap Hole Gate was reached through several field and hot tests which were divided into the following subjects:

- a) Slide gate design and drive system as well as the mounting on the vessel
- b) Quick exchange of the Gate with a manipulator for the off-line replacement of the refractory material
- c) Operational features with closed start of tapping avoiding start-up slag and reduced slag carry over to the ladle while tapping.

Several tests were necessary in order to define the ideal refractory combination and tensioning system. The pneumatic drive was chosen for safety reasons.

The manipulator was specially designed for the handling of the Gate, in order to reduce the downtime of the vessel to a minimum. All other works on the Gate are done off-line.

## 2. Description

The INTERSTOP Tap Hole Gate Type TAP 120, consists of the following three main components:

- Base with the drive connection
- Gate with protection box (Gate)
- Drive assembly (pneumatic cylinders with a special bell crank design)

The base, drive connection and the lateral guide rails are bolted onto the tap hole flange of the vessel.

The Gate is handled with the manipulator while mounting/dismounting to and from the base.

The drive consists of two pneumatic cylinders which are mounted below the supporting ring of the vessel.

The Tap Hole Gate is manually operated from the operator control panel of the BOF, or through an automatic control, triggered by the early slag detection or ladle weight system.

## 3. BOF Operation

The BOF is charged and tapped on the same side. During charging the Gate is in the open position. Then the Gate is closed just before tapping while the vessel is rotated into the tapping position. After a few seconds of holding time (in order to allow the slag to float up) the Gate is reopened. After reaching the desired ladle filling the gate is automatically closed by using the signal from the ladle weight measuring system and then the vessel is turned back in the upright position. If slag is flowing through the tap hole before reaching the desired ladle filling, the Gate is automatically closed based on the early slag detection signal. The shut-off movement lasts only 0.3 seconds. This quick movement is one of the advantages against other systems. The Gate is opened again when the vessel stands vertically, and the slag is dumped afterwards.

## 4. Mounting/Dismounting of the Gate

The Gate is handled with the help of a manipulator. Two racks for the storage of the relined and the used Gate are also located on the manipulator. A device for the exchange of the adapter brick (link of the tap hole channel with the Tap Hole Gate) is mounted likewise on this manipulator.

All handling cycles are controlled from the pulpit of the manipulator through an hydraulic control system.

A change of the Gate and the tap hole channel sleeve immobilizes the BOF for 35 minutes, but the Gate change needs 10 minutes only (Figure 4).

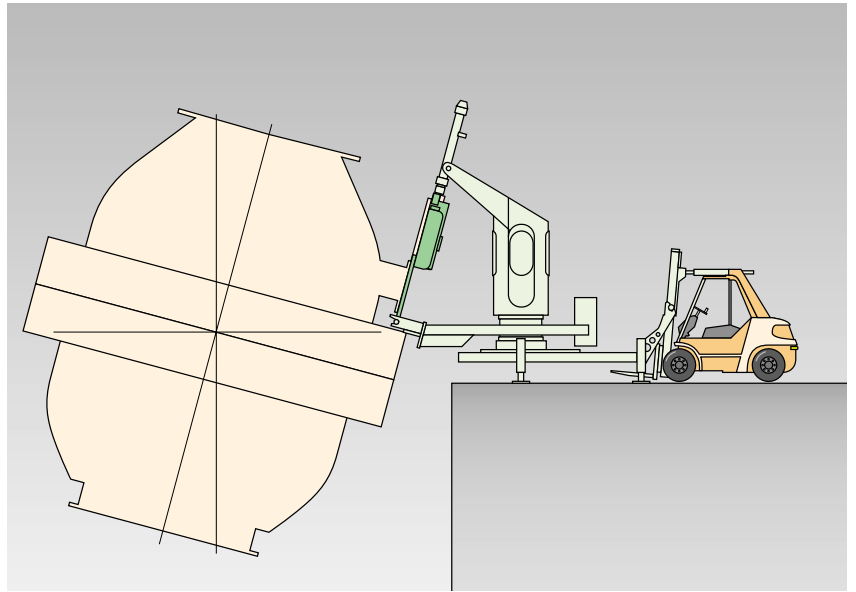


Figure 4: Manipulator lay-out

## 5. Metallurgy/Results

During trials in spring 1997 more than 300 melts were tapped with the INTERSTOP Tap Hole Gate Type TAP 120. All comparisons have been made with the existing conventional practice applying a slag hammer device. The metallurgical advantages of the system were determined by measurements of the slag depth in the ladle after tapping and the mass balances of phosphorous, vanadium, chromium and the amount of aluminium added for desoxidation.

When the tap hole has to be changed, the adaptor brick and its holding ring are dismantled after taking off the Gate. The tap hole is then cleaned and redone with a repair set by means of the LAG machine. After setting the adaptor brick and holding ring the relined Gate is mounted with the manipulator.

## 6. Slag Depth Measurements in the Ladle

A number of 30 melts were tapped unkilld without the addition of lime and alloying material. Entering the secondary metallurgy station, a slag depth measurement with the Amepa Slagmeter was performed. To reach a higher accuracy the measurement was done twice and the average value was calculated. The slag depth was then converted into the mass of carry over slag. Figure 5 compares the results of the trials with the conventional practice. It can be seen, that the amount of carry over slag was significantly reduced to 70% which is equivalent to the reduction of 400 kgs carry over slag per heat.

## 7. Phosphor Balance

The mass balances of phosphor from the converter and the final sample in the secondary metallurgy station were made to prove the slag depth measurements by calculating the amount of carry over slag. The balance was corrected by the phosphor input of alloying material, especially ferromanganese for a total number of 2000 heats. The cumulative frequency of this amount of carry over slag is presented in figure 6.

Comparison of the Amount of Carry Over Slag from the Converter with and without the Converter Tap Hole Gate Type TAP 120

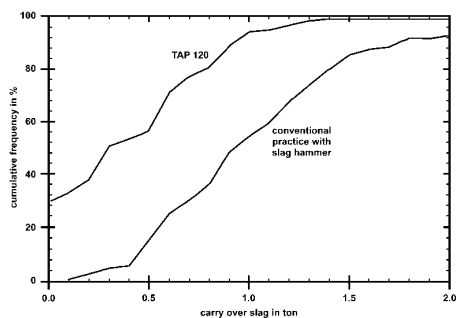


Figure 6: Carry over slag

It can be seen that the use of the Tap Hole Gate is profitable against the existing practice. The average mass of carry over slag is reduced from 0.9 t down to 0.5 t. More than 90% of the melts have less than 1.0 t of such carry over slag. This improvement leads to a decrease in the aluminium consumption for desoxidation and Al alloying. Figure 7 shows this reduction.

Taking these results into consideration it is justified to say, that the design and the installation of the Tap Hole Gate is an effective instrument to reduce and to impede the carry over slag from the converter to the ladle and thus a desired metallurgical step for the production of ultra clean steel to the corresponding quality standard.

Slag Depth Measurement in the Ladle after Converter Tapping for the Determination of Carry Over Slag

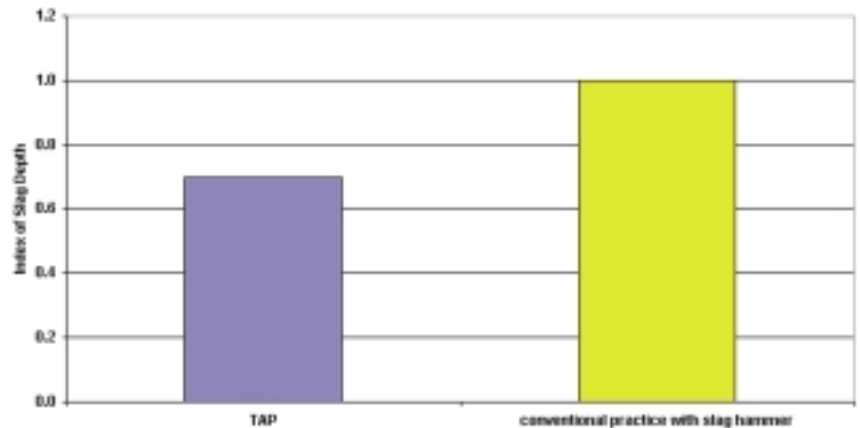


Figure 5: Index of slag depth

Comparison of the Al Consumption for Desoxidation and Alloying in the Ladle

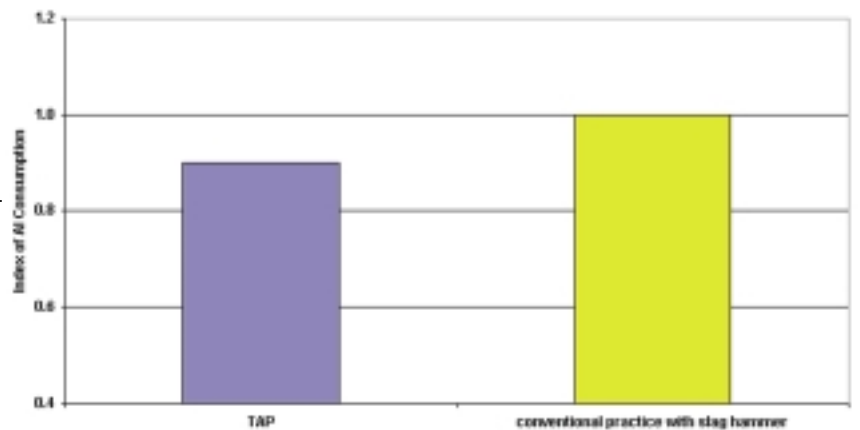


Figure 7: Index of Al consumption

## 8. Summary

With the introduction and the industrial operating experience of the new INTERSTOP Tap Hole Gate Type 120 at Salzgitter AG, Salzgitter, the following advantages have been confirmed:

- Safe operation on BOF application
- Optimal handling by means of a specially developed manipulator to reach min. BOF immobilisation time
- Improved metallurgical and economical results due to reduced amount of carry over slag

These advantages leads the Salzgitter AG to equip all 3 Converters with the INTERSTOP Tap Hole Gate Type 120.

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