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# Technical Report

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## Saving fuel by efficient crown insulation

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### 1. Introduction

Most glass producers all over the world use furnace insulation as a standard practice, trying to reduce the heat losses from the furnace walls to a minimum level. The glass furnace crown covers a large area of the furnace and when insulated significant savings of energy can be achieved. According to Wosinski [1], the heat losses from the silica crown are about 5 % of the total heat loss in a glass melting furnace.

According to the current practice, the thermal insulation of the main crown usually comprises several layers of light silica bricks [2 to 5]. This type of insulation reduces the heat losses from 4500 to 5000 W/m<sup>2</sup> to 1750 to 2500 W/m<sup>2</sup>. The refractory producers have succeeded in improving the insulating efficiency of the light silica bricks. One of the leading producers [5] gives as an example a crown insulation with two layers of insulation brick with a density of 0.65 g/cm<sup>3</sup>, reducing the crown heat losses to 2480 W/m<sup>2</sup>. A previous insulation with three layers light silica bricks with a density of 1.0 g/cm<sup>3</sup> reduced the heat losses to 2500 W/m<sup>2</sup>.

The latest trends and practice among the leading glass producers are to apply crown insulation with maximum efficiency [6]. The limiting factor for the degree of the insulation being applied is the cost of the insulating materials compared with the amount of the saved fuel. Silica insulating bricks are compatible for reducing heat loss of the crown, but with increasing thickness of the insulation, thermal efficiency becomes less due to the rising thermal conductivity of both silica and insulation [3]. The efficiency of the crown insulation can be improved by applying Insulation Fire Brick (IFB) (5), but in this case a patching material is needed as a neutral barrier between the silica brick and IFB. The efficiency can be also increased by adding some layers of blanket type insulation, but this multi-layer construction has the disadvantage of limited detection of or accessibility to any hot spot that may develop [3].

According to our own observations and calculations covering a period of 20 years, there is a certain limit in respect of increasing the efficiency of the crown insulation and decreasing the heat losses, which is at about 900 to 1000 W/m<sup>2</sup>. Applying more insulation beyond this limit will

give practically no significant heat loss reduction and fuel savings and no pay back.

The aim of this article is to introduce glass producers to the use of thermal insulation of silica crowns with maximum efficiency based on the positive experience and know-how of Lubisol Engineering Co. This know-how incorporates our new method for hermetic sealing of the silica crowns by cold chemical welding [7], leading to reduced corrosion and long service life in combination with efficient thermal insulation and fuel savings.

### 2. Crown insulation and rat-holing

The main obstacle for the implementation of an efficient thermal insulation of glass furnace silica crowns is the strong conservative tradition in the glass industry worldwide. The prevailing conception for many years in the past was that the more efficient insulation would entail the disadvantages of a higher corrosion rate and "rat-holes" in the silica crown. In recent times this "theory" has been rejected, and many authors are suggesting the application of a highly efficient crown insulation to increase the temperature inside the silica above the temperature of condensation of alkaline fluxing substances [8 and 9].

The quality of the silica available now is much higher, but in spite of that rat-holes are still present from time to time in most of the glass furnace silica crowns. Rat-holing is still a serious problem especially for the furnaces with oxy fuel firing [4, 8 and 9].

It is well known that the hot face of the silica brick becomes covered with a glassy phase acting as a protection barrier against further corrosion [10]. The real problem is the condensation corrosion in the loose joints between some of the bricks, allowing hot flue gasses to pass through and to condense in the cooler parts. This leads to the formation of holes in the crown, known as "rat-holes".

According to our observations, any degree of thermal insulation applied over a new silica crown may lead to "rat-holing" if and when the crown brickwork was not built fully airtight. It is well known, however, that building an airtight crown is a rather difficult task due to a variety of reasons:

a) insufficient quality of some silica bricks with large tolerances in the dimensions;

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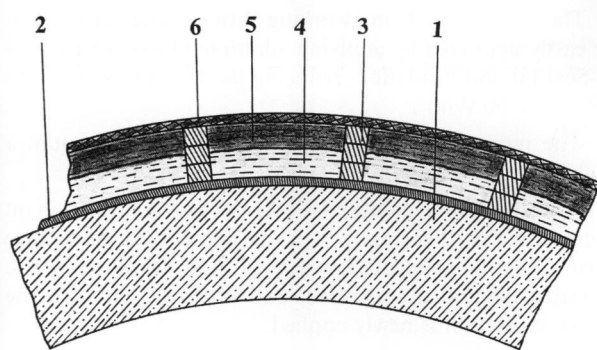


Figure 1. Typical Lubisol package with various insulating layers: 1: silica crown, 2: Si-Seal patch, 3: light silica bricks, 4: Lubisol-1 P insulation, 5: Lubisol-2 SL insulation, 6: Lubisol-3 (cover coat).

- b) low quality and poor plasticity of the silica mortar together with some mistakes and deviations during the building of the silica crown creating loose joints in the brickwork;
- c) cracks formed during a poor heating-up of the furnace crown;
- d) other reasons with minor influence.

### 3. 'Lubisol' insulation package

The 'Lubisol' insulation package incorporates a very efficient crown insulation, including a hermetic sealing layer applied directly over the silica crown to make it airtight. For this purpose we invented the Lubisol Si-Seal hermetic sealing kit, a new product having unique properties [7]. Applied in only 10 to 15 mm thickness directly over the whole silica crown it acts as a barrier against corrosion and rat holing, preventing totally the passing of hot flue gases and fumes through the crown brickwork. The Si-Seal kit features a very strong and durable adhesive bond towards the silica crown up to 162 °C. The crown of any working glass furnace can be upgraded with this protection layer, and so the service life of this crown can be prolonged for a very long period of time. This new unique sealing process resulting in a strong and durable chemical bonding can be best described as cold chemical welding of silica crowns.

The thermal insulation included in the Lubisol package (figure 1) incorporates one layer of Lubisol-1 P monolithic insulation or light silica bricks, one layer of Lubisol-2 SL monolithic insulation and one layer of Lubisol-3 finishing cement. Light silica bricks can be used as the first insulating layer if they are available in the glass factory, left from previous campaigns.

The main advantage of the Lubisol insulation is the very low specific weight and the high efficiency of the insulation due to the very low thermal conductivity factor. The super-light insulation has a specific weight of only 0.3 g/cm<sup>3</sup> and a thermal conductivity factor of 0.075 W/(m K). This contributes to reducing the needed thickness of the insulation with a reduced load over the silica crown. At the same time, it brings the rather important advantage of reducing the needed material costs of the insulation.

The efficient crown insulation also has a beneficial effect on the glass melting process. The well-insulated crown ac-

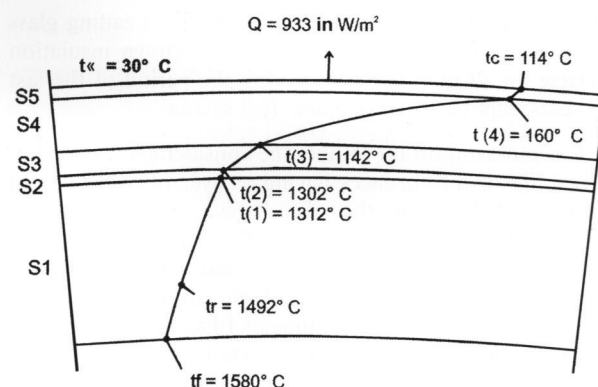


Figure 2. Heat loss calculation with Lubisol insulation being applied; S1: silica crown, 450 mm thick, S2: Lubisol Si-Seal kit, 15 mm thick, S3: Lubisol-1 P insulation, 75 mm thick, S4: Lubisol-2 SL insulation, 150 mm thick, S5: Lubisol-3 covering cement, 30 mm thick,  $T_c$ : cold face temperature,  $T_f$ : furnace temperature,  $T_r$ : temperature in 1/3 of crown.

cumulates a bigger amount of energy, acting as a barrier against heat fluctuation in the melting tank, thus achieving better homogeneity of the molten glass and improving the glass quality.

### 4. Practical results

The package of Lubisol insulating materials, including the Si-Seal kit, has been applied with great success on more than 65 glass furnaces in 18 countries all over the world. When the crown is insulated with 240 mm Lubisol insulation, the heat losses are being reduced from 4800 to 5000 W/m<sup>2</sup> down to 900 to 1200 W/m<sup>2</sup>, resulting in considerable fuel savings (figure 2). These figures are almost twice lower than the traditional light silica insulation having heat losses between 1750 and 2500 W/m<sup>2</sup>. The average level of fuel savings being achieved has been 1.0 to 1.5 % for furnaces where the existing insulation was upgraded with the more efficient Lubisol package, and about 4.0 to 4.5 % for furnaces where no crown insulation was used in the previous campaign.

We have made continuous monitoring on many glass furnaces with efficient Lubisol crown insulation, including seven float glass furnaces and 25 big sheet glass and container glass furnaces. It has been observed that the Lubisol crown insulation does not involve a higher corrosion rate, due to the fact that the maximum crown temperature has not been increased or changed. All these furnaces were operated at the same maximum crown temperature needed for the glass melting as before the upgrading, and the application of a more efficient crown insulation gave as a result only a reduction in the amount of fuel coming to the burners.

The Lubisol crown insulation package achieved real fuel savings of about 2.0 % on six float glass furnaces in the USA, and between 1.5 and 3.0 % fuel savings to many sheet glass, container glass and technical glass furnaces all over the world. A leading technical glass producer in the USA has applied Lubisol insulation on four furnaces since 1996, the latest application being in 2003. A very efficient crown insulation and hermetic sealing was applied on several con-

tainer glass furnaces in the Czech Republic. Leading glass producers in India have applied Lubisol crown insulation package on all their furnaces during the period of the last ten years, reporting considerable fuel savings.

It is most important to note the considerable increase in service life of the furnaces having a layer of Si-Seal Cold Chemical Welding on the silica crown. Several furnaces where the Si-Seal hermetic sealing was applied for the first time in 1999 are now in excellent condition, without any signs of corrosion or rat hole problems during a period of four years. In such cases a lifetime of 10 to 12 years without any corrosion problems can be expected.

Thus, the Lubisol crown insulation package offers the best combination of efficient crown sealing and insulation at rather low competitive cost with fuel savings between 1.0 and 4.5 %, and at the same time contributes to a very long service life of the silica crown of ten years or more.

## 5. Conclusion

a) A new type of very efficient crown insulation package has been developed, where the problems of condensation corrosion and "rat holing" have been solved with a new type of hermetic sealing layer, applied by cold chemical welding. This new special hermetic sealing layer totally prevents the movement and passing of hot flue gases and vapors through the silica brickwork as well as any condensation corrosion.

b) We strongly recommend that all glass furnace silica crowns have a highly efficient thermal insulation, reducing the fuel cost and imposing a beneficial effect on the glass melting process as a whole. If the heat losses from a silica crown are more than 1200 W/m<sup>2</sup>, this should be considered as useless wasting of energy.

c) The insulation of any working furnace silica crown can be easily upgraded by applying additional layers of Lubisol Si-Seal kit and insulation, reducing the heat losses down to 1000 to 1200 W/m<sup>2</sup>.

d) The more efficient crown insulation does not entail a higher corrosion rate.

e) With the implementation of efficient crown insulation on their furnaces, the glass producing companies can reduce their total fuel budget between 1.0 and 1.5 % when the crown insulation is upgraded, and up to 4.5 % when the crown insulation is newly applied.

## 6. References

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