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Title:	**Annual LPG Gas Consumption for Ladle Pre-heater Station**

Authorization

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Revisions

This document has been revised according to the following schedule:

Revision	Date Approved	Nature of Revision	Prepared by
00	See title page	First Issue	N Kekana

Contents:

1.0 PURPOSE

The purpose of this document is to provide the annual LPG gas consumption rate for the ladle pre-heater station at Area 26 Smelter Facility.

2.0 SCOPE

The document covers the calculations for the amount of LPG gas consumed annually by the Tecflame burner at the ladle pre-heater station.

3.0 REFERENCES

The following are referenced in this document:

[1] Alsoufi, M. S. (2016). Dr. *Economical and Technical Way of Ladle Pre-heating by the Use of Flameless Oxyfuel (HDS/LPG) Gas in the Steel Industry*, 6.

[2] Chapman, R. (2019, September 30). *Introduction to High Velocity Burners and Ladle Preheating*. Retrieved from FireBridgeInc: https://www.firebridgeinc.com/blog/introduction-to-high-velocity-burners-and-ladle-preheating/

[3] NLM-SAR-08 001 Rev.03 Smelter Safety Assessment Report

[4] Installation, dry-out, and sintering procedures for castables G-33

[5] Tecflame High-Temperature Burner Brochure

4.0 DEFINITIONS AND ABBREVIATIONS

4.1 DEFINITIONS:

No definitions applicable.

4.2 ABBREVIATIONS:

LPG	Liquefied Petroleum Gas

5.0 THEORY [1][2]

In a foundry, a ladle is a vessel used to transport and pour out molten metal (Figure 1).

Casting ladles are used for pouring molten metal into the moulds meant for producing casting/cast products. It is important for the ladles to receive, transfer, and deliver the molten metal without letting the molten metal cool down below an unacceptable threshold. Material heat loss in a ladle below a certain point results in severe maintenance and repair issues, as well as product loss and wasted energy. To minimize molten metal cooling during pouring, the ladle must be as nearly as hot as the molten metal itself (Chapman, 2019). The ladles are lined with low cement castables. The refractory lining needs preheating, so that thermal shock and damage to the refractory lining and temperature drop in the ladle are minimized. The preheating of the ladle is usually performed with a gas-fired burner which injects a combustion flame into the interior of the ladle to the desired temperature between 1000°C and 1200°C. The temperature of

the ladle during preheating can be measured and controlled using a thermocouple or pyrometer. Ladle preheating involves consumption of large quantity of fuel, such as natural gas or LPG gas (Alsoufi, 2016).

Figure 1: Molten metal pour out from ladle

5.1 LADLE HEATING PROCESS [2]

The ladle heating process consists of three main stages; drying, curing and preheating, as shown in Figure 2. Drying involves the removal of moisture from newly lined ladles. Curing is when the refractory lining is set. Lastly, preheating is when optimal ladle temperature is reached for use. While all these stages have slightly different needs, they all require temperature uniformity. In drying stages, uneven temperature distribution will result in retained moisture, which at later stages can be trapped and result in steam explosions. Uniform temperature distribution during the preheating stages and in ladle use will increase preheating efficiency and minimize heat loss from the molten steel. Therefore, it is essential that the burner systems in place for these stages can deliver heat to the entire ladle evenly [2]. The Tecflame high velocity gas burners offer a practical, cost effective approach to solving this problem.

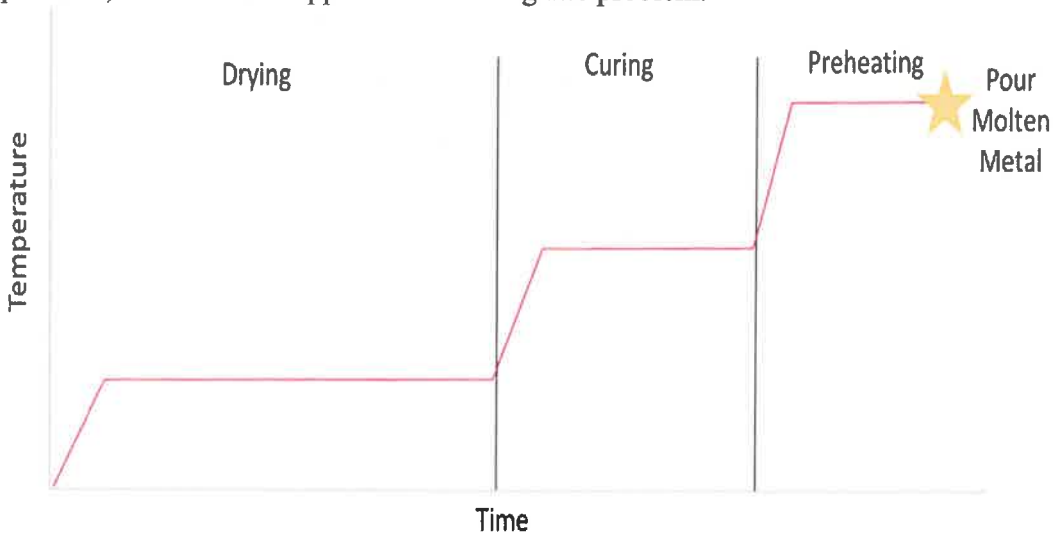

Figure 2: Ladle heating curve

6.0 SMELTER FACILITY OPERATION DESCRIPTION

To account for system shut-down and maintenance the Smelter Facility will a have a furnace availability of 90%, therefore, the furnaces will run for about 330 days per year. There will be three 8 hours-shifts per day. The furnace will require 4 hours to melt the material fully and bring it to the correct temperature [3], thus the ladles will require to be preheated approximately twice per shift. The new ladle refractory lining needs to be dried once, the dry-out schedule of the lining depends on its thickness, e.g. a 300 mm lining takes ~4 days (96 hours) [4]. Curing requires keeping the flame low for duration of 2 to 3 hours. Preheating the ladle must be done with a full flame touching up to the ladle bottom; the inside of the ladle must be dull red in colour (approx. temp 1200°C). This takes about 30 minutes to an hour. The Tecflame burner has an energy consumption rating of 1.5 – 2GJ/hr [5].

7.0 ANNUAL GAS CONSUMPTION CALCULATIONS

Annual number of ladle preheats:

$$2\frac{heats}{shift} \times 3\frac{shifts}{day} \times 330\frac{days}{year} = 1980 heats/year$$

Assuming that preheating the ladle will take 30 minutes

$$1980\frac{heats}{year} \times 0.5\frac{hr}{heat} = 990 hrs/year$$

The amount of LPG gas required:

The specific calorific value of LPG gas is 46.1 MJ/kg or 94MJ/m^3.

Therefore, the burner will consume

$$1.5\frac{GJ}{hr} \times \frac{1000MJ}{1GJ} \times \frac{1kg}{46.1MJ} \approx 32.5 kg/hr \ of \ LPG$$

Alternatively,

$$1.5\frac{GJ}{hr} \times \frac{1000MJ}{1GJ} \times \frac{1m^3}{94MJ} \approx 16 m^3/hr \ of \ LPG$$

The daily consumption of LPG gas by the ladle heater is approximately 98kg.

Thus, the annual LPG gas consumption is 32 175 kg per year.