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Scrap preheating system for arc furnaces at Fundición Monclova, S.A.

Final Report

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1. INTRODUCTION

From the energy diagnostics performed earlier at Fundicion Monclova, S.A. we found that an important energy saving measure, among others found, was that which relates to preheating scrap in the steel smelting process.

The basis for this improvement are founded on using a less expensive fuel (natural gas) for the initial scrap preheating and then melting the metal using electric energy, instead of using electric energy through the entire process as it is done today.

The benefits obtained for the company would be two different kinds:.

First the economic benefit as part of the smelting process switches from expensive electric energy to cheaper natural gas. (We have to remember that most of the electric energy in Mexico comes from thermoelectric plants which use hydrocarbons, natural gas among them, they have an average production efficiency of around 33% giving us a greater advantage in this kind of energy source exchange.)

Secondly we have that if metal fusion is performed with a starting temperature higher than the current one without preheating, smelting times at the electric arc furnaces will be reduced and consequently process production capacity will increase, if the metal preheating is done outside the furnaces and does not interrupt it's operation.

The steel factory has two 5 ton smelting furnaces which usually operate out of sync and their total cycle time from loading scrap to pouring liquid metal is around 200 minutes, so each 100 minutes a cast is completed as a maximum production level without delays.

The goal of this project is to reduce electric energy consumption at the furnaces by feeding preheated scrap to these furnaces and to increase process productivity by reducing smelting time at the arc furnaces.

The scheme in this case is to add an extra scrap preheating station to the process which should be have the capacity to prepare material for both furnaces without affecting their operation, this in order to obtain the best results for the projects feasibility.

The technic of preheating scrap before sending it to the furnace is not new in Mexico and has been a practice in the industry for a long time, with good economic savings and considerable increases in productivity.

This technic consists in anticipating, out side the electric furnace and with cheaper heating energy, a step of the smelting process that normally occurs inside the furnace itself: adding sensible heat to the raw material to take it from ambient temperature to a higher temperature, which will be technically viable and economically feasible, which in this case is around 600°C.

2. DEVELOPMENT

2.1 PRODUCTION LEVELS

Main production from both electric arc furnaces is made of liquid steel for granulation and liquid steel to manufacture rolls (special steel castings). The main products from the complete production process are listed below:

- Forged ingots
- Steel granules
- Cast steel parts

Monthly production levels for 1997 in tons of steel for two different products are show below :

Table #1, -Production Levels for 1997 up to this date for Whiting Furnace #1 and Whiting Furnace #2 in tons of liquid steel.

Period	Granule Ton	Forge Ton
January	571.908	175.089
February	620.632	153.294
March	491.772	236.522
April	643.050	369.493
May	626.694	261.968

* *This information was provided by operations department at the foundry.*

2.2 OPERATION TIMES

Average furnace operation times, according to study performed in previous a project were divided into :

Gross Time : this time contemplates the complete casting cycle.
Connected Time : reefers to effective time in which the furnace is trying to smelt the metal.
Casting Time - Casting: contemplates the time in which the furnace is empty and waiting to be reloaded for the next cycle and which is called time from cast to cast.
Maintenance Time: this time covers from the point that the metal has reached its optimum casting temperature and stays in the furnace waiting for adjustments and to be casted.

Table # 2. Furnace operation times (minutes).

Furnace	Product	Gross Time	Connected Time	Time Cast -Cast	Maintenance Time
Furnace 1	Granules	194.55	138.28	35.12	21.14
	Special	350.76	236.10	63.48	41.38
Furnace 2	Granules	209.77	126.65	41.82	41.30
	Special	317.42	208.80	73.27	36.80

* The above data was obtained from a statistical analysis performed to the furnaces during the energy diagnosis performed earlier (see Attachment A.)

2.3 ENERGY CONSUMPTION

Energy consumption in the furnace is at aprox. 4,000 Kwh for a complete cast, but it is necessary to hake some corrections before taking a number as valid since not all steels as a product consume the same quantity of energy.

In the following table we show the average consumption for electric energy for each arc furnace and you can see that in special steel castings consumption increases due to the high maintenance period for adjustments.

Table # 3. Energy consumption by cast in electric arc furnace expressed in Kwh.

Furnace	Global	Granule	Special
Whiting Nº 1	4,043.7	3,838.71	5,637.81
Whiting Nº 2	4,222.20	3,980.07	4,841.46

* The above data was obtained from a statistical analysis performed to the furnaces during the energy diagnosis performed earlier (see Attachment A.)

Specific arc furnace consumption is shown next as they show the ratio between electric energy and ton of liquid steel :

Table # 4. Arc Furnace specific consumption in kWh/Ton.

Furnace	Global	Granules	Special
Whiting Nº 1	717.38	695.21	859.41
Whiting Nº 2	761.74	724.81	827.00

2.4 ENERGY AND MATERIAL BALANCE FOR CURRENT PROCESS.

Starting with the energy -material balance made at the furnaces and taking design initial values we have the following starting data :

General Data :

Scrap initial load	5,500 kg *
Final liquid steel product	4,900 kg *
Fusion time (cast)	120 min.(2 hr) *
Electric energy consumption	3,653 kWh **
Specific consumption	745 kWh/ton **
Energy requires for fusion	386 kWh/ton **
Final Fusion efficiency	52% **
Number of casts per month	150 *

* Data collected at work area

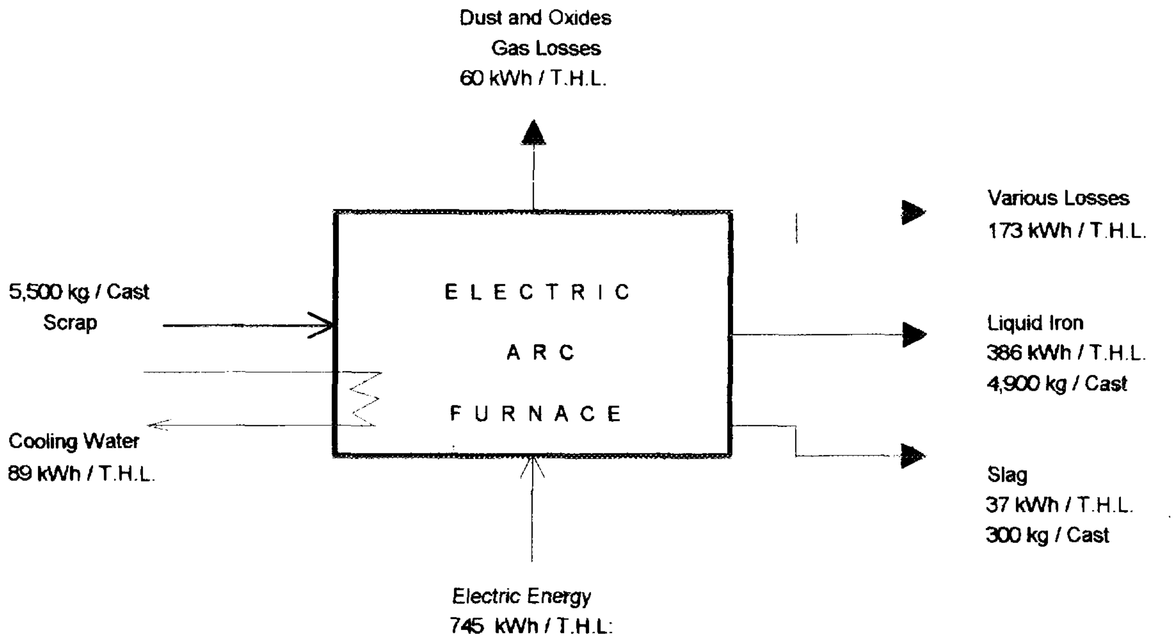
** Data measured or calculated.

Energy consumption distribution.

Concept	kWh / cast	kWh / ton	Percentage
Liquid Iron	1,891	386	52%
Energy in slag	180	37	5%
Dust, oxides and gases	294	60	8%
Various losses	852	173	23%
Cooling water	436	89	12%
Electric energy	3,653	745	100%

Data obtained from measurements and later calculations

Figure N° 1: Diagram for current balance of steel fusion process.



This energy and material balance at the electric arc furnace was obtained from a field work collecting information about their operation, flows, temperatures, loads and taken some considerations as valid.

The diagram gives us all energy input and output concepts per mass unit (Kwh/ton of liquid metal) for the furnace's final product.

2.5 ENERGY OPERATING COSTS

Operating costs for both furnaces is made up mostly of electric energy usage, the breakdown for the current rate on the region is as follows :

Specific Electric Energy Consumption	745 kWh/ton
Liquid Steel Production per Year	9,960 Ton/year (830 Ton/month)
Operating time in base period	1,911 hr/year
Operating time in peak period	4,655 hr/year
Electric energy consumption for these times	
Electric energy consumption for fusion	7,420 MWh/year
Electric energy consumption in intermediate period	5,260 MWh/year
Electric energy consumption in base period	2,160 MWh/year

The cost of electric energy for the month of July in the northeast region in H-M rates is :

by kilowatt of invoisable demand	$ 41.3550 pesos	o	$ 5.3019 USD
by kilowatt -hour of peak energy	$ 0.78526 pesos	o	$ 0.1007 USD
by kilowatt -hour of intermediate energy	$ 0.25253 pesos	o	$ 0.0324 USD
by kilowatt -hour of base energy	$ 0.20680 pesos	o	$ 0.0265 USD

*Change of mony $ 7.8 pesos/USD

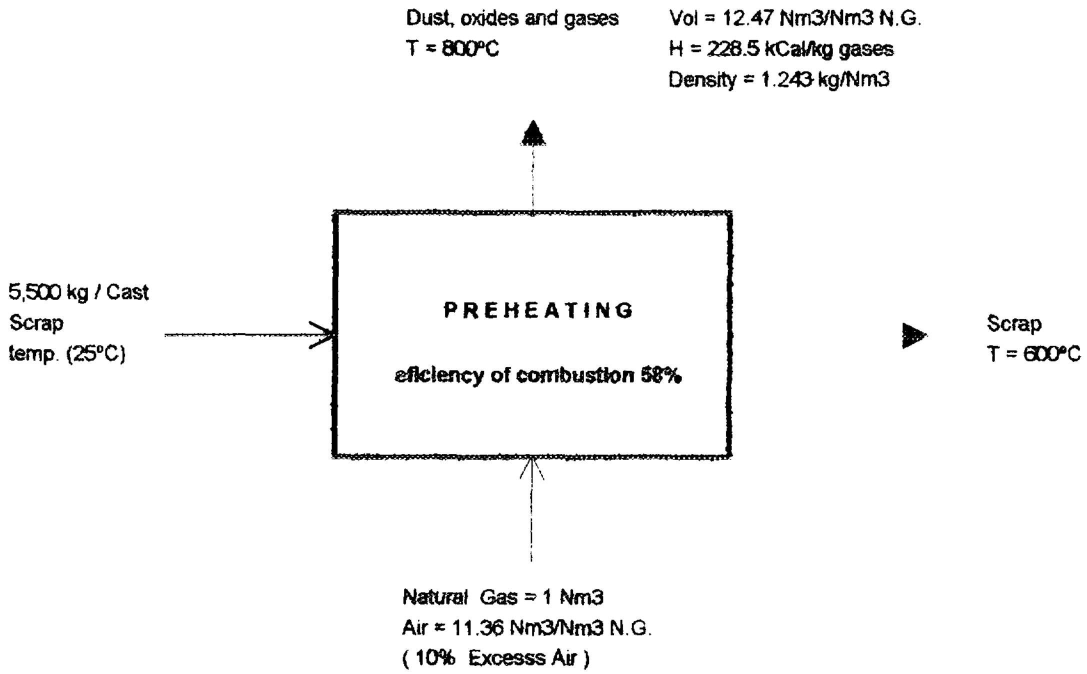
Energy cost in intermediate period	$ 170,300 USD/year
Energy cost in base period	$ 57,300 pesos/year
Total energy consumption costs for fusion.	$ 227,600 pesos/year

This is the cost for electric energy consumption in the steel fusion process, the next step will be obtaining the electric energy consumption costs using the new system.

2.6 NEW PROCESS USING PREHEATER

The following diagram shows material flows that should be considered for scrap preheater design, which will be the main equipment in the new system.

Figure # 2. Scrap preheater block chart showing inputs and outputs.



Preheater load, which is 5,500 Kg, is obtained from current need and load capacity of the furnaces.

Data on exhaust gases, volumetric flow, enthalpy and density as well as combustion air flow are obtained from material and energy balances for natural gas combustion at 10% excess air and 800°C for exhaust gas temperature.

2.6.1 PREHEATER EFFICIENCY

Efficiency (n) is the ratio of useful energy used over available energy in the fuel, this can be obtained indirectly subtracting the percentage of present losses from 100%. The following formula is used to obtain the efficiency of our preheating equipment.

n = 1 - (fumes flow x density x enthalpy)/(I.C.P. of Natural Gas)

So the expected efficiency of the preheater will be close to 58% related to the Lower Calorific Potential of Natural Gas

2.6.2 THERMAL LOAD FOR SCRAP (Fe)

This concept is very important in designing a new fusion system with scrap preheater and the physical- chemical properties of calorific capacity for Iron is :

Cp (Cal/mol) = 4.13 + 0.00638 T (K)   Range (25°C a 600°C)

For these conditions we have that the accumulated energy is 4,523 Cal/mol.

The required energy to take the scrap load from 25°C to 600°C is shown in the following Table

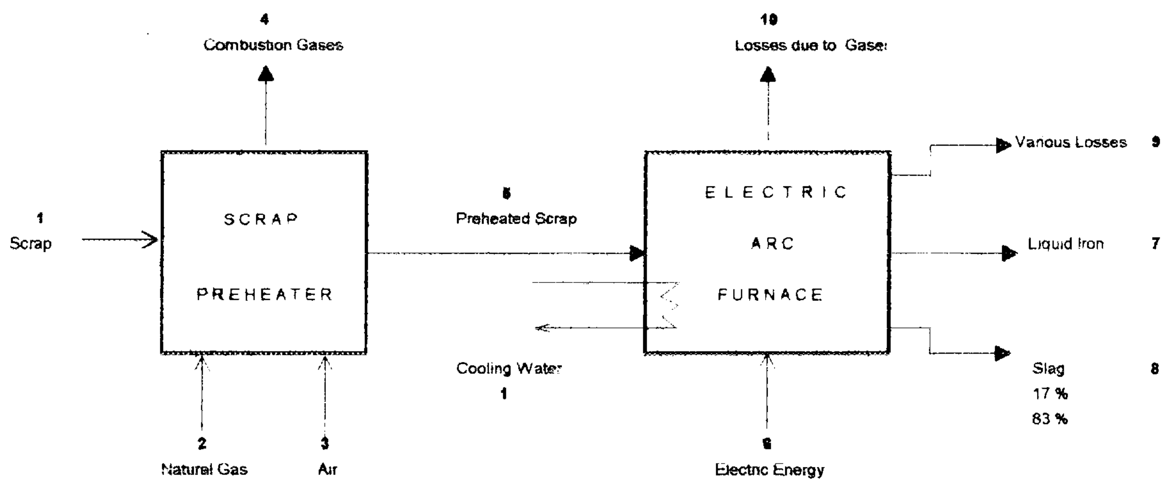
Table # 5 : Increase in temperature and percentage of heat related to total energy requires for fusion.

Initial Temp.	Final Temp.	Cal/mol	kWh/Ton	%
25°C	500°C	3,585	75.9	20
25°C	600°C	4,523	95.7	25
25°C	1,730°C	18,240	386.0	100

From this information we can se that 25% of the energy required to smelt metal in an adiabatic process can be substituted for a less expensive energy.

2.6.3 MATERIAL BALANCE FOR THE NEW PROCESS

Figure # 3 Energy and material balance block diagram for steel smelting with scrap preheating.



In the following table we show the data and characteristics for different input and output currents for both processes that will make up the smelting process at FUMOSA.

Table # 6 Ratio of lows for fusion process with a preheater.

CURRENT	DESCRIPTION	MATERIAL FLOW	TEMPERATURE	HEAT
1	Cold Scrap	5,500 kg.	25 °C	0
2	Natural Gas	91 Nm^3	25 °C	769 Mcal
3	Combustion Air	1,034 Nm^3	25 °C	0
4	Combustion Gases	1,135 Nm^3	Close to 800°C	322 Mcal
5	Preheated scrap	5,500 kg.	600 °C	446 Mcal
6	Electric Energy	———	———	2,788 kWh
7	Liquid Metal	4,900 kg.	1,700 °C	1,421 kWh
8	Slag	300 kg.	1,600 °C	181.3 kWh
9	Various Losses	———	———	637 kWh
10	Dust and Gases	———	1,700 °C	221 kWh
11	Cooling Water	210 GPM	4 °C (ΔT)	328 kWh-

2.6.4 ENERGY OPERATING COSTS IN THE NEW PROCESS

The new operation cost for the smelting process would be made up of two different concepts, the strongest will still be electric energy mainly in the later phases and natural gas used in the initial phases. Cost breakdown is as follows :

a) Electric Energy

Specific Electric Energy consumption	570 kWh/ton
Liquid Steel Production	9,960 Ton/year (830 Ton/month)
Operating time in base period	4,655 hr/year
Operating time in base period	1,911 hr/year
Electric energy consumption for these times	
Electric energy consumption for fusion	5,677 MWh/year
Electric energy consumption in intermediate period	4,025 MWh/year
Electric energy consumption in base period	1,652 MWh/year

The cost of electric energy for the month of July in the northeast region in H-M rates is :

by kilowatt of invoiceable demand	$ 5.3019 USD
by kilowatt -hour of peak energy	$ 0.1007 USD
by kilowatt -hour of intermediate energy	$ 0.0324 USD
by kilowatt -hour of base energy	$ 0.0265 USD

Energy cost in intermediate period	$ 130,300 USD/year
Energy cost in base period	$ 43,800 USD/year
Total energy consumption costs for fusion	$ 174,100 USD/year

b) Gas natural

Natural Gas consumption for the preheater	19 Nm3/ton metal
Liquid Steel Production	9,960 Ton/year
Natural Gas consumption for the preheater	189,240 Nm3/year
Natural Gas Cost	$ 0.68 pesos/Nm3
	$ 0.0872 USD/Nm3
Total cost for natural gas consumption	$ 16,500 USD/year
Both energy costs add to a total of	$ 190,600 USD/year

2.7.- SCRAP PREHEATING USING A BURNER

Really it is about a preheating station, to put a name to it, mounted outside the current line trajectory whose components would be a complete combustion system including burner, gas and air feed in a pit, also the support structure for the container and the equipment, a set of two containers minimum with an clam type unloading devise and it upper lid. This would be a rough overview of this equipment which meets certain characteristics in low cost and ease of use.

It is a very accessible equipment as far as purchasing cost, around $400,000 pesos and will give us an investment return in a short period compared to the other two options.

Handling and operation are simple and does not use much space in the area, so that it does not make it difficult to actuate the rest of the operations being performed in the area.

The preheater will be conformed by a combustion system based on a high speed burner capable of working with high air excesses which will be placed in a pit with a cover made of refractory concrete (Go to appendix B,C, y D).

3. TERMINAL SECTION

Next we will show you the results obtained from this work

Table # 7 Comparative Summary for both processes.

Concept	Current Fusion Process	Process with preheater
Electric energy consumption	7,420 MWh/year	5,677 MWh/year
Natural gas consumption	not used	189,240 Nm3/year
Energy cost	$ 227,600 USD/year	$ 190,641 USD/year
Economic Savings		$ 36,923 USD/year

In this table we can see the reduction expected both in energy consumption as well as in costs, which provides a good margin for the investment on the equipment to be implemented.

The cost of the investment is approximately $ 53,333.33 USD, simple ROI = 1.44 years.

The electric energy cost is growing up month by month, this does that the proyect will be more profitable.

The ROI is the 2.16 years (see Appendix A)

APPENDIX A

ECOMOMIC EVALUATION

Evaluación Económica

Sistema de Precalentamiento de Chatarra

Datos de Entrada

Medida:	1			
Descripción:	Instalación de Precalentador			
Inversión:	$	416,000.00	pesos M.N.	
Ahorro Anual:	$	288,000.00	pesos M.N.	
Tasa de Rentabilidad:		30%	anual	
No. de Periodos:		5	años	

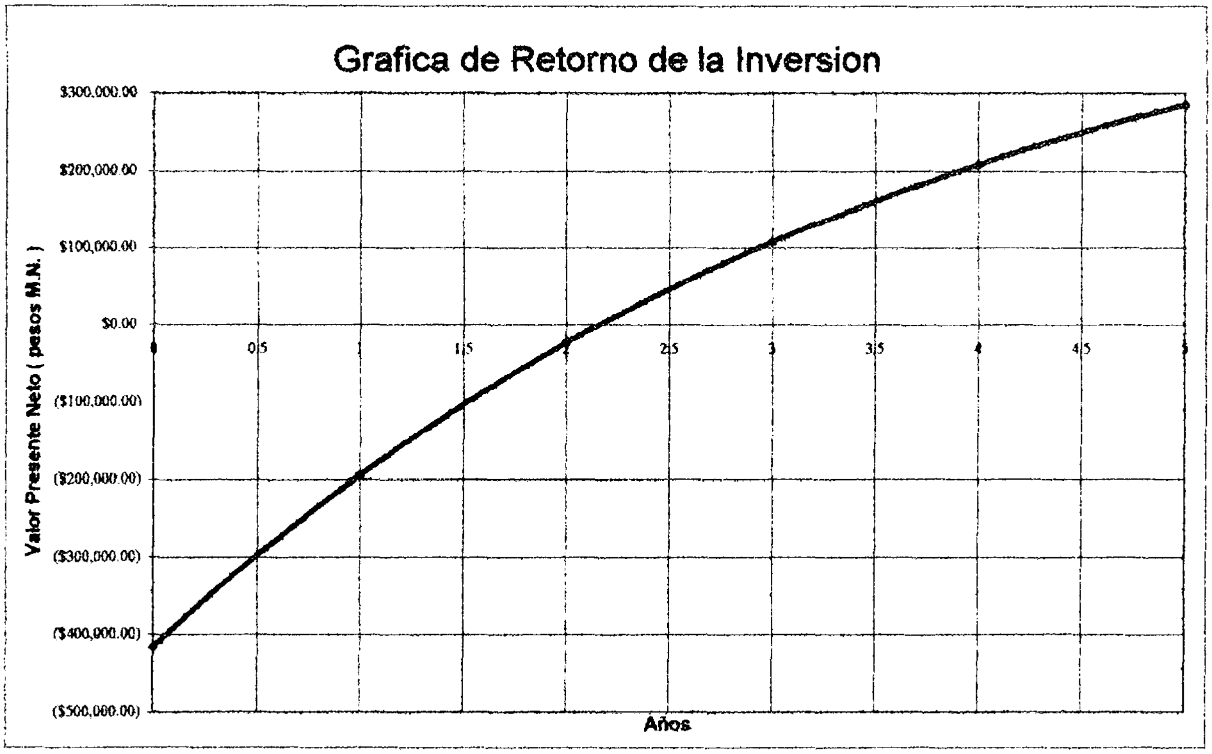
Tasa Mensual de Descuento ***2.21%***

Año	Flujo de dinero		VPN
0	-416,000		($416,000.00)
1	288,000	288,000	($194,481.54)
2	288,000	288,000	($24,047.34)
3	288,000	288,000	$107,040.51
4	288,000	288,000	$207,877.32
5	288,000	288,000	$285,444.09
6		288,000	
7		288,000	
8		288,000	
9		288,000	
10		288,000	

Resultados

Valor Presente Neto	$285,444.09	pesos M.N.
Tasa Interna de Rendimiento	63.26 %	anual
Relación Beneficio-Costo	1.69	
Periodo de Recuperación de Inversión	2.16	años

Referencia : El tipo de cambio actual es de 7.8 pesos M.N. por cada USD



APPENDIX B

SCRAP PREHEATING SYSTEM

SCRAP PREHEATING SYSTEM

1.0 GENERAL CHARACTERISTICS

The preheater will be of the vertical type contained in a pit and will have the following characteristics:

1.1	Type of Heating	Indirect trough combustion gases
1.2	Maximum Operating Temperature	800°C
1.3	Heating Medium	Natural Gas
1.4	Nominal Burner Capacity	5,056,000 BTU/hr
1.5	Effective Burner Capacity	4,850,000 BTU / hr

2.0	APPROXIMATE DIMENSIONS	
2.1	Preheater Diameter	2.5 m
2.2	Pit Depth	2.8 m

3.0 CIVIL WORK

Civil work will consist basically in the construction of two side by side pits, one to house the preheater systems and the other as a maintenance entrance for such equipment and as fresh combustion air supply. Approximate dimensions for these pits are :

3.1	Depth of both pits	2.8 m
	Preheater pit diameter	2.5 m
3.2	Length of Maintenance Pit	2.0 m
3.3	Maintenance it Width	1.5 m

4.0 CONSTRUCTION MATERIALS

4.1 Structural Materials

The support structure for refractory material in the preheater pit will be through supports made of 8" beams and an 8" channel frame over which a 1/2" thick plate will be placed.

4.2 Combustion Chamber

Combustion chamber has the function of protecting flame development of the scrap to be preheated and will be fabricated with AI.330 (Stainless Steel), to achieve an optimum behavior

4.3 Refractory Material

The refractory material will be constructed, from bottom to top, by a 9" layer of insulating concrete for 1200°C and a 4 ½" layer of refractory concrete for 1200°C.

5.0 COMBUSTION EQUIPMENT

Combustion equipment will be conformed based on a high speed burner and excess air with a 5,056,000 BTU/hr capacity that will allow maximum operation flexibility. The combustion equipment will have the following elements:

Item.	Quant.	Description	Price
5.01	1	High Speed and low NOX MCA emission burner. HAUCK Mod. SVG-160 with a nominal capacity of 5,056,000 BTU/Hr (4,850,000 BTU/Hr effective in site). Includes Igniter for automatic start.	
5.02	1	Turbo-ventilator for MCA combustion air : HAUCK MOD. TBA-20-7 ½ with a capacity of 51,000 SCFH when operated with air at sea level. Includes a 7 1/1 Hp Three Phase Motor directly coupled, TEFC, 220/440V, 60Hz.	
5.03	1	2 ½ " diam. Ball Valve, 125 PSIG.	
5.04	1	2 ½ " diam. dial gage , 0-7 Kg/Cm2 range, ¼" diam. lower connection .	
5.05	1	MCA gas pressure regulator. FISHER MOD. s-202 with 1 ½" diam. and ½" diameter orifice.	
5.06	1	2 ½ " dial diam. gage , 0-30 PSIG range, ¼" diam. lower connection .	
5.07	1	¾" diameter Ball Valve, 125 PSIG	
5.08	1	Limiting Orifice Valve, HAUCK brand, LVG-507 model, ¾" diam. orifice.	
5.09	1	Orifice Plate type Gage, HAUCK MOD. OMG-125-5285, 2 ½ " diam.	
5.10	1	Limiting orifice Valve, HAUCK Mod. LVG-525, 2 ½ " diam.	
5.11	1	Pressure Regulator, MAXITROL Mod. RV-53, 1" diam.	
5.12	1	Proportional Valve, KROM SHRODER, Mod. G165A02, 2 ½ " diam.	
5.13	1	Bleed-off Tee for impulse line.	
5.14	1	3/8" diam. Needle Valve for impulse line.	
5.15	1	2 ½ " dial diam. gage , 0-30 PSIG range, ¼" diam. lower connection .	
5.16	1	Manual Butterfly valve, HAUCK Mo. BVA-160, 6" diam	
6.0		PROTECTION EQUIPMENT. Electronic flame failure supervision system with automatic start that fill all safety requirements and regulations demanded by SECOFI in Mexico and by the IRI and FIA agencies in the USA. The equipment will be made up of the following elements:	
6.01	1	Low Gas Pressure Limiter, KROM-SHRODER, Mod. DG-50NT.	

6.02	1	High Gas Pressure Limiter, KROM-SHRODER, Mod. DG-50HT.
6.03	1	Low Gas Pressure Limiter, KROM-SHRODER, Mod. DG-150NT.
6.04	1	Automatic Reset Shut Off valve, KROM-SHRODER, Mod. VG65N031ds93, 2 ½ " diam.
6.05	1	Venting Solenoid Valve, ASCO, Mod. 8215C63 NA, 1 1/4" diam.
6.06	1	Automatic Reset Shut Off valve, KROM-SHRODER, Mod. VG65N03LDS93, 2 1/2" diam.
6.07	1	Bypass Solenoid Valve,. JEFFERSON, Mod. 1330LA06, 3/4" diam.
6.08	1	ignition Transformer, 120 V primary, 6000 V secondary .
6.09	1	U.V. Photocell, HONEYWELL, Mod. C7027a1049.
6.10	1	Flame Failure Protection Relay, HONEYWELL, Mod. RA890G with Q270A mounting base.

7.0 CONTROL EQUIPMENT

Control equipment will be based on an automatic butterfly valve installed in the air line and will be operated manually by the equipment operator, this because it is physically impossible to install safely and efficiently a temperature detection equipment.

7.01	1	Automatic Butterfly Valve, HAUCK, Mod. BVA-460, 6" diam.

8.0 AIR PIPES

Air pipes will be fabricated with 16 gage C.R. sheet metal diameters bigger than 4" and in black 40 gage steel pipe for smaller ones. It is considered that the gas supply is located at a maximum distance of 3 meters from the end of the equipment.

9.0 AIR PIPES

Air pipes will be fabricated with 16 gage C.R. sheet metal diameters bigger than 4" and in black 40 gage steel pipe for smaller ones.

10.0 ELECTRIC MATERIAL

Electric material that shall be used in the installation of power lines shall be shielded wire that can work at a maximum temperature of 120°C and to withstand a maximum voltage of 600V. Of the required gage, all electrical wires shall be routed by ducts; when less than 6 threads, thick wall electric conduit must be used.

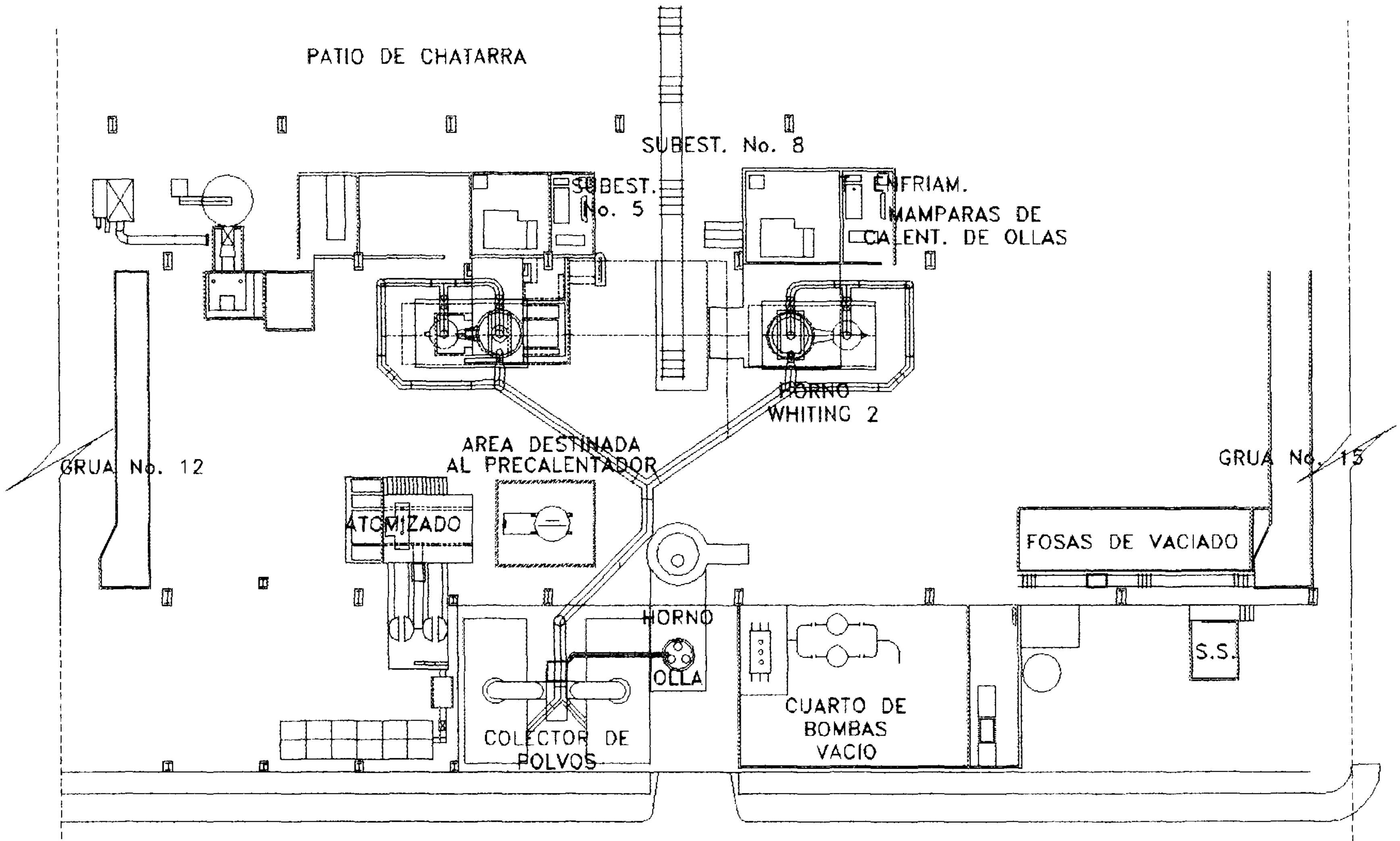
11.0 CONTROL PANEL

Control Panel where the following elements shall be installed in addition to item 6.10 :

1	Thermo-magnetic Switch
1	Purge Timer
1	Toggle switch
9	Indicator Lights
1	Set of Auxiliary Relays,
1	6 Point Alarm Circuit
1	Sound Alarm
1	Momentary contact push button
1	Button station

APPENDIX C

PLANT DIAGRAM

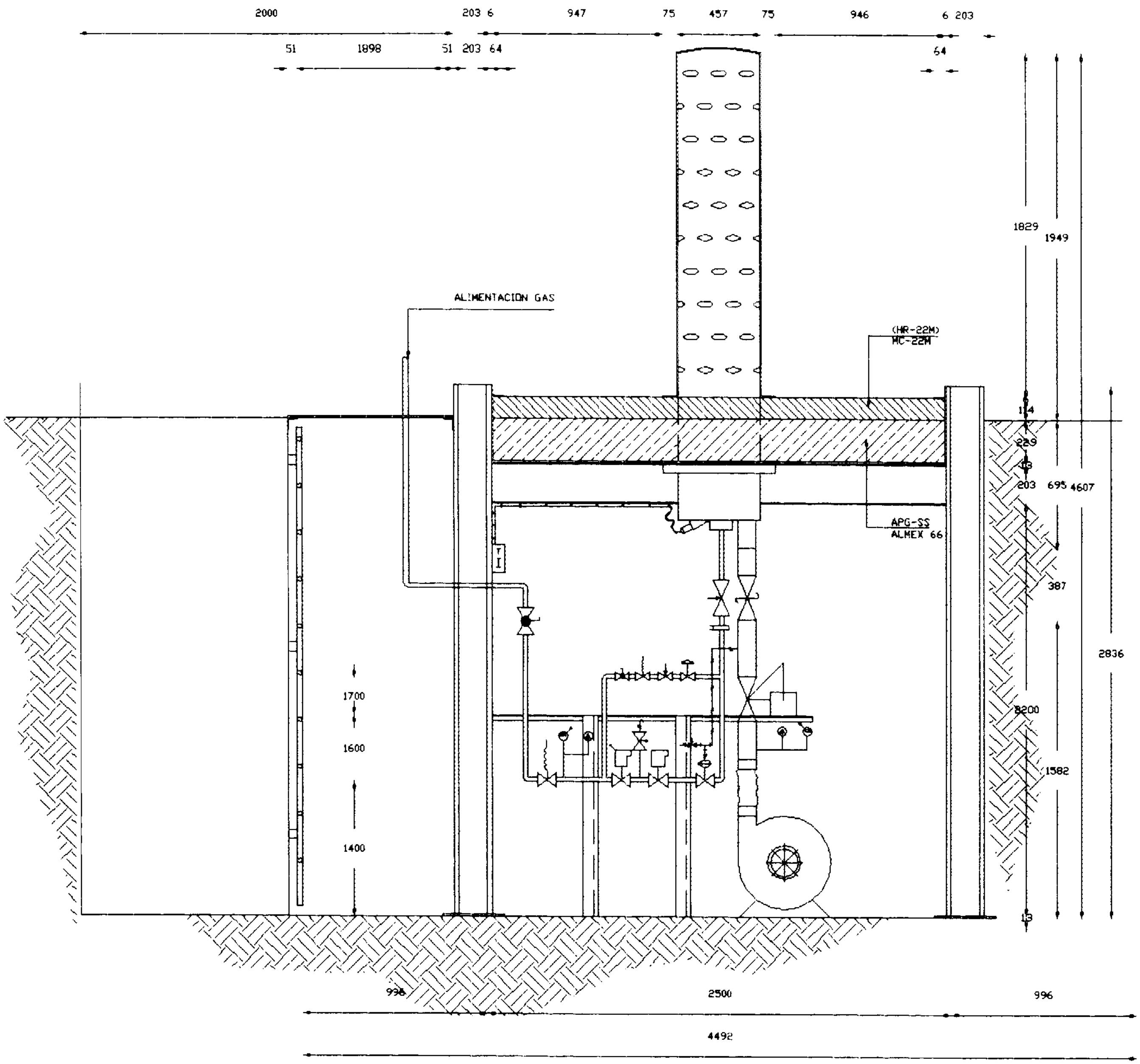


FUNDICION MONCLOVA S.A. DE C.V.

FRONTERA COAHUILA DESCRIPCION: DIAGRAMA DE PLANTA	FECHA: 8 DE SEP. DE 1997

APPENDIX D

SCRAP PREHEATER SYSTEM DIAGRAM



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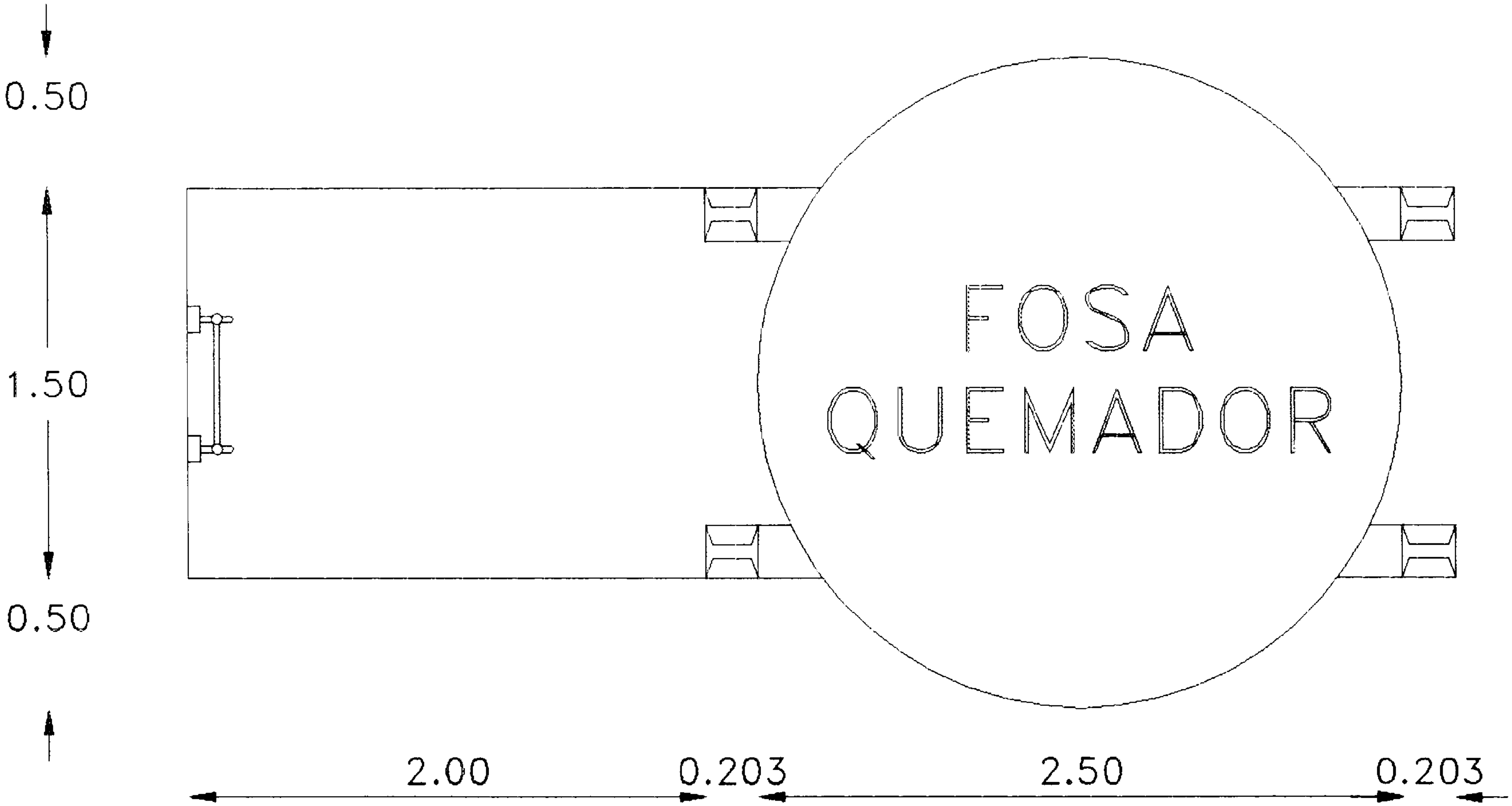
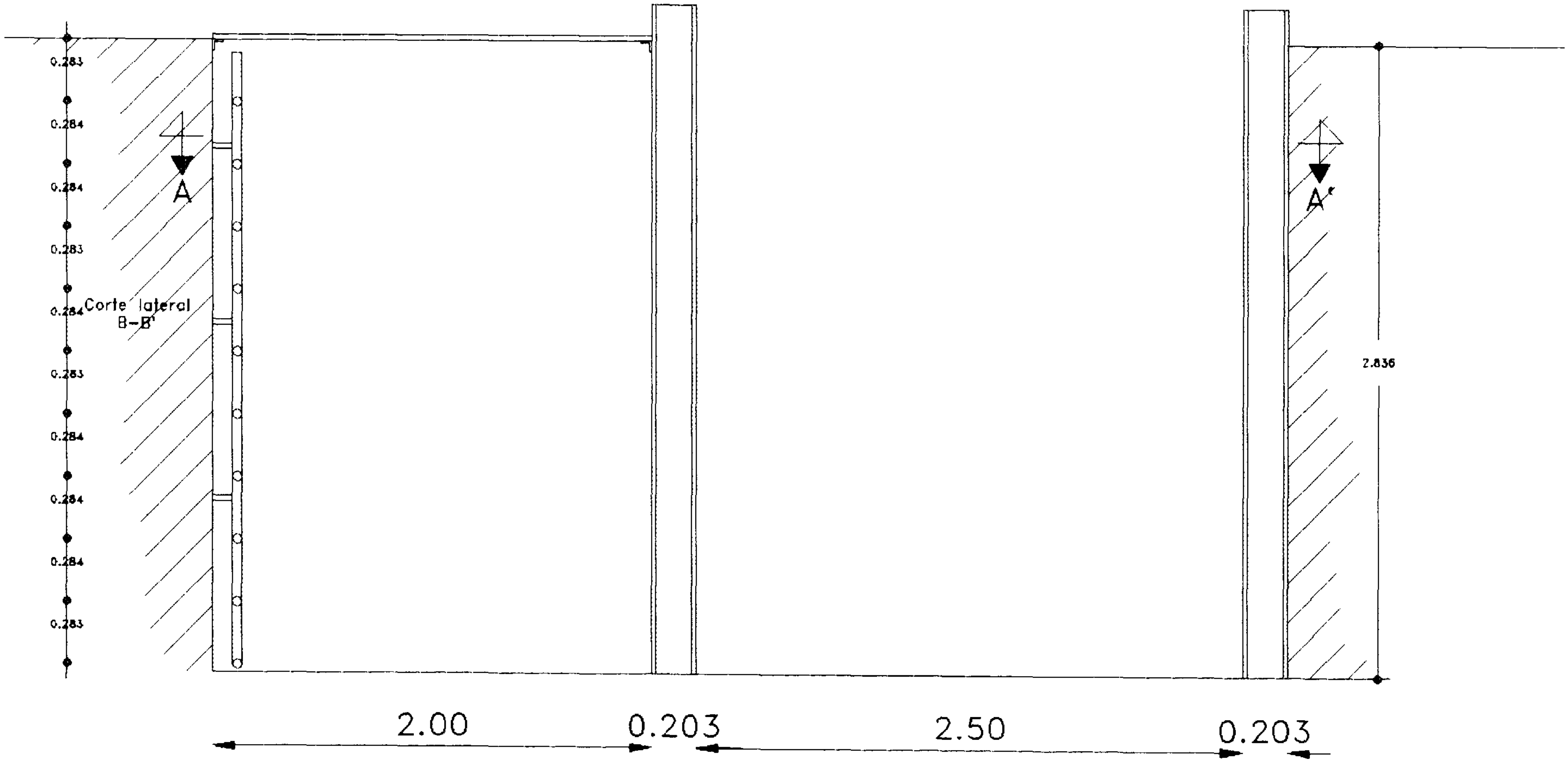
FRONTERA COAHUILA DESCRIPCION: DIAGRAMA DE CORTE	FECHA: 8 DE SEP. DE 1997



FUNDICION MONCLOVA S.A. DE C.V.

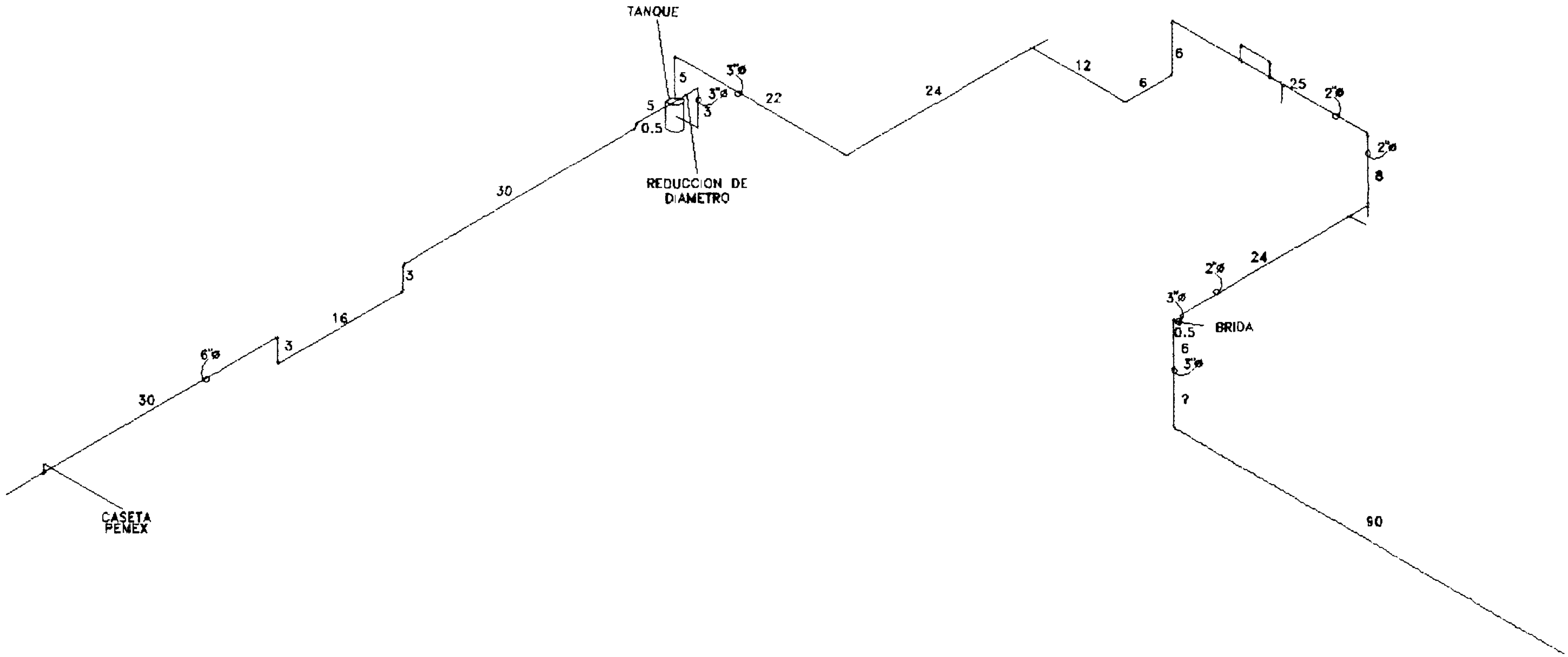
FRONTERA COAHUILA DESCRIPCION: ESTACION DE PRECALENTAMIENTO	FECHA: 8 DE SEP. DE 1997



FUNDICION MONCLOVA S.A. DE C.V.

FRONTERA COAHUILA
DESCRIPCION: ESTACION DE PRECALENTAMIENTO

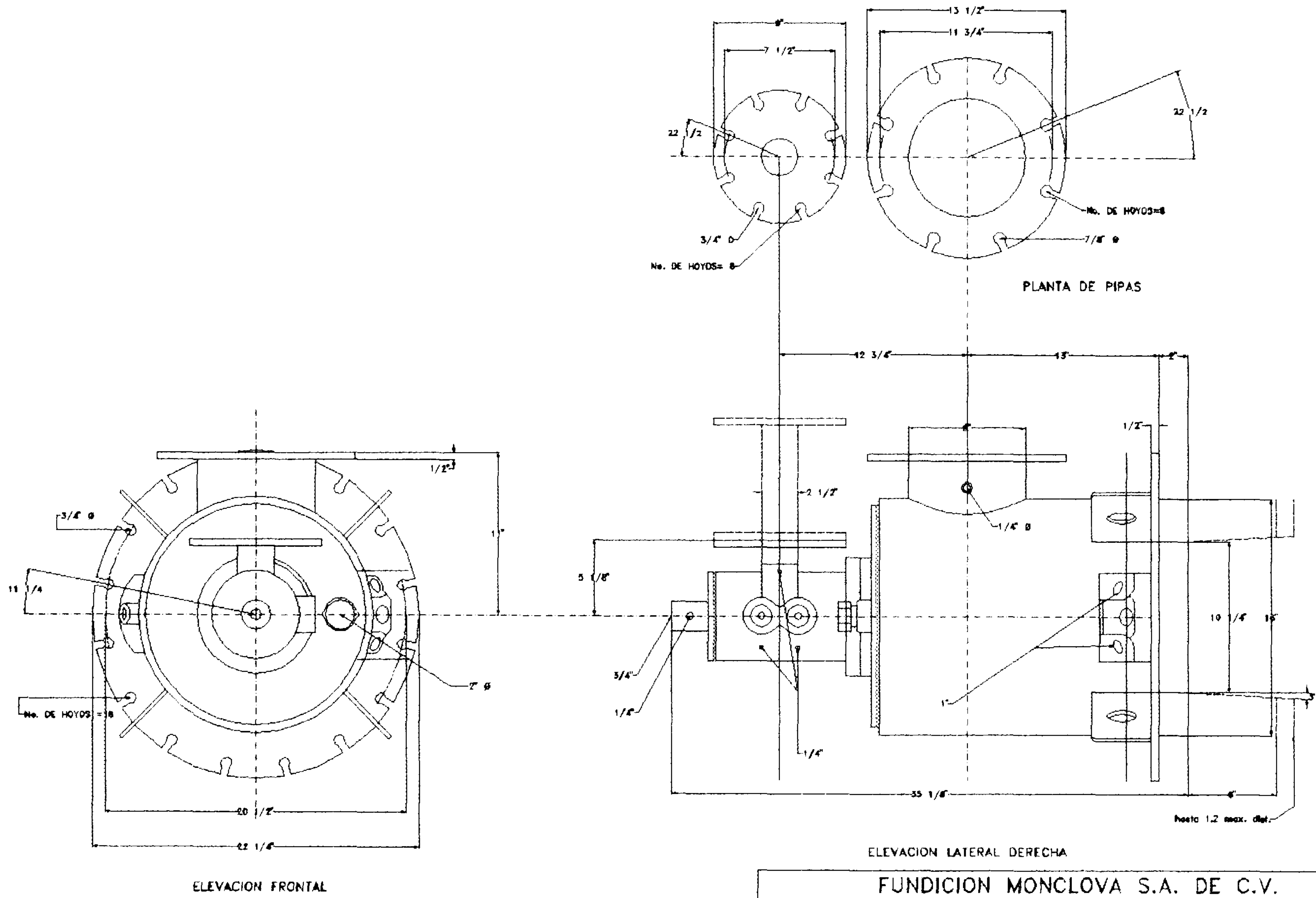
FECHA:
8 DE SEP. DE 1997



FUNDICION MONCLOVA S.A. DE C.V.	
FRONTERA COAHUILA DESCRIPCION: DIAGRAMA DE PLANTA	FECHA: 8 DE SEP. DE 1997

APPENDIX E

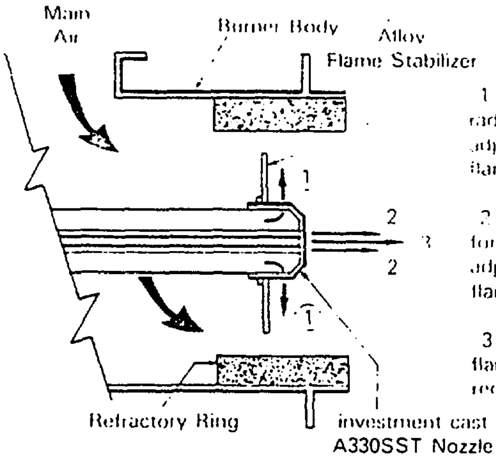
BURNER DESIGNATION



FUNDICION MONCLOVA S.A. DE C.V.

PLANO DE:
BURNER DESIGNATION: 4384-9
ESC. 1:10
17 DE NOVIEMBRE DE 1997

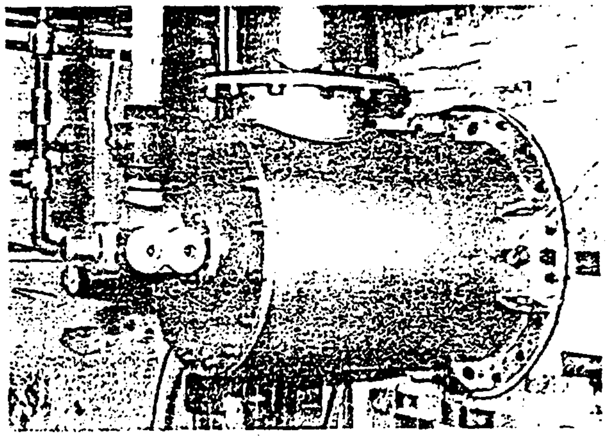
North American Mfg. Co. Cleveland, OH 44105 USA	Low NOx FUEL DIRECTED MAGNA-FLAME BURNERS	BULLETIN 4384 4-92



1 Radial gas - Increasing radial gas flow (with flame adjustment screw S) shortens flame.

2 Forward gas - Increasing forward gas flow (with flame adjustment screw L) lengthens flame.

3 Jet gas - used to maintain flame definition as input is reduced.



Manual flame adjustment screws, as shown here on the burner gas connection, adjust flame shape.

3 to 55 million Btu/hour...

For furnaces, boilers, process heaters, dryers, etc. up to 2000 F...

Standard Low NOx capability...

Fits the flame to the combustion chamber...

Distributes the heat where it's needed...

High turndown capabilities...

Fuel Directed Burner bodies and backplates are fabricated of heavy gauge welded steel. Internal parts include a front refractory ring, alloy flame stabilizer, and an investment cast A330SST nozzle.

Burners use gas pressure to create a flame shape and heat pattern that is most advantageous for the installation they are firing. A controlled flame shape is **desirable** in almost any application -- it is **essential** in many to realize optimum furnace performance.

4384 Fuel Directed Magna Flame Burners are used with ambient temperature combustion air on a wide variety of furnaces operating up to 2000 F. Fuel directed principles enable these burners to vary flame configuration from approximately 750 000 Btu/hr per foot of length to 2 000 000 Btu/hr per foot. User can manually select optimum flame shape with the flame adjustment, which is an integral part of the gas connection.

OPERATION

Burners are designed for 6″wc maximum recommended air pressure. Operation is quiet and the burner is stable over a wide range of air/gas ratios ranging from 30% fuel rich to 1000% excess air at 6″wc. Stoichiometric turndown is 10:1 with 6″wc main air pressure. For multiple burner installations requiring high turndown capability, air inlet orifices should be considered to ensure adequate header pressure for uniform air distribution at low inputs.

Standard design is for 8 psig gas at the burner. With certain operating limitations, the burner can use as little as 2 psig gas: consult your North American Mfg. Sales Engineer.

A constant gas jet at 8 psi and 5% of maximum capacity maintains flame definition as input is reduced.

A low fire start is required at 1″wc or less main air pressure.

COMBUSTION AIR CAPACITIES, scfh

long flame mode

Capacities are reduced up to 10% in short flame mode.

Burner designation	air pressure 0.06″wc*	3″wc	6″wc†
4384-8	4 070	28 600	40 700
4384-9	7 100	50 800	71 500
4384-10-A	8 900	63 000	89 200
4384-10-B	11 300	80 000	113 000
4384-12	16 000	114 000	160 000
4384-14	20 000	142 000	200 000
4384-16	26 000	187 000	264 000
4384-18	33 000	238 000	337 000
4384-20	42 000	296 000	419 000
4384-22	51 000	361 000	509 000
4384-24	61 000	430 000	608 000

* min. air rate † max. recommended press.

RANGE OF FLAME LENGTHS (2000 F Furnace), feet‡

with 8 psig gas

Air/gas ratio set for 10% excess air

Burner designation	SHORT FLAME (10% reduced capacity) air pressure 3″wc	6″wc	LONG FLAME (full capacity) air pressure 3″wc	6″wc
4384-8	3	4	8	14
4384-9	3½	4½	9	15
4384-10-A	3½	5	10	16
4384-10-B	4½	6	12	18
4384-12	5	7	14	20
4384-14	5½	8	15	24
4384-16	7	10	20	30
4384-18	8½	12	25	34
4384-20	10½	15	30	40
4384-22	13	18	32	45
4384-24	15	20	40	50

‡ Flame lengths will be longer in a lower temperature furnace.

CONTROL

Mass flow control is recommended. Standard 4384 Fuel Directed Burners have a single gas connection with internal radial/forward gas adjustment for flame shaping.

Main and center jet gas should be supplied to the burner at the same time. See flow control schematic.

PILOT and FLAME SUPERVISION

Burners are ignited with a gas-boosted pilot. Pilot air pressure must be at least 10"wc, and pilot regulator must be cross-connected to the pilot air line (see Sheet 4014).

If flame supervision is used, pilot must be of the interrupted type. UV flame detection is recommended (using an 883 D adapter).

LOW NOx

The 4384 Fuel Directed Burner is an inherently Low NOx burner. In conjunction with other NOx reducing features, it is capable of meeting emission limitations for new or retrofit applications in environmentally sensitive installations. Contact your North American Mfg. Sales Engineer for specific applications.

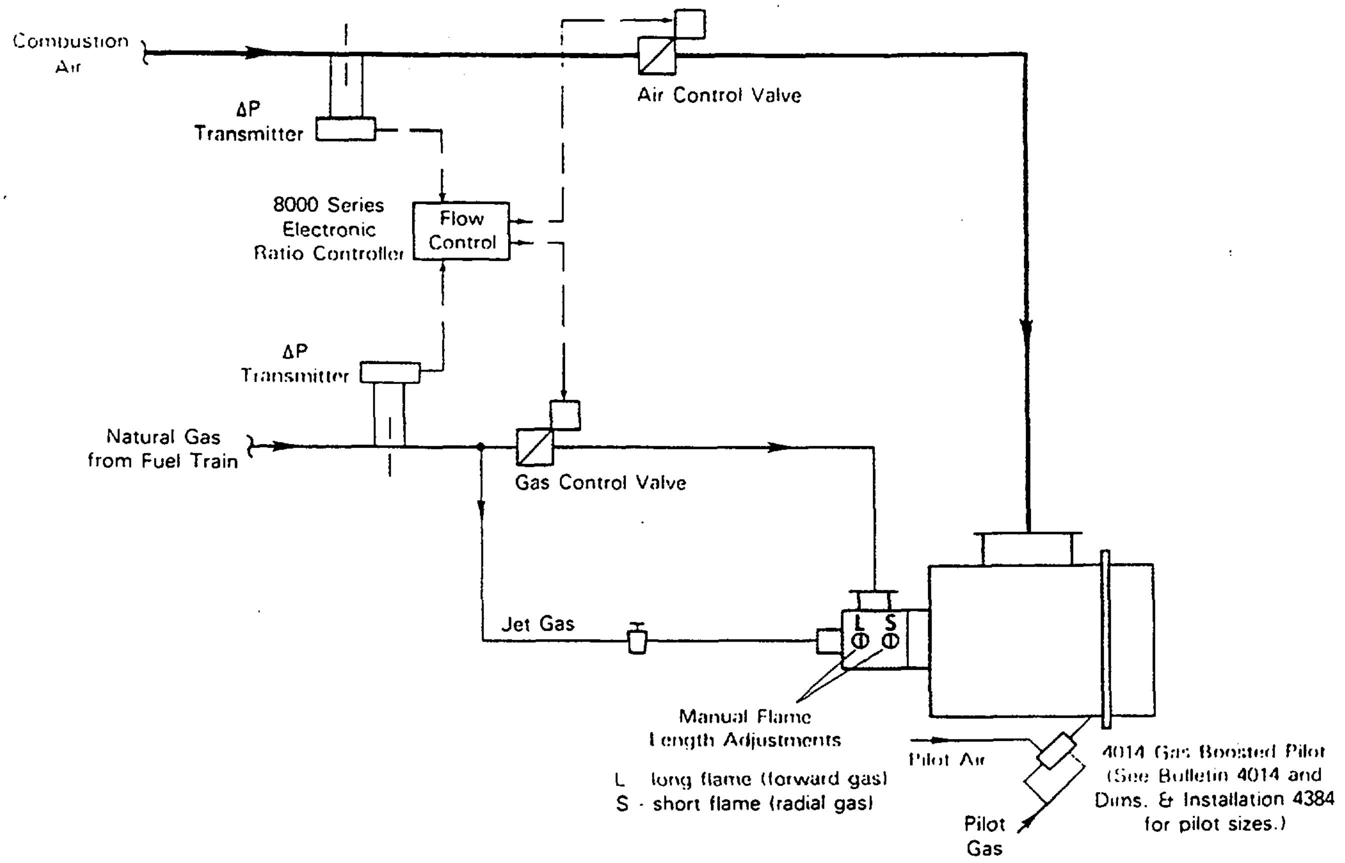
BURNER TILE CONSTRUCTION

4384 Burners do not include a tile. Tunnel shapes and recommended installation shown on Dimensions & Installation 4384.

OTHER FUELS

For other gaseous fuels and oils, contact your North American Mfg. Sales Engineer.

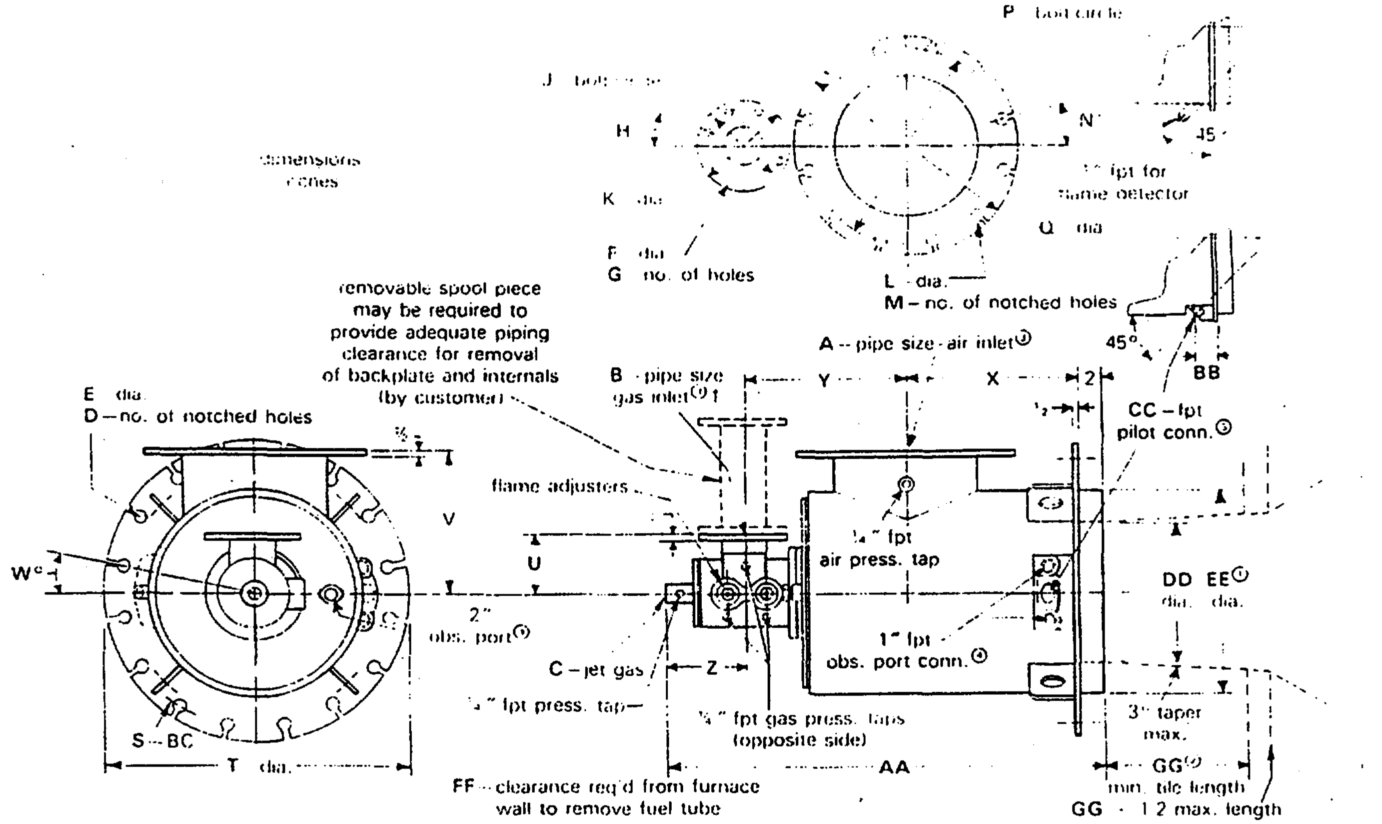
Typical Single Burner Fuel Directed Flow Control Schematic



BURNER ADJUSTMENTS

1. The flame length adjusters are located on the side of the gas inlet connection. Initially set both the short (S) and the long (L) flame adjustment screws equally open. (Fully close both adjusters by turning them clockwise, then open 2 turns.)
2. Establish pilot flame. See Bulletin 4014 for instructions.
3. Establish main flame. If main flame cannot be established, open (S) and (L) flame adjustment screws equally until a flame is established.
4. With an established flame, drive the system to high fire. Set air/fuel ratio. Using the (S) and (L) flame adjustment screws, make the desired flame length adjustments. If high fire gas flow cannot be reached, open the (S) and (L) flame length adjustment screws equally until the proper gas flow is obtained. Correct air/fuel ratio as required.
5. Drive the system to low fire. Set air/fuel ratio. If used, adjust jet gas valve to improve the low fire flame definition.
6. Drive the system to high fire and verify flame length and air/fuel ratio.

WARNING: Situations dangerous to personnel and property can develop from incorrect operation of combustion equipment. North American urges compliance with National Safety Standards and Insurance Underwriters recommendations, and care in operation.



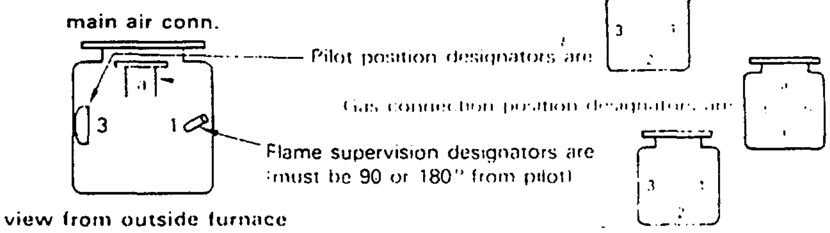
Burner designation	A③	B③†	C	D	E	F	G	H°	J	K	L	M	N°	P	Q	S	T	U
4384-8	6	2½	¾	16	¾	—	—	—	—	—	7/8	8	22½	9½	11	18½	20¼	5 1/8
4384-9	8	2½	¾	16	¾	—	—	—	—	—	7/8	8	22½	11¾	13½	20½	22¼	5 1/8
4384-10A	10	2½	¾	16	¾	—	—				1	12	15	14¼	16	22½	24¼	5 1/8
4384-10B	10	2½	¾	16	¾						1	12	15	14¼	16	22½	24¼	5 1/8
4384-12	12	2½	¾	16	¾	—	—	—	—	—	1	12	15	17	19	24½	26¼	5 1/8
4384-14	14	2½	¾	20	¾	—	—	—	—	—	1 1/8	12	15	18¾	21	26½	28¼	5 1/8
4384-16	16	2½	¾	20	¾	—	—	—	—	—	1 1/8	16	11¼	21¼	23½	28½	30¼	5 1/8
4384-18	18	4	1	20	7/8	¾	8	22½	7½	9	1¼	16	11¼	22¾	25	30½	32¼	7 11/16
4384-20	20	4	1	24	7/8	¾	8	22½	7½	9	1¼	20	9	25	27½	32½	34¼	7 11/16
4384-22	22	4	1	24	7/8	¾	8	22½	7½	9	1¼	20	9	26	29½	34½	36¼	7 11/16
4384-24	24	4	1	24	7/8	¾	8	22½	7½	9	1 3/8	20	9	29½	32	36½	38¼	7 11/16

† -9 thru -16, 2½" th'd; -18 thru -24, 4" ANSI flange

Burner designation	V	W°	X	Y	Z	AA	BB	CC③	DD	EE①	FF	GG②	Pilot assembly designation
4384-8	9½	11¼	10	11 7/8	7 3/8	31¼	2 3/16	1¼	8½	14	57 5/8	5	4014-1-T
4384-9	11	11¼	13	12¾	7 3/8	35 1/8	2 3/16	1¼	10¼	16	57 5/8	6	4014-1-T
4384-10A	12½	11¼	15	14 3/8	7 3/8	38¾	2¾	1½	11¼	18	64 7/8	7	4014-2-T
4384-10B	12½	11¼	15	14 3/8	7 3/8	38¾	2¾	1½	12¼	18	64 7/8	8	4014-2-T
4384-12	13½	11¼	17½	15 7/8	7 3/8	42¾	2 7/8	2	14¼	20	73 1/8	9	4014-3-AT
4384-14	14½	9	18½	16 7/8	7 3/8	44¾	2 7/8	2	16¼	22	76 7/8	10	4014-3-AT
4384-16	15½	9	19	17 3/8	7 7/8	45¾	2 7/8	2	18¼	24	78 7/8	11	4014-3-AT
4384-18	16½	9	19½	19 5/8	8¼	49¼	2 7/8	2	20¼	26	86¾	12	4014-3-BT
4384-20	17½	7½	20½	20½	8¼	51 1/8	2 7/8	2	22¼	28	87½	13	4014-3-BT
4384-22	18½	7½	21½	22 3/8	8¼	54	2 7/8	2	24¼	30	93¼	14	4014-3-BT
4384-24	19½	7½	22½	23½	8¼	56 1/8	2 7/8	2	26¼	32	97½	15	4014-3-BT

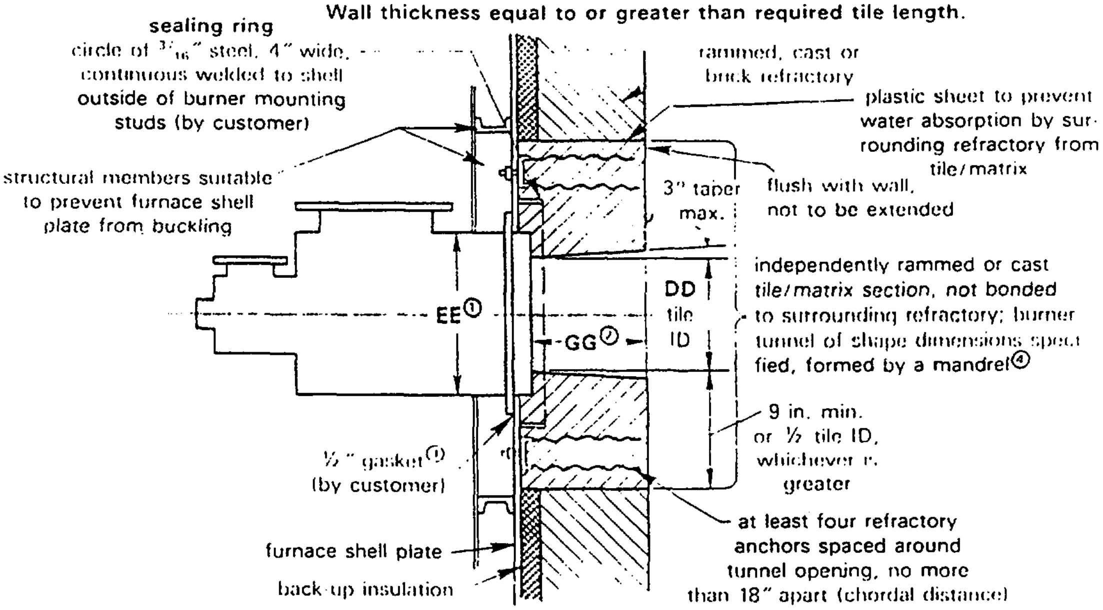
① Furnace opening should be ½" larger than dimension EE for -8 thru -14; ¾" larger than dimension EE for -16 thru -24.
② Any tile length greater than GG × 1.2 should have a 30° angled flare from the standard tile extension.
③ Burner must be ordered with locations designated. See reverse side.
④ Backplate and pilot observation ports included with burner.

Arrangement Designators are specified relative to the main air connection at 12 o'clock and should be listed for pilot, gas, and flame detector in that order. Good practice dictates that neither the pilot nor the flame supervision device be on the bottom of the burner.



Fuel Directed Burner Tile Installation Recommendations for Hard Refractory Lined Furnaces

FIGURE 1
Wall thickness equal to or greater than required tile length.



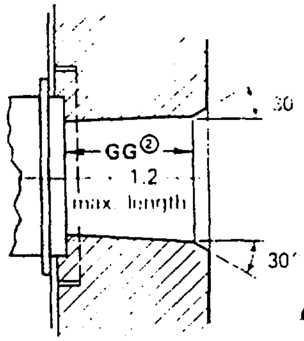
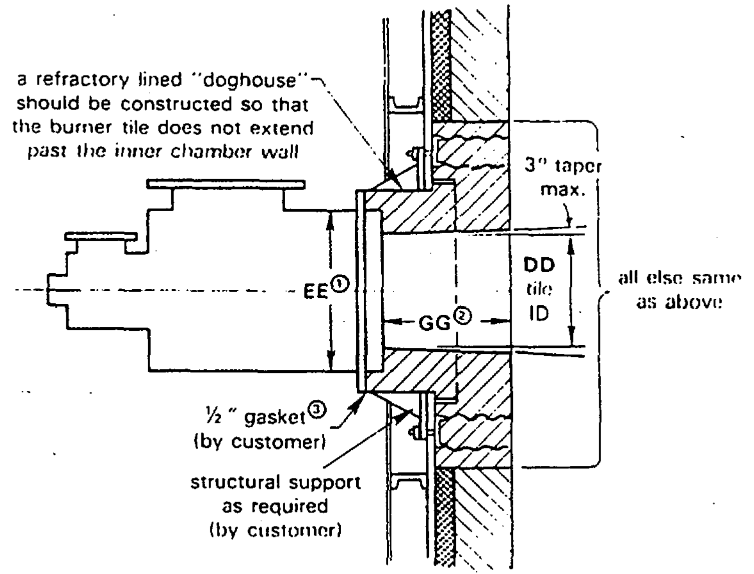


FIGURE 2
Wall thickness less than required tile length.



① Furnace opening should be ½" larger than dimension EE for -8 thru -14; ¾" larger than dimension EE for -16 thru -24.
② Any tile length greater than GG × 1.2 should have a 30° angled flare from the standard tile extension.
③ Two wraps of ½" soft fiber glass rope (Davlyn #100801 or equivalent) suitable for 1000 F service. North American can supply as part no. R540 0365. Specify length when ordering.
④ Expansion joints must be provided in surrounding refractory to prevent pressure being exerted on cast or rammed burner tunnel section.

WARNING: Situations dangerous to personnel and property can develop from incorrect operation of combustion equipment. North American urges compliance with National Safety Standards and Insurance Underwriters recommendations, and care in operation.