LANEMARK INTERNATIONAL

FD BURNER/PROCESS AIR HEATING APPLICATION MANUAL

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SECTION 1 - INTRODUCTION

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1.1 OVERVIEW

The Lanemark FD process air heating burner is a natural partner for the Lanemark TX tank heating burner system.

Very often components have to be dried following immersion or spray treatments such as degreasing, phosphating and so on. Further drying or curing may be necessary following the application of a final paint finish.

Lanemark FD burners are also very widely used in application areas `in their own right'. For example, textile and food product drying.

Lanemark FD burners are compact, clean burning, nozzle mix burners suitable for direct (or indirect) firing applications.

1.1.1 LANEMARK ADVANTAGES

* Compact combustion over a wide turndown ratio.
* Excellent flame stability under widely differing combustion chamber conditions.
* Fast response to changes in process load demand.
* Excellent accessibility to all burner components and minimal maintenance requirements.
* One manufacturer for TX high efficiency tank heating and FD process air heating burner requirements.

1.1.2. APPLICATIONS

Typical applications for Lanemark FD gas burners included the drying, curing or finishing of:

METAL PRODUCTS
TEXTILES & PAPER PRODUCTS
POTTERY, CERAMIC & GLASS PRODUCTS
PLASTIC MOLDINGS & RUBBER GOODS
CROPS & FOOD
CLOTHES (LAUNDRIES)

1.1.3 MARKET OPPORTUNITIES

Like its TX burner system counterpart the combustion characteristics of the Lanemark FD burner system allow the design engineer to apply direct fired techniques to a wide range of application possibilities.

Usually sales will be made to OEM customers who are designers and builders of process heating equipment. However good possibilities also exist for the conversion of existing inefficient steam, old fashioned gas or expensive to run electric heating systems.

1.2 WHAT AN END USER NEEDS TO KNOW ABOUT THE FD PROCESS AIR HEATING BURNER SYSTEM.

Industrial process air heating can be an expensive exercise. In these times of fluctuating (or usually rising) energy costs, an end user needs to minimize his expenditure on fuel while maximizing his product throughput through his machine(s) with a minimum of `down' or `turnaround' times.

He may need plant which is adaptable to changes in product type, volume throughput and variable process temperatures.

Lanemark FD burners meets these criteria without exception.

COMPARISONS WITH OTHER HEATING METHODS

1.2.1 Steam/Hot Water
1.2.2 Thermal Oil
1.2.3 Electricity
1.2.4 Burner Systems

1.2.1 STEAM/HOT WATER

Process dryers were often heated by a steam or hot water heat exchanger system fitted into the process air distribution ductwork. The heat exchangers usually take the form of a car radiator type matrix which should minimize pressure drop whilst maximizing the heat transfer.

The main disadvantages of this type of heating system are :-

1. Low overall efficiency
2. Lack of controllability & flexibility
3. Temperature limitations.

Transmission Inefficiency

a) Many central boiler plants are located a considerable distance from the point of application of their steam or hot water outputs.

   If a boiler itself is operating at an efficiency of 75% it will probably lose in excess of 10% of its output over the transmission network between the boiler location and the process application. The secondary heat transfer efficiency from the process air heat exchanger unit is likely to be around 80%.

   A combination of these overall heat exchanger ratios results in an overall system efficiency of approximately 54%.

   Therefore for every 1 unit of heat required by the process tank, 1.85 units of fuel input is required at the boiler.

b) Where boilers have seen better days or where transmission pipework is poorly insulated, even a 54% overall efficiency level may not be possible. The cost per useful unit of heat output will then be proportionally higher.

Control Inefficiency

Close control of process air temperatures can be difficult with these indirect heating methods. Many plants have to cope with components of various sizes passing along an individual production line. It is particularly necessary in these instances that the process heating equipment respond quickly to the sudden changes in heat demand that will occur.

Central System Turndown Inefficiency

A central boiler usually supplies energy for more than one application. Often factory space heating is achieved by using steam or hot water unit heaters or radiant panels. During summer months when space heating is not required, it can be extremely inefficient and costly to maintain boiler operation at partial load for process requirements which pertain only to the heating of process solution tanks and/or dryer equipment.

There are also other costs associated with the operation of boilers which should not be overlooked. Chemical treatment of feed water, boiler operator and insurance costs must also be considered.

Temperature Limitation

Factory steam distribution pressures are typically less than 10 bar (150 psi) which limits the steam temperature to 185ºC (365^{o}F). Steam process air heater batteries are therefore limited in the air temperatures that they can deliver. Lanemark FD burners are capable of operating upto 450ºC (850^{o}F) in their standard construction.

1.2.2 THERMAL OIL

The same efficiency controllability and flexibility arguments equally apply to the use of thermal oil as a heat transfer medium.

Additionally thermal oil is expensive and the systems require particular care in operation and maintenance. The higher temperatures possible with thermal oil permit operation of dryer plant upto around 315ºC (600^{o}F).

1.2.3 ELECTRICITY

Process air dryers can be efficiently heated using electrical elements but their running costs are usually prohibitive.

1.2.4 BURNER SYSTEMS

Indirect Fired Systems

Gas or oil burners have been used for process air heating applications for many years.

Oil burners can usually only be applied for **indirect** heating applications due to the rather unclean nature of their combustion. In these systems the burner will fire into a combustion chamber that will reside in the process air flow. Secondary heat exchanger pipes may be fitted to the exhaust end of the combustion chamber to maximize the operating efficiency.

Gas burners are also used occasionally with this type of heat exchanger arrangement where direct contact between the flame and the process air (usually in flammable situations) cannot be permitted.

The main disadvantages of this approach is that the efficiency of the system is unlikely to exceed 80% and frequently is considerably less. Control of the process air temperature is also slower than the alternative **direct fired** approach.

Direct Fired Systems

As its name implies direct fired systems utilize gas burners which burn directly into the process air flow which is to be heated. The products of combustion mix directly with the process air (and as a result become greatly diluted) to provide a highly efficient transfer of heat to the process.

Alternative temperature control arrangements can be selected depending upon the accuracy required by the process. These arrangements vary from the simple hi/lo configuration to the ultimate fully modulating approach. Many industrial drying applications utilize the simple hi/lo arrangement where oven temperature control can be typically permitted to vary by + or – 5ºC (10^{o}F).

Fully modulating control systems continually monitor the process air temperature and react instantly. As a result extremely close temperature control is achieved with these systems.

The Lanemark FD burner is ideally suited to these direct fired applications where close temperature control is required which in turn implies that the burner must be able to operate over a wide range of gas inputs, commonly termed `high turndown'.

The construction principles of the FD burner provide this `high turndown' capability with turndown ratios of upto 50:1 being achievable on the larger burner models.

Another major consideration is that the length of the flame should be as short as possible. On many direct fired oven processes the burner is operating relatively close to the air inlet of a main process air recirculation blower. It is obviously important that the flame is not permitted to be drawn into the blower inlet, nor to directly impinge on any part of the process chamber construction. Specific guidelines are available relating to FD burner mounting arrangements. (See relevant section of the Installation and Start Up Manual).

1.3 FD BURNER TERMINOLOGY

Combustion Chamber : The area directly in front of a burner utilized for combustion. In indirect heating systems the exhaust or secondary heat exchanger ductwork will be fitted to the discharge end of the combustion chamber.

In direct heating systems the combustion chamber will also serve as a mixing chamber to transfer heat to the process air flow.

Combustion Tube : A cylindrical housing fitted in front of the burner to protect the flame from process air velocities in excess of 6 m/sec (20 ft/sec).

Controls : Burner supervision equipment.

Exhaust/Air Dilution : The proportion of the process air flow which is exhausted/introduced to maintain the desired environmental conditions within the heated space.

FD Burner : A compact forced draught nozzle mix burner enclosing the burner head assembly, ignition and flame rectification electrodes, (U.V. scanners may also be used). The burner will also usually incorporate a combustion air blower and simple air control damper arrangement.

Gas Train : Gas supply system incorporating main and pilot (start) valves.

Process Air Blower/Fan: Main air blower/fan used to (re) circulate heated process air within oven, chamber, duct, etc.

Re-circulation airflow (%): The proportion of the total process air flow that is continually re-circulated within the heated space.

Temperature Controller: Electronic temperature control device (differential typically + or – 0.5ºC (1ºF) with optional temperature display. Normally used in conjunction with modulating gas burner control trains.

Thermostat: Temperature control device (differential typically + or – 3ºC (5ºF). Normally used in conjunction with hi/lo gas burner control trains.

Turn down ratio : The ratio between the maximum heat input required by a process and the minimum heat input required by a process.

Lanemark Process Burners

FD Burner Selection Guide

Model Range	***Heat Input***		**E**	**C**	**E(GA)**	**C(GA)**
FD5	30,000 - 400,000 Btu/h (9 - 117 kW)		✔	✔	**X**	**X**
	30,000 - 750,000 Btu/h **(**9 - 220 kW)		✔	✔	✔	✔
FD10	45,000 - 1,200,000 Btu/h (13 - 352kW)		✔	✔	✔	✔
	45,000 - 1,500,000 Btu/h (13 - 440 kW)		✔	✔	**X**	**X**
FD15	60,000 - 2,250,000 Btu/h (18 - 660 kW)		✔	✔	✔	✔
FD20	75,000 - 3,000,000 Btu/h (22-880 kW)		✔	✔	✔	✔

Burner Type applies to columns E, C, E(GA), C(GA).

Feature Summary

				E	**C**	**E(GA)**	**C(GA)**
Natural Gas				✔	✔	✔	✔
Propane				✔	✔	✔	✔
230v or 110v controls				✔	✔	✔	✔
On/off or High/low gas control				✔	✔	X	X
Modulating gas (only) control				●	●	X	X
Modulating gas + air control				X	X	✔	✔
Modulating motors	-	3 wire (24/110/230v)		●	●	✔	✔
	-	4 - 20mA		●	●	●	●
	-	0 - 10v DC		●	●	●	●
Controls plate mounted				✔	X	✔	X
Controls fitted in control box				X	✔	X	✔
Flame sensing electrode				✔	✔	✔	✔
UV flame sensing			●	●	●	●	
3 phase combustion air fan			✔	✔	✔	✔	
Fan contactor fitted				X	●	X	●
Single phase combustion air fan				●	●	●	●
Protective burner cowl				X	✔	X	✔
Multiple gas train handings				X	✔	X	✔
Downfiring arrangement				X	●	X	●
Satronic burner controllers				✔	✔	✔	✔
Landis & Staefa burner controllers				X	●	X	●
Johnson Controls main monobloc valves				✔	✔	✔	✔
Dungs main monobloc gas valves				●	●	X	X

KEY TO BURNER TYPE/FEATURE LISTING

FD_E	Basic burner assembly
FD_C	As FD_E but fitted with control box & protective cowl
FD_E(GA)	As FD_E but fitted with gas+combustion air control
FD_C(GA)	As FD_C but fitted with gas+combustion air control

Standard Feature	✔
Option available	●
Not available	X

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SECTION 2

2.1 FD BURNER SYSTEM LOAD CALCULATIONS & SURVEY GUIDELINES

2.1.1. Enquiry Form and Guidelines

2.1.2. Additional Background Information

2.1.3. The Job Estimate and Customer Proposed

2.2 ENGINEERING DATA

Burners

Gas Train Piping

Controls

Flame Lengths

Combustion Air Pressure Requirements

2.1 <u>FD BURNER SYSTEM LOAD CALCULATIONS & SURVEY GUIDELINES</u>

The success of each FD burner application is dependent on the attention that is paid to the detail at the project survey stage.

The FD Burner Enquiry Form (see Appendix 1) should be used as a checklist for all inquiries both to provide the basis for burner sizing and also to act as an 'aid memoir' to ensure that all the burner engineering issues are addressed.

2.1.1. ENQUIRY FORM AND GUIDELINES (See Appendix 1)

One enquiry form should be completed for each process heating system or for each individual stage where a multiple stage installation is planned, (unless each stage is to be identical).

Company, Address, Name, Position, etc.

This data relates to the organization to whom
the quotation is to be addressed.

Project Identification/Process Line/Equipment Identification & Stage

Enter the Project Identification/Process Line/Equipment Identification & Stage Name, number or reference for each plant/stage to be considered.

Existing Heating System (where applicable)

Indicate the type of the existing heating system if a replacement/retrofit is under consideration.

Operating Specifications

Complete the fprm as required providing details of whether the application is to be direct firing or indirect firing, the maximum and minimum required heat inputs, the air velocity and staic pressure, the process temperature, whether there is a possibility of flammable vapours being present in the airflow (see note below), the re-circulation and exhaust/make up air flows and finally the required mode of operation (on/off, high/low (gas only), modulating (gas only), or modulating (gas+combustion air).

NOTE: Flammable Vapours: If flammable vapours are present the customer must specify that direct firing is acceptable and that he will take the necessary precautions in his process heating system design.

Combustion Area Details

Insert information relating to the area immediately in front of the burner and also indicate the type/thickness of wall insulation that will be present.

Burner Location Details

Information is required to determine the intended position/location of the FD burner relative to the main process air fan.

If the burner is to be mounted on the negative/inlet (preferred) side of the main process air fan and is to fire directly towards the fan inlet, the distance from the burner face to fan inlet must be stated to ensure that adequate clearance will be available for the maximum flame length.

Fuel & Electrical Requirements

Provide details of the type of gas fuel that will be used together with the supply pressure. For the electrical specification state the intended combustion air fan motor voltage etc, the control voltage & the type of control signal (modulating burners only).

System Sketch, Reason for change & Additional Comments

Complete these sections to provide additional background information for the project.

2.1.2 BACKGROUND INFORMATION

Combustion Chamber Details.

The air velocity within the combustion chamber is required to determine whether an extended combustion tube will be required.

It is important that the combustion chamber pressure is recorded.

If the burner location had been specified as required on the negative (inlet) side of the main process air fan then the combustion chamber pressure should be negative.

Conversely if the burner is to be located 'downstream' of the burner at the positive (discharge) side of the main process air fan then the combustion chamber pressure should be positive.

If the combustion chamber pressure is greater than 1.25 mbar (+0.5" w.g). or less than –5 mbar (- 2.0"w.g). Lanemark engineers should be consulted to ensure that a suitable burner combustion air arrangement can be provided.

If the combustion chamber pressure is positive two alternative approaches to the burner combustion air supply can be considered.

a) Either provide an elevated combustion air pressure by using an uprated blower.

or

b) In cases of higher pressures install a simple damper arrangement in the main air ductwork with a combustion air take off duct fitted prior to the damper. The damper should reduce the downstream main air pressure by 5 mbar (2" w.g) to provide the necessary differential across the burner cone assembly required for satisfactory combustion.

Note: A positive combustion chamber pressure must also be noted in respect of the required burner head gas pressure. For full output on natural gas a burner head gas pressure of 5-7.5 mbar (2-3" w.g) is required. If the combustion chamber pressure is for example +25 mbar (+10" w.g) then the burner head gas pressure will need to be 30 – 32.5 mbar (12-13" w.g) and the gas train sized accordingly. In extreme cases a gas booster may be required.

The combustion chamber dimensions should be noted to ensure that adequate clearance exists for combustion and flame length. Flame impingement on any duct surface must be avoided.

The insulation data is required to ensure that suitable mounting arrangements can be made for the burner.

Burner Selection Details.

<u>The burner rating is most often supplied by the customer and no further burner sizing considerations are therefore necessary in these cases.</u>

However if a calculation of anticipated duty is required based on the data inserted in the Plant Applications Details section (perhaps for a retrofit burner application) then the following basic procedure can be adopted.

$$Q = (Q_R + Q_M)/\ 0.91$$

where Q is the required burner rating (gross)
Q_R is the recirculation heat input requirement(net)
Q_M is the make up heat input requirement (net) for any fresh air input

Where $Q_R = RD \times SH \times T_1$
and $Q_M = M \times D \times SH \times T_2$

R is the recirculation air flow
D is the density of the air
SH is the specific heat of the air
T_1 is the temperature difference between the maximum operating temperature and the recirculation air flow
T_2 is the temperature difference between the maximum operating temperature and ambient incoming air temperature.

NOTE: No account has been taken of oven wall losses or warmup requirements which are obviously dependent upon the overall size/volume of the process plant and warm up time requirements.

Combustion Air Supply

If a non standard combustion air blower arrangement is required (for example a multiple burner air supply), details should be provided.

Combustion Tube

An extended combustion tube should be requested if the process air flow will be greater than 6 m/sec (20ft/sec) across the face of the burner.
Standard extended combustion tube data is shown in Section
The extended combustion tube will "protect" the flame from excessive bending in the airstream.

Gas Train/Controls Selection.

Indicate the required gas train/controls configuration, whether Lanemark is to supply these items, and whether any particular specifications have to be met.

Fuel and Electrical Requirements.

Details of the fuel type and pressure together with a full listing of the electrical requirements are required in this section.
Please note that for modulating gas trains/controls the actual modulating control signal is derived from an external temperature controller.

Burner Location

Wherever possible FD burners should be mounted horizontally.

Other firing attitudes are permitted but particular care should be taken to avoid the combustion air fan motor from being subject to excessive temperatures which can occur following plant shutdown if, for example, the burner is firing vertically downwards.

Controls Location

On `unpackaged' burner systems ignition and air pressure sensing pipe lengths should be kept to a minimum. If the burner is relatively inaccessible a local control box can be provided to house the necessary ignition transformer, air pressure switch and 3-way air valve(s). The burner programmer may then be mounted in a separate remote enclosure which would be fitted with control switches and lamps together with any temperature control equipment if so desired.

Temperature Measurement/Control

Any temperature measurement/control devices should be installed following complete mixing of the combustion products and the main process air flow. Often the best mounting position will be after the main air fan and close to the area where the hot process air stream is being applied to the product which is being heated.

2.1.3 THE JOB ESTIMATE AND CUSTOMER PROPOSAL

The Lanemark quotation proposal will incorporated data as noted in Section 2.1. and shall include the cost to supply some or all of the following basic system components :-

FD Burners including combustion air blowers
Gas Trains
Burner Controls
Temperature Controls

The quotation will included a restatement of the essential design criteria extracted from the Enquiry Form.

Any assumptions made will be highlighted. We strongly advise that this restatement of essential design criteria be passed on to the client in the final proposal, in order that he may review, modify as required, and formally accept the parameters of the design being offered.

For retrofit applications and provided sufficient data has been included on the original enquiry form, efficiency comparisons can be made between the FD system proposal and that of the equipment currently in use. Fuel consumption and running cost comparisons can then be made which when linked to the overall end user project cost (i.e. including installation and start up costs) will provide the client with a basis upon which to make a project pay back analysis.

2.1 ENGINEERING DATA

Burner Arrangements (including combustion tube)

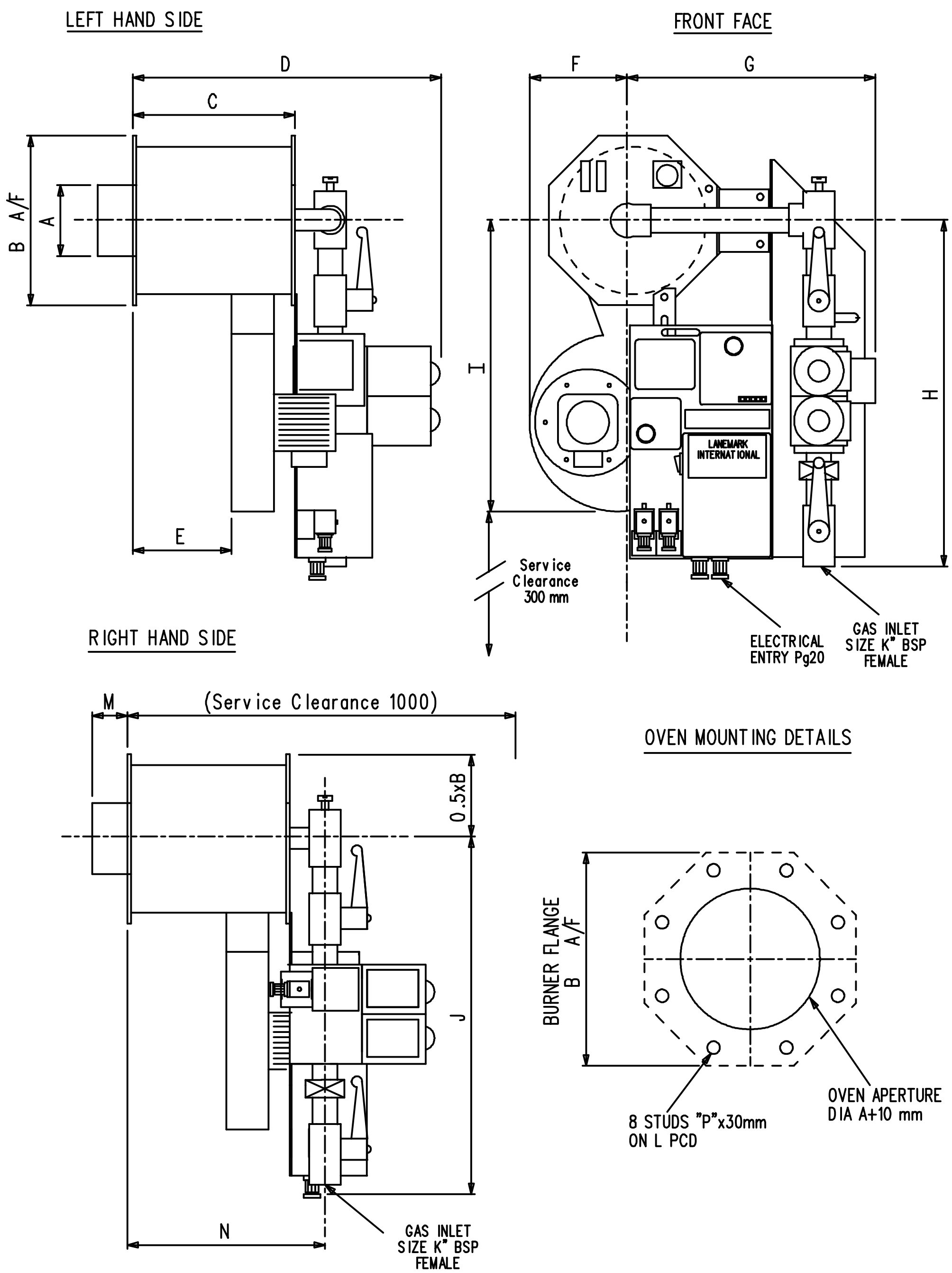
Gas Train Piping - typical

Controls – typical wiring diagram

Flame Lengths

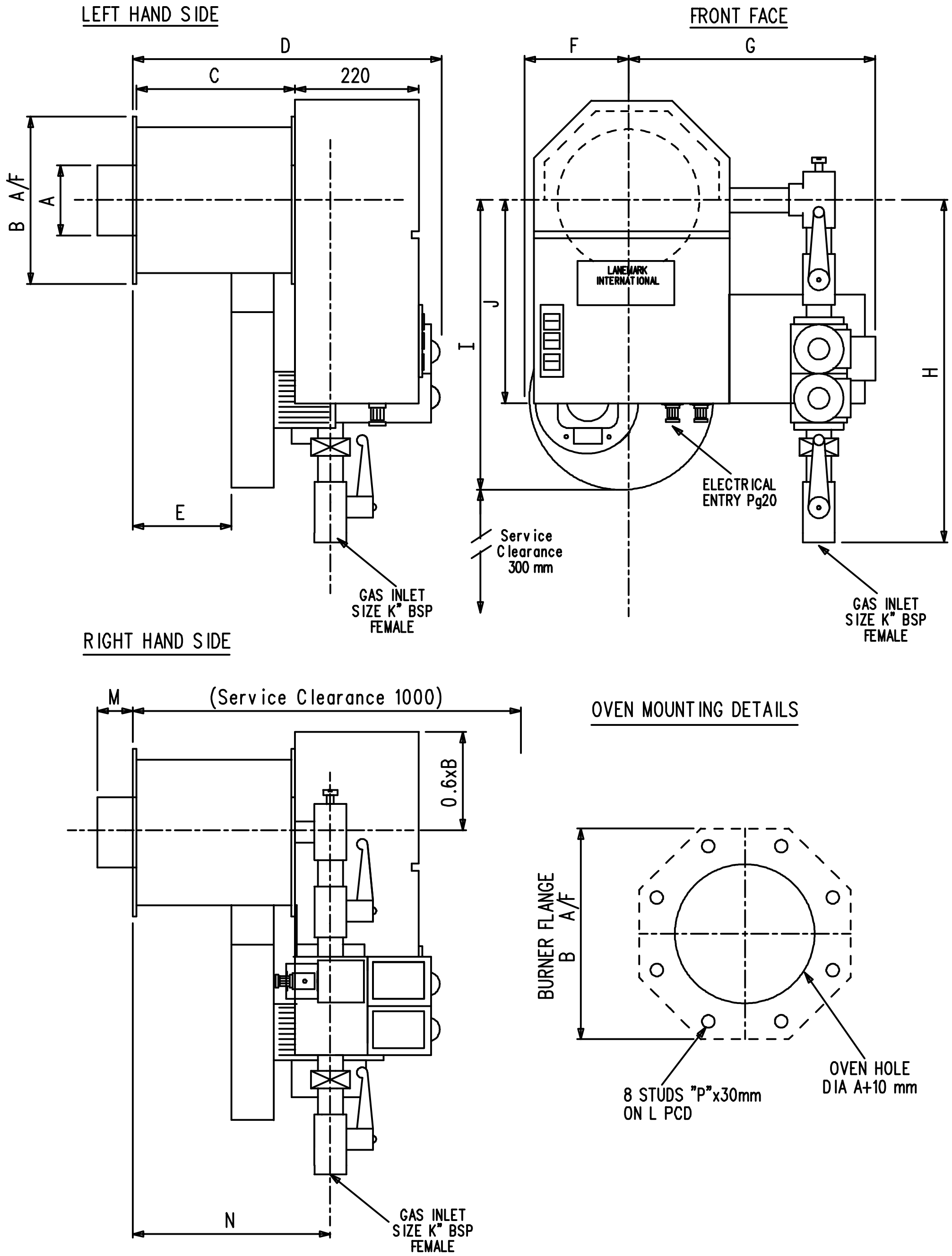
Combustion Air Pressure Requirements

Fig 1 FD_C AND FD_C(GA)GENERAL DIMENSIONS (mm)



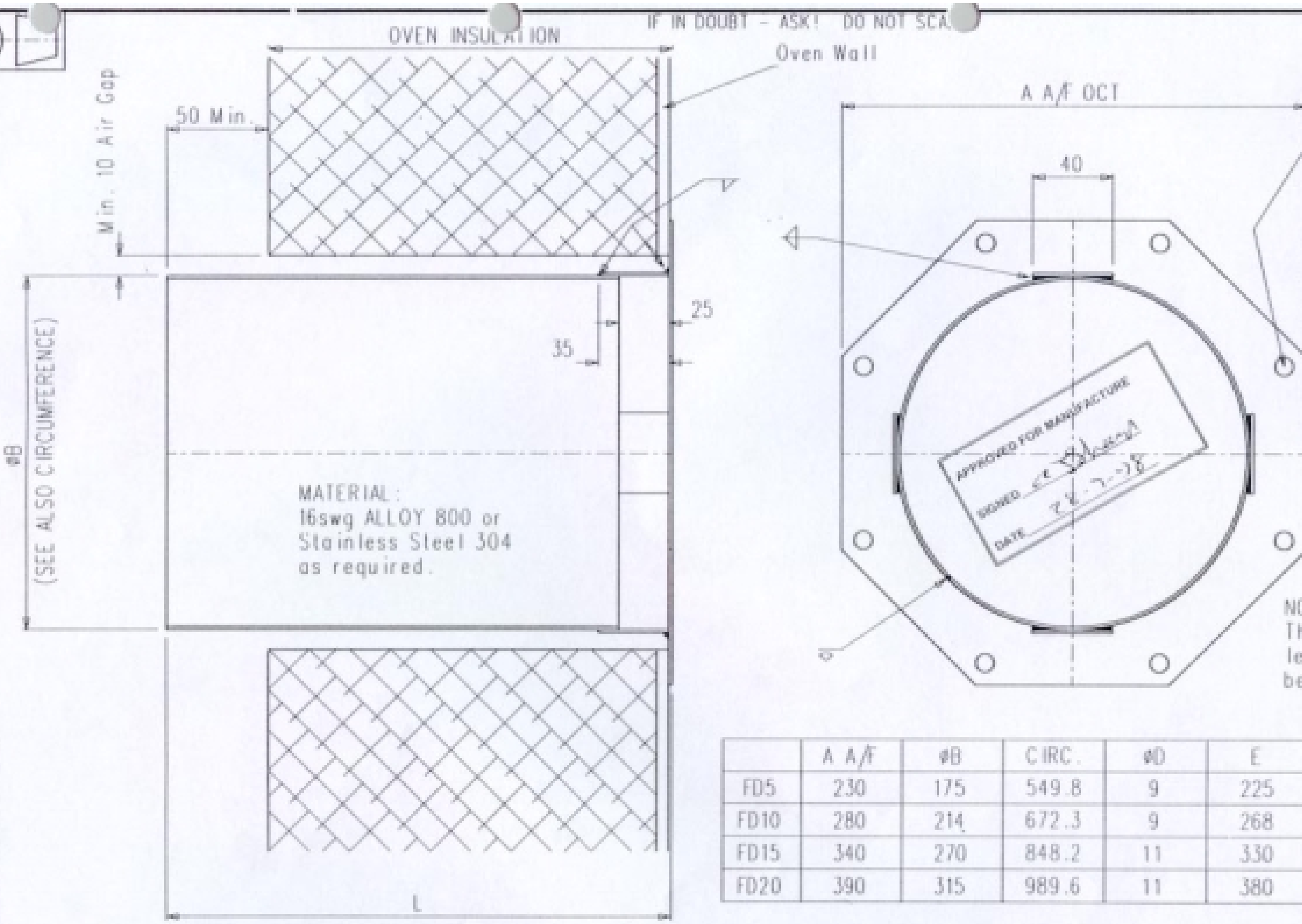
<u>FD E & FD E(GA) OUTLINE SCHEMATIC (For dimension tables please see Appendix 2)</u>

Fig 1 GENERAL DIMENSIONS (mm)



FD C & FD C(GA) OUTLINE SCHEMATIC (For dimension tables please see Appendix 2)

IF IN DOUBT - ASK! DO NOT SCALE



8 x øD HOLES SPACED AS SHOWN ON 'E' PCD.

FOR THE PROTECTION OF:-

1) Flame from HIGH AIR FLOWS. [Greater than 20 ft/sec (6m/sec)]

2) Oven Insulation from Flame Impingement.

NOTE:
These are standard lengths but others can be made as requested.

	A A/F	øB	CIRC.	øD	E	L
FD5	230	175	549.8	9	225	200
FD10	280	214	672.3	9	268	250
FD15	340	270	848.2	11	330	300
FD20	390	315	989.6	11	380	350

DRG No 40 024

SCALE at A3	MATERIAL	TOLERANCES UNLESS OTHERWISE STATED = ± 1.5	DIMENSIONS ARE IN MM (Inches)	CUSTOMER	ASSEMBLY	DR'N BY	DATE	CHECKED	DATE
1 : 2	As Stated				40 026	AJS	06/03/91	AET	28/07/98

ISSUE	1	2	3
CHANGE No	0131	0226	1426
DATE	13/03/91	15/01/92	09/07/98
SIGNATURE	AJS	AJS	AJS

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TITLE: FD COMBUSTION TUBE

JOB No | REF No | SHT 1 / OF 1

DRG No 40 024

CODE C3

LANEMARK INTERNATIONAL Ltd

GAS TRAIN DESIGN

DRG No. 55 637

DATE	DESTINATION COUNTRY	APPLICATION	HANDING	FUEL	ISS BY	SUPPLY VOLTAGE
05/01/00	ALL	Remote	L & R	Nat / Prop	AS	230 V.A.C. 50 Hz

SCHEMATIC DRAWING

Approximate Size:

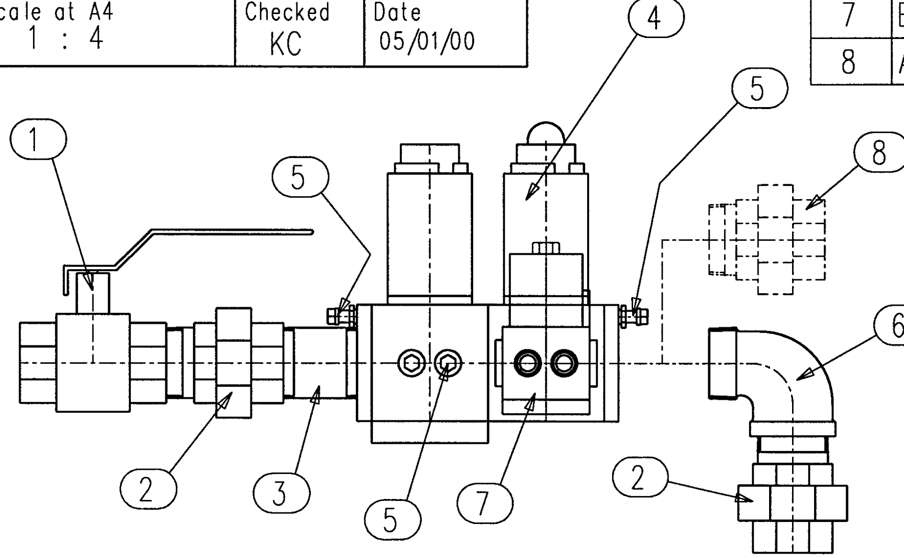
O/ALL LENGTH	O/ALL WIDTH	O/ALL HEIGHT
555	100	225

TYPE: GM4 230V 1xBYPASS

ISSUE	1		
CHANGE No	1775		
DATE	05/01/00		
SIGNATURE	AJS		

Scale at A4	Checked	Date
1 : 4	KC	05/01/00

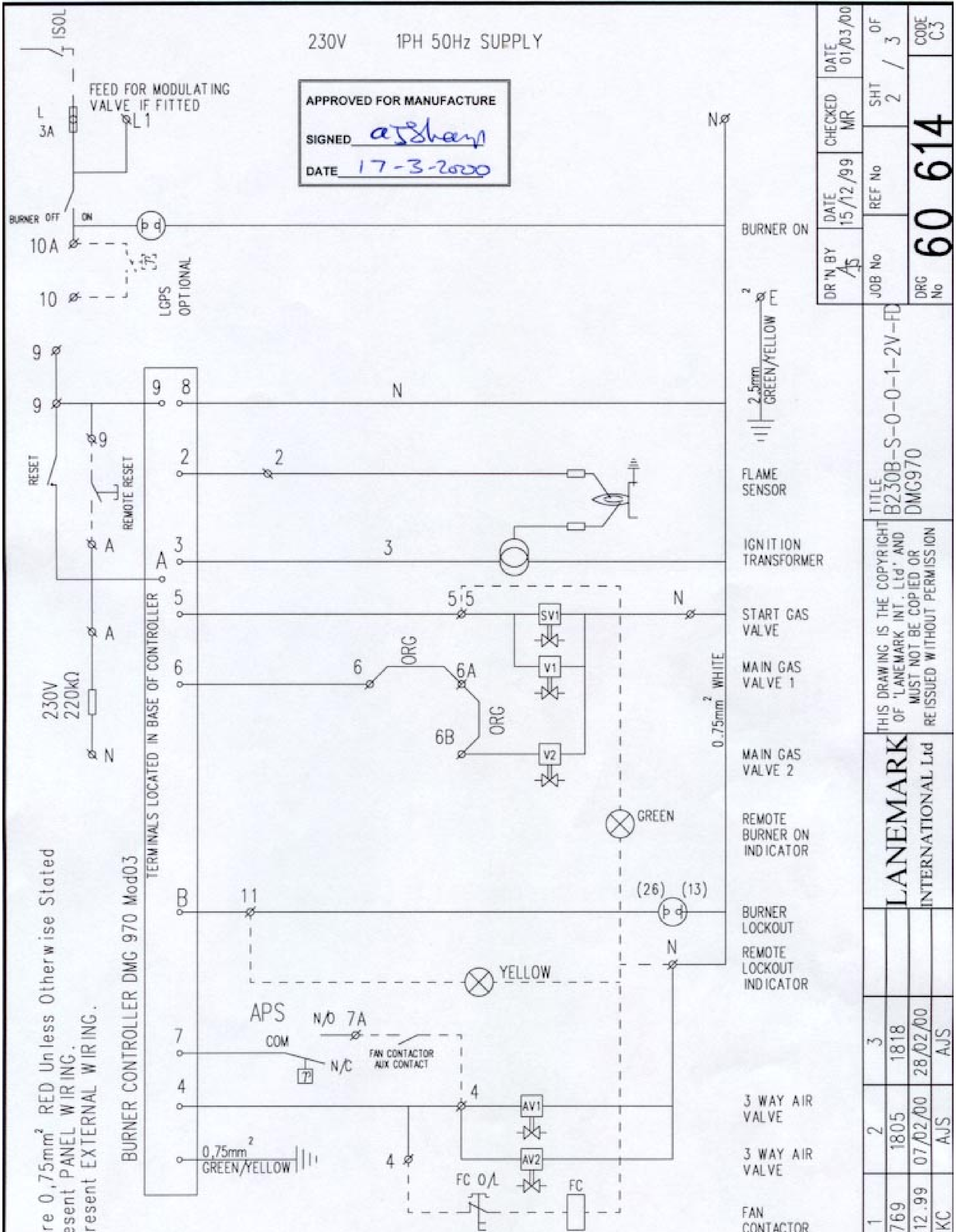
Item	Description	Part No
1	1 1/2" GAS BALL VALVE	15055
2	1 1/2" M/F UNION	18100
3	1 1/2" BARREL NIPPLE	18099
4	JOHNSON GM4 GAS BLOCK	10518
5	PRESSURE TEST POINT	22030
6	1 1/2" ELBOW	18243
7	BYPASS VALVE	10421
8	ALTERNATIVE – 1 1/2" M/F UNION	18100



APPROVED FOR MANUFACTURE

SIGNED________

DATE________



TERMINALS: FOR SERVICE ENGINEER'S USE ONLY
6 and 6A – LOW FIRE HOLD LINK
TERMINALS: THERMOSTAT or TEMPERATURE CONTROLLER
6A and 6B = SET POINT:– HIGH/LOW CONTROL
NOTE! LINK TERMINALS for ON/OFF CONTROL
9 and 10 = a) ON/OFF CONTROL / HIGH LIMIT (ALARM)
+b) ANY OTHER EXTERNAL INTERLOCKS IN SERIES
NOTE! LINK TERMINALS if NO LIMIT/EXTERNAL INTERLOCKS USED

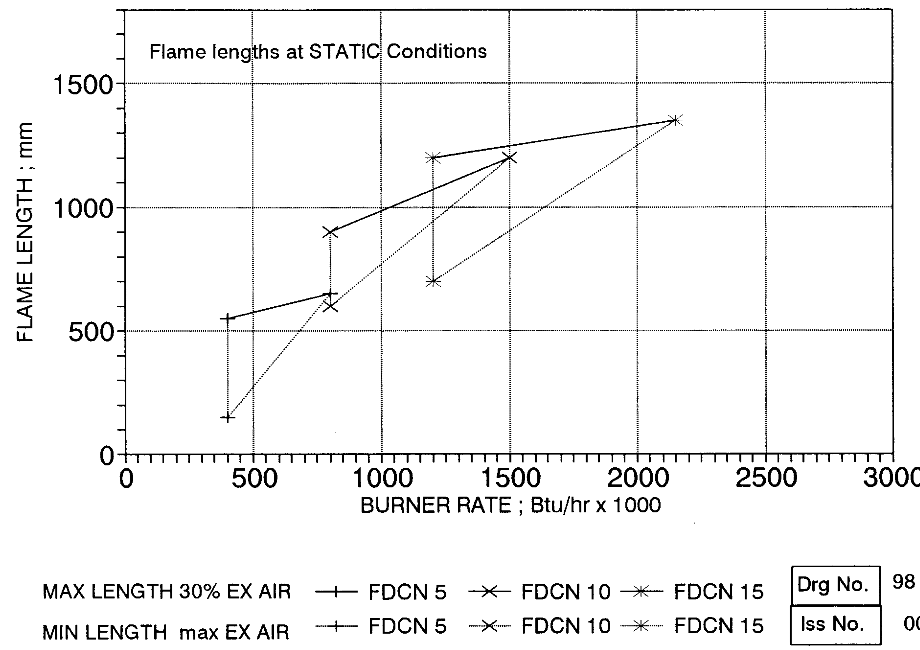
ø PANEL TERMINAL

DRG No 60 614

CODE C3

date1/3/94

FD C-N mkIII
FLAME LENGTH vs Burner Rate



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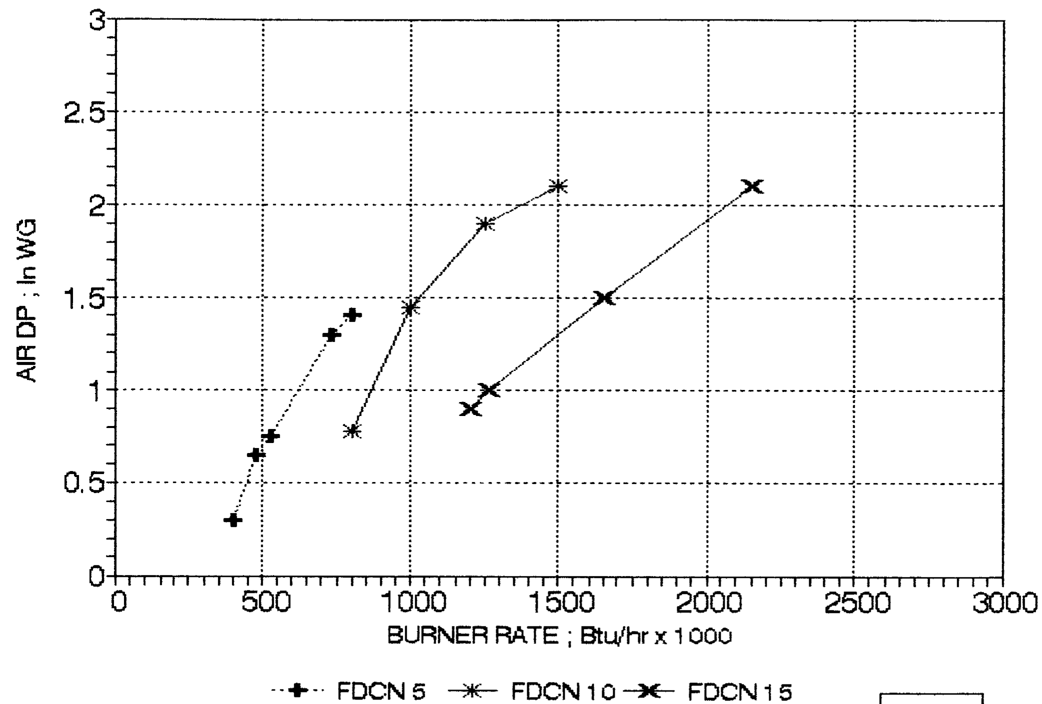
FD C-N mkIII
AIR DP vs Burner Rate

date 1/3/94



ALL DATA at 30% EXCESS AIR

Drg No.	98 023
Iss No.	001

SECTION 3

SELLING THE FD BURNER/PROCESS AIR HEATING SYSTEM

3.1 INTRODUCTION

3.2 MARKET AREAS

3.2.1 HEATING METHODS

3.2.2 APPLICATION AREAS & METHODS

3.3 CUSTOMER TYPES

3.3.1 THE ORIGINAL EQUIPMENT MANUFACTURER (OEM)

3.3.2 THE INSTALLATION CONTRACTOR

3.3.3 THE END USER

3.3.4 THE CONSULTING ENGINEER

3.3.5 THE GAS SUPPLY UTILITY

3.1 INTRODUCTION

What do FD burners do? They preheat, heat, dry, stove, cure or bake products.

Where are FD burners used? They are used in forced air convection ovens or dryers.

What alternative heating systems are there?

a) Convection ovens or dryers heated by steam batteries, thermal oil, hot water heat exchangers, electric elements or outdated gas or oil burner arrangements.

b) Radiation ovens heated by gas or electric radiant emitters.

c) Conduction drying.

What types or product areas could benefit from the use of FD burners? The main markets are associated with :-

a) Product finishing - metals, wood, plastic etc.

b) Textiles and paper drying.

c) Pottery, ceramic and glass production.

d) Plastic molding and rubber goods manufacture.

e) Crops and food production.

f) Clothes drying (laundries).

3.2 MARKET AREAS

3.2.1 HEATING METHODS

A. Convection Ovens and Dryers

Convection ovens and dryers are normally either of a `box` type construction which is a closed cubicle suited to batch production methods or the `conveyor` or tunnel based systems which are open ended and designed for a continuous production flow.

Ovens or dryers used in the `low' temperature range upto 450ºC (850º F) are typically produced in a double skin construction incorporating a layer of insulation to minimize heat loss. Any access doors will also be insulated. The oven or dryer control system will supervise the operating temperature(s) (which can vary on some oven designs), and can utilize process timers, motor switchgear, time switches, process program controllers, temperature controllers and so on. These controls will also include any necessary interlocks to ensure the safe operation of the gas burners, combustion air and main process air fans.

Convection ovens and dryers are the most commonly found of this type of process heating system, representing perhaps 80% of the available market compared to a 10% share devoted to radiant ovens and dryers, 5% to conduction methods and the last 5% to various combination ovens which use some combination of any two (or all three) of the convection, radiation and conduction methods.

In convection ovens or dryers heat transfer occurs by direct contact between the wet object and the hot process air flow. The resultant vapour is then carried away by the process air flow.

Air is a very convenient medium for heat and mass transfer. Air has a low specific heat and can therefore be raised in temperature very quickly. For mass transfer, a small increase in the air temperature increases the quantity of moisture it can carry. For example in a dryer, an increase in air temperature from 38 – 42º C (100ºF to 110ºF) + (10%) increases its moisture carrying capacity by about 35%. Therefore air is an excellent and very flexible drying medium.

The usual method of maximizing efficiency in a convection oven or dryer is to recirculate some of the process air back through the system. This technique also tends to give a more even temperature distribution and therefore provides a more uniform result than the simple "single stage" type of plant.

The ratio of recirculated air to the vented air must not be too high otherwise humidity and/or the level of contaminants will build up which at best will seriously retard the oven or drying process or at worst lead to a potentially dangerous situation particularly if solvents are involved.

As discussed in Section 1, convection ovens or dryers can be heated by either indirect or direct methods.

In the **indirect** air heating system process air is blown or sucked across a heat exchanger which is heated by a gas or oil burner, hot water, steam, or thermal oil. The process air at no time comes into direct contact with the material to be heated and therefore cannot be contaminated in any way be the heating system.

The usual reasons for indirectly heating the product occurs when (a) the product is sensitive to possible contamination by combustion gases eg. some foodstuffs or (b) if any flammable vapors are present in the oven space.

Direct air heating systems mix combustion gases and the main process air flow. Gas has a particular advantage to other burner fuels due to its relative cleanliness when burned and can therefore be employed in many cases where product contamination must be avoided.

The hot air utilized in a direct fired process heating system is generated from either an external (and sometimes packaged) air heating assembly or from burner system built directly into the ductwork associated with the oven/dryer construction.

The principle advantages of a **<u>direct</u>** fired gas process air heating arrangement compared with alternative indirect methods are :-

a) **EFFICIENCY** : 20-25% higher which leads to substantially lower operating costs.

b) **ENHANCED TEMPERATURE CONTROL RESPONSE** : Operating temperatures can be reached quicker and the system will respond faster to changes in process load and process temperature variations.

c) **CHEAPER INSTALLATION**

d) **ADAPTABILITY** : Conversion of existing convection ovens/dryers to direct gas firing is relatively simple and inexpensive. Lower operating costs, improved product quality all result from the installation of this faster and more controlled process heating approach.

Gas when compared to other fuels is :

a) Cleaner
b) Requires less maintenance
c) Compact
d) More efficient
e) More controllable
f) More adaptable

Steam heating is still common for a very large number of low temperature oven and drying applications. As discussed in Section 1 the associated indirect heating inefficiencies coupled with steam's need for large, expensive, inflexible ancillary equipment and its inherent temperature limitations are big drawbacks where economy, flexibility and higher production rates re required.

B. <u>Radiation Ovens & Dryers</u>

Radiation heat processing depends on the efficient generation and transmission of infra red energy and its absorption by the article to be heated.

Because of the nature of infra red radiation, in that like light it travels in straight lines, the materials to be processed must present a flat smooth plane normal to the path of the radiation. Articles having more than one plane surface can be effectively treated by arranging general radiating surfaces in the same planes as exhibited by the surfaces of the article.

Articles which are irregularly shaped will, if dried by radiation only, suffer from "shadowing" of parts of the article by these irregularities. Presuming nothing can be done about the irregularity of the surfaces, this shadowing effect can be overcome, to some extent, by the re-radiation within the irregularities, by conduction through the material and by the natural setting up of small convection air currents within the various irregularities. The relative success of this secondary heating is wholly dependent on the nature (e.g. thermal conductivity) of the article.

The best way to overcome severe shadowing is to supply additional warm air convection.

Radiation heating systems do however have some advantages :-

a)	**FAST WARM UP**	**:**	Radiant panels and plaques can reach operating temperatures from cold rapidly (perhaps 4-5 minutes) compared to the usual 15-30 minutes for modern convection based equipment.
b)	**SIMPLICITY & FLEXIBILITY**	**:**	Gas fired radiant heaters are very light, compact and highly adaptable. The process heating system can be tailor made to fit the specific requirements of individual products placing the heat exactly where it is wanted. Units can be added or subtracted.
c)	**OVEN ZONE TEMPERATURE**	**:**	In continuous operation the ability to "grade" the radiant energy along the length of the oven or dryer is very important. Simply by setting the gas controls, "strong heat" can be applied in the first stage or zone of an oven or dryer when the material is perhaps very wet, and "gentle heat" towards the exit. Conversely the product can be heated gently at the entrance to the dryer and more strongly in the latter stages when heat treatment of the product (eg curing) is required.
d)	**COST**	**:**	Radiant heating schemes are relatively inexpensive.

These factors plus the ability to be able to vary the transmitted radiant flux density quickly, to suit a variety of surface conditions, lend themselves particularly to continuous and automatic processes.

The disadvantages associated with radiant heating result from the nature of radiant heat.

Drying or processing rates using radiation **alone** are adversely affected by :-

a) **IRREGULAR SURFACES:** (See above)

b) **ABSORPTION RATES :** Different color paints and surfaces will absorb more radiation than others. For example dark, matt surfaces will dry faster than light, polished surfaces. The strength of the heat radiation (flux density) must be adjusted for different colour surfaces.

Also the relative thickness of the surface being treated will affect the rate at which production can be maintained. High absorptivity films allow drying in depth, but low absorptivity may cause surface hardening giving incomplete results.

Production can often be greatly increased and the reject rate reduced by introducing forced convection heating to radiation ovens and dryers.

This helps the heat transfer to the products and the mass transfer of any resulting vapor away from the material.

Conversely because of the advantages of radiant heating, its addition to convection and conduction drying methods very often gives excellent results usually in the form of increased production rates, shorter drying times, more even drying etc.

C. **Conduction Ovens and Dryers**

Conduction drying involves the heat transfer to the wet solid through contact with retaining walls, conveyor rollers etc. **Any vapors must be removed independently by natural or forced convection** (or in some instances by discharge into a vacuum).

3.2.2 APPLICATION AREAS AND METHODS

A) **Product Finishing**

Drying or curing requirements associated with product finishing occur at two stages :-

1. Following pretreatment

2. Following final treatment (e.g. painting)

Pretreatment

Typical pretreatment processes include spray or dip liquid degreasing, cleaning, phosphating, etc. often associated with Lanemark TX tank heating burner systems.

Articles are usually `wet' at the conclusion of their pretreatment (unless they are dried as a result of a final immersion in a very hot final liquid stage which has the effect of flash drying the component).

The articles must be dry before moving on to the final treatment stage.

This is achieved by either naturally drying under static conditions, cold air forced convection provided by high pressure blowers or by heated dryers.

Final Treatments

Following pretreatment and drying, articles receive their final treatment which often involves the application of various types of paint finish (eg. powder coating).

Most paints used for industrial finishes can be dried or cured at temperatures upto around 200ºC (350ºF). Newer "low bake" paint technology permits drying or curing at around 100ºC (210ºF).

The aim of paint drying is to achieve a high quality finish and therefore cleanliness and uniformity are of prime importance.

The most popular methods of paint drying, curing or baking use convection, radiation or convection/radiation combination methods.

Direct gas fired process heating methods are popular and the recirculation of hot main process air flows can often be employed to minimize energy requirements. Recirculation rates vary from 10% to 90% depending on the anticipated concentration of contaminants which can be expected.

B) **Textiles and Paper Drying**

In the textile and paper industries the products may often need to be dried more than once during manufacture. This is especially so in the textile industry where drying usually follows washing, bleaching, dyeing etc. In the manufacture of artificial fibers and paper sheet, drying may be the culminating process which transforms the raw stock into the final product.

The basic materials of the textile and paper industries are hygroscopic. Some form of mechanical de-watering - eg. squeeze rollers, or vacuum extraction usually precedes thermal drying.

However some viscose rayon type yarns may for example contain up to 70 - 80% moisture content and do not lend themselves to mechanical drying methods.

The two established types of dryers in the textiles and paper industries are :-

1) **Contact or Conduction Dryers -** continuous roller drying - used extensively in the paper industry but with limited use for textiles where inferior yarns may be produced due to shrinkage.

2) **Convection Dryers -** either batchwise in drying chambers where the material is suspended or in continuous types of process dryers.

3) **Radiation Dryers -** used occasionally.

C) **Pottery, Ceramic, Glass Production**

Direct gas fired convection ovens are commonly used in the production of these items. Again the processes can be of the `batch' type or semi continuous utilizing `tunnel' type plant.

In pottery and ceramics drying a clay `body' is prepared by mixing various raw materials with water to give `a plastic' material which is then molded to the required shape.

To be of any use, the ceramic ware must be hardened by `biscuit' firing at 1100 – 1200ºC ( 2000-2,200ºF ), but first the `green' ware must be carefully dried to a very low moisture content to avoid shrinkage cracks, warping or bursting caused by steam developed in the material. Drying is therefore a very critical operation the manufacture of ceramic wares and pottery.

Drying often takes place in batches in a drying chamber. The popular method is the hot floor method - i.e. the natural convection of warm air from steam pipes in the floor. But for large scale production of standard articles, continuous drying methods are necessary in conveyorised tunnel dryers.

To minimize damage during drying, the mass of the wares is heated to an even temperature in very humid air. No drying takes place in this pre-heating zone of the tunnel. Then the humidity is progressively reduced - slowly at first then more rapidly as the ware passes through the tunnel.

Direct gas fired air heaters provide an economic answer for drying `green' ware before biscuit firing. Here the advantages of cleanliness accuracy and controllability are of vital importance.

Infra-red drying is usually avoided unless he ware is very thin.

D) **Plastic Moldings and Rubber Goods Manufacturing**

Rotary molding machines for the production of plastic goods often utilize direct fired convection techniques.

Rubber products require drying, and curing at various stages of their manufacture and hot air direct fired process heating systems offer a flexible economic and responsive solution to these heating problems.

E) **Crops and Food Production**

The principle aim of drying crops and foodstuffs is to facilitate storage. This applies particularly to perishable items.

A further advantage often arises from drying. Most crops and food in their fresh state, contain between 60% and 90% water and drying reduces their weight and volume considerably. This in turn reduces the costs of handling, packaging, transport and storage.

The main problem in food drying is to remove only the water and to retain the food's appearance, flavour and vitamin value.

Crop dryers can be of the pneumatic conveyor, tray or rotary types. Often propane is used as the gas burner fuel due to the remoteness of the locations. Direct gas fired air heaters usually have **no** adverse effects on crop quality.

Food dryers fall into similar categories.

F) **Clothes Drying (Laundries)**

Direct gas fired convection dryers can significantly reduce the overall energy consumptions in laundries where the `traditional' heating medium is steam.

3.3 CUSTOMER TYPES

The following types of customer, specifying authority or influencing authority exist in all market areas.

1. The end user
2. The installation contractor
3. The consulting engineer
4. The original equipment manufacturer (OEM)
5. The gas supply utility.

3.3.1 THE END USER

A. Product Finishing

Manufacturing companies who have their own product finishing processes will provide a significant customer base for FD system sales.

Such companies usually employ capable works engineering staff who are able to suggest opportunities and are therefore able and willing to liaise on equipment layout design proposals.

Energy conservation and operational flexibility are seen to be important factors when considering either a change of heating system to an existing piece of plant (a retrofit) or when specifying the design criteria that should be included within a new product finishing facility. Works engineers will often require assistance with the preparation of a financial justification which has to be submitted to company accounting management.

Specialist metal finishing companies tend to fall into two categories depending on size and area of specialisation.

1) The larger and more specialist finishing company will operate in a similar manner to the general manufacturing company described above, but with particular attention being paid to running costs which are understood to be of vital importance to their operations.

2) The smaller specialist finishing company is often rather more difficult to work with as they often seek the simplest and cheapest methods of heating (e.g. electric) from a capital cost viewpoint, even though the running cost arguments are quite apparent!

B. Food and Drink and Others

Food, drink and other process industry end users are generally well able to quantify their heating requirements but will require guidance concerning the various application areas which are potentially suited to FD burner systems due to the current domination of the industry by steam/hot water arrangements.

3.3.2 THE INSTALLATION CONTRACTORS

Some end users rely on the advice and guidance of contractors who regularly provide installation capabilities.

Installation contractors can therefore influence the equipment selection decision.

The type of installation contractor can vary from the small company (sometimes with a plumbing or limited heating and ventilating industry background) to the largest specialist process heating installation concerns. The range of experience with the use of FD type equipment will consequently vary accordingly.

3.3.3 THE CONSULTING ENGINEER

The larger type of new process engineering project may utilise the services of a consulting engineering company.

3.3.4. THE ORIGINAL EQUIPMENT MANUFACTURERS (OEM)

The OEM is a very important client base. OEM's range from small companies who work almost on a 'jobbing shop' basis for local manufacturing companies (including food and drink) to the large OEM's who specialise in certain produce areas of metal finishing pretreatment plants, food industry crate washing machines and so on.

The particular attraction of the OEM sector is that once 'specified' the FD burner system would enjoy repeat orders with little further design assistance requirements. However the competition will be fierce and OEM sales will require the smallest contribution margins.

3.3.5 THE GAS SUPPLY UTILITY

Natural gas, and LPG utilities often have strong links with their customer network. It is true that some utilities take more of an interest in the equipment used by their customers than others. However the local gas utility companies should see the FD system as an opportunity to 'tie' the end user to a gas load which is not possible with central boiler systems where fuel changes frequently occur.

Enlightened gas utility companies may therefore assist with the location of suitable end user companies and may even offer facilities to send direct mail shots to selected customers by SIC code using their 'billing databases'.

APPENDIX 1

FD BURNER/PROCESS AIR HEATING

ENQUIRY FORM

FD BURNER/PROCESS AIR HEATING ENQUIRY FORM
LANEMARK INTERNATIONAL LIMITED

Company ____________________ **Name** ____________________

Address ____________________ **Position** ____________________

____________________ **Telephone** ____________________

____________________ **Fax** ____________________

____

Date ____________________ **E-mail** ____________________

Project Identification ____________________ **Process Line** ____________________

Equipment Identification ____________________ **Stage** ____________________

Existing Heating System (where applicable)

Type/heat input ____

Operating Specifications

Direct fired ____________ **Yes/No** **Indirect fired** ____________ **Yes/No**

Max heat input ____________ **kW/Btu/h** **Min heat input** ____________ **kW/Btu/h**

Air velocity ____________ **m/s ft/s** **Static pressure** ____________ **mbar/in w.g**

Process Temperature ____________ **ºC/ºF** **Flammable vapours** ____________ **Yes/No**

Re-circulation Air Flow ________ **m^3/h ft^3/h** **Exhaust/Make up air flow** ________ **m^3/h ft^3/h**

Operating mode: ________ **On/Off** ________ **High/Low (gas only)** ________ **Modulating (gas only)**

________ **Modulating (gas + air)**

Combustion Area Details

Length ________ **mm/m/in/ft** **Width** ________ **mm/m/in/ft** **Depth** ________ **mm/m/in/ft**

Insulation: **External** ______ **Internal** ________ **Yes/No** **Thickness** ________ **mm/in**

Burner Location (relative to main system fan)

Inlet side ________ **Yes/No** **Discharge side** ________ **Yes/No**

Distance from fan ________ **mm/m/in/ft** **Max fan operating temperature** ________ **ºC/ºF**

Fuel and Electrical Requirements

Fuel	**Natural Gas**	_______	**Propane**	_______	**Other**	__________________
	Pressure	_______	**mbar/bar/in w.g/psi**			
Electrical Supply	**Combustion air fan:**	_______	**Volts**	______	**Phase**	______**Hz**
	Controls:	_______	**Volts**	______	**Phase**	______**Hz**
	Control signal: **(modulating burners only)**			______	**3 wire direct drive**	
				______	**4-20mA**	
				______	**0-10VDC**	
	Feed back potentiometer			______	**Yes/No**	______ **Ohms**

System Sketch

Please indicate burner mounting position relative to the main airflow and the area available for combustion.

Reason for considering change of heating system (where applicable)

Additional Comments

Lanemark International Limited
Lanemark House
Whitacre Road
Nuneaton
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U.K

Tel: +44 (0) 24 7635 2000
Fax: +44(0) 24 7634 1166
E-mail: info@lanemark.com

APPENDIX 2

FD BURNER DIMENSIONS

Fig 1 FD_C AND FD_C(GA)GENERAL DIMENSIONS (mm)

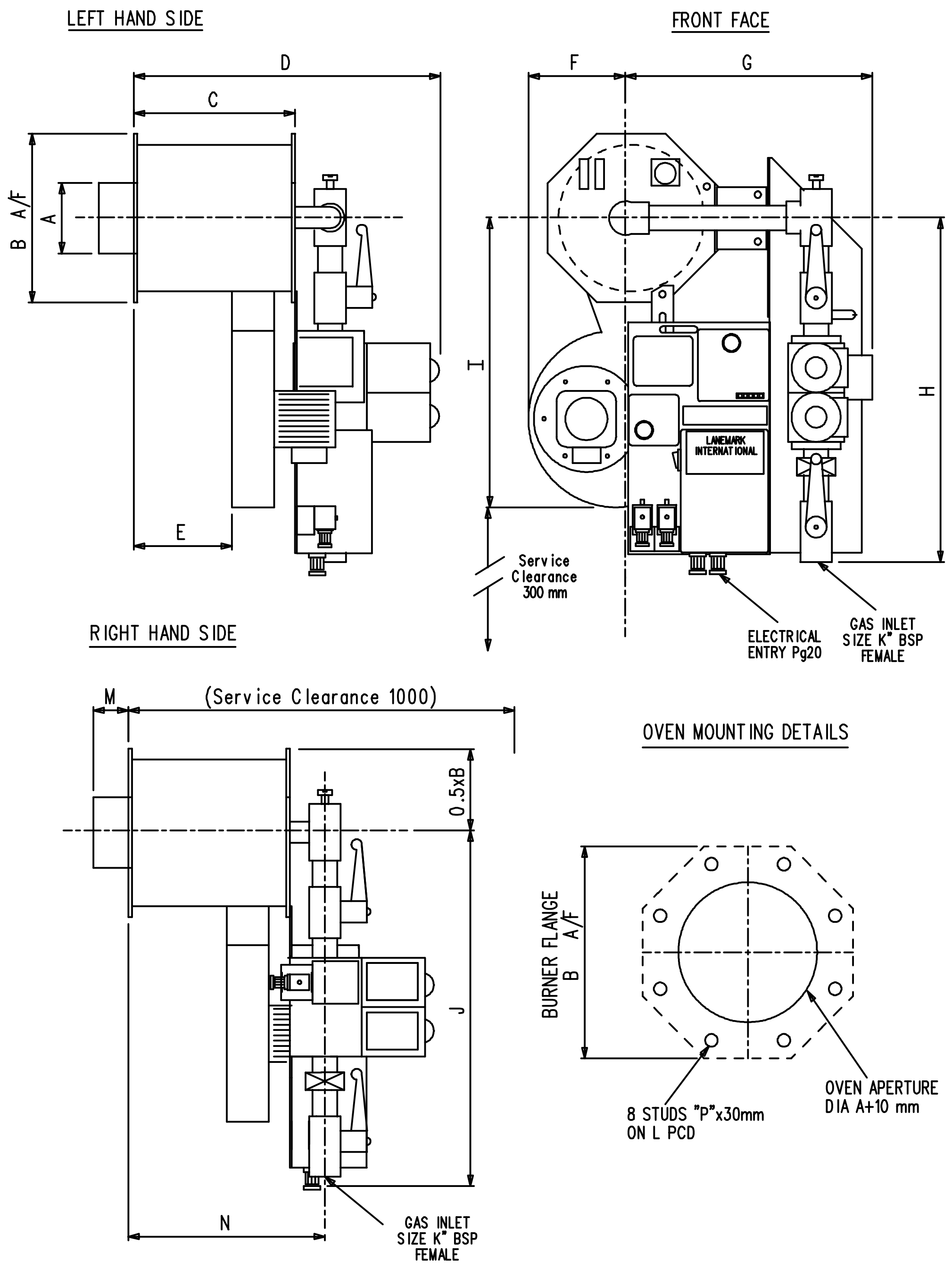
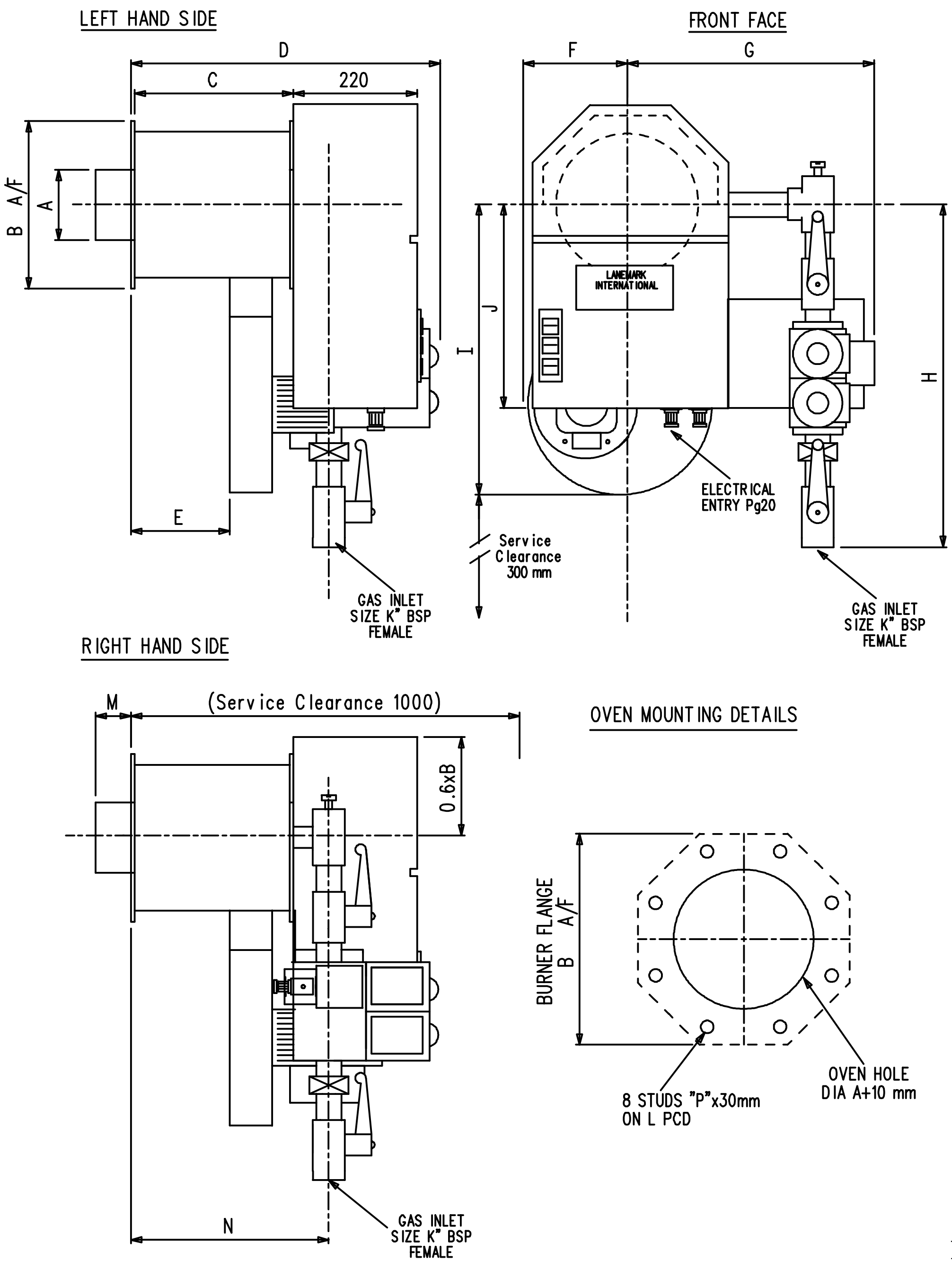


Fig 1 GENERAL DIMENSIONS (mm)



FDC & FD C(GA) OUTLINE SCHEMATIC

FD 5 / 10 / 15 / 20 E   DIMENSIONS

FD 5 E 9-117 kW Johnson G96 Gas Train ½”	A	B	C	D	E	F	G	H	I	J	K In.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	150	230	200	370	100	220	360	360	400	500	3/4	225	50	280	8	28	38

FD 5 E 9-220 kW Johnson GM2 Gas Train 1”	A	B	C	D	E	F	G	H	I	J	K In.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	150	230	200	430	100	220	360	470	400	500	1	225	50	280	8	30	40

FD 10 E 13-352kW Johnson GM2 Gas Train 1”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	190	280	250	500	110	240	390	470	450	530	1	268	50	310	8	34	44

FD 10 E 13-440 kW Johnson GM4 Gas Train 1 ½”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	190	280	250	500	110	240	390	500	450	530	1 1/2	268	50	310	8	36	46

FD 15 E 18-660 kW Johnson GM4 Gas Train 1 1/2”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	240	340	300	560	150	240	390	500	500	520	1 1/2	330	50	400	10	42	52

FD 20 E 22-880 kW Landis SKP20/10 Gas Train 2”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRIC STUD	Net Weigh t Kg	Gross Weight Kg
	280	390	350	780	170	250	550	1100	560	600	2	380	50	470	10	96	106

For FD 5 / 10 / 15 and 20 types “E” and “C” where modulating gas with fixed air has been specified dimension “ H “ the length of the gas train increases to account for the additional length of the modulating ball valve as follows :-

FD 5 add 80 mm to dimension “ H “.
FD10 add 100 mm to dimension “ H “.
FD15 add 100 mm to dimension “ H “.
FD20 add 150 mm to dimension “ H “.

FD 5 / 10 / 15 / 20 C DIMENSIONS

FD 5 C 9-117 kW Johnson G96 Gas Train ½”	A	B	C	D	E	F	G	H	I	J	K In.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	150	230	200	370	100	220	360	360	400	340	¾	225	50	280	8	29	41

FD 5 C 9-220 kW Johnson GM2 Gas Train 1”	A	B	C	D	E	F	G	H	I	J	K In.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	150	230	200	430	100	220	360	470	400	340	1	225	50	280	8	32	42

FD 10 C 13-352kW Johnson GM2 (1”) Gas Train 1”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	190	280	250	500	110	240	390	470	450	340	1	268	50	310	8	43	53

FD 10 C 13-440 kW Johnson GM4 Gas Train 1 ½”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	190	280	250	500	110	240	390	500	450	340	1 1/2	268	50	310	8	45	55

FD 15 C 18-660 kW Johnson GM4 Gas Train 1 ½”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	240	340	300	560	150	240	390	500	500	370	1 1/2	330	50	400	10	52	62

FD 20 C 22-880 kW Landis SKP20/10 Gas Train 2”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	280	390	350	780	170	250	550	1100	560	420	2	380	50	470	10	101	112

For FD 5 / 10 / 15 and 20 types “E” and “C” where modulating gas with fixed air has been specified dimension “ H “ the length of the gas train increases to account for the additional length of the modulating ball valve as follows :-

FD 5 add 80 mm to dimension “ H “.
FD10 add 100 mm to dimension “ H “.
FD15 add 100 mm to dimension “ H “.
FD20 add 150 mm to dimension “ H “.

FD 5 / 10 / 15 / 20 E (GA) DIMENSIONS

FD 5 E (GA) 9-220 kW Johnson GM4 (loflo) Gas Train 1”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	150	230	200	430	100	220	360	470	500	500	1	225	50	280	8	33	43

FD 10 E (GA) 13-352 kW Johnson GM4 (hiflo) Gas Train 1 ½”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	190	280	250	500	110	240	390	500	550	530	1 1/2	268	50	310	8	39	49

FD 15 E (GA) 18-660 kW Johnson GM4 (hiflo) Gas Train 1 ½”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	240	340	300	560	150	240	390	500	620	520	1 1/2	330	50	400	10	48	60

FD 20 E (GA) 22-880 kW Landis SKP70/10 Gas Train 2”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	280	390	350	780	170	250	550	1100	700	600	2	380	50	470	10	96	106

FD 5 / 10 / 15 / 20 C (GA) DIMENSIONS

FD 5 C (GA) 9-220 kW Johnson GM4 (loflo) Gas Train 1”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	150	230	200	430	100	220	360	470	500	340	1	225	50	280	8	35	45

FD 10 C (GA) 13-352 kW Johnson GM4 (hiflo) Gas Train 1 ½”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	190	280	250	500	110	240	390	500	550	530	1 1/2	268	50	310	8	48	58

FD 15 C (GA) 18-660 kW Johnson GM4 (hiflo)Gas Train 1 ½”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRI C STUD	Net Weight Kg	Gross Weight Kg
	240	340	300	560	150	240	390	500	620	520	1 1/2	330	50	400	10	58	70

FD 20 C (GA) 22-880 kW Landis SKP70/10 Gas Train 2”	A	B	C	D	E	F	G	H	I	J	K in.BSP Female	L	M	N	P METRIC STUD	Net Weight Kg	Gross Weight Kg
	280	390	350	780	170	250	550	1100	700	420	2	380	50	470	10	101	112