Palestine Polytechnic University

College of Engineering

Electrical Engineering Department

Graduation Project

Gas Burner Upgrading.

Project Team

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College of Engineering & Technology

Electrical & Computer Engineering Department

Project Name

Convert gas burner from two stage mode to modulation mode with auto calibration and monitoring of gas flue combustion.

Project Team

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According to the orientation of the Supervisor of the project and the examined committee is by the agreement of the staffers all, sending in this project to the Electrical & Computer Engineering Department are in the collage in the Engineering & Technology by the requirements of the department for the step of the Bachelor's Degree.

Project Supervisor Signature

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Committee Signature

……………………………….   ……………………………

Department Head Signature

…………………………….

Dedication

We dedicate this Project to .....

To our Parents

To our Friends

To our Families

Acknowledgment

To all the one whom teach me and help me, to whom that support me to achieve this scientific degree, to the supervisor of the project Prof. Abdel-Karim Daud, to all faculty members in the Electrical and Computer Engineering Department, we dedicate this project that may support other research in the future.

Abstract

Factories are working on two stages – high & low flame- Liquified Petroleum Gas (LPG) burners. The two stages system works on two pressure values high & low. The project aims to work on modulating mode which means that the burner controller will select the needed capacity according to the real load by installing pressure transducer. Working on modulating mode will reduce the running cost since the burner will not operate directly on the high capacity as two stages system.

During running of the burner on modulating mode; the ratio between air and gas will change according to the burner capacity and though there is a necessity to check that combustion is complete. In order to check if the combustion is complete; O2 sensor will be installed at the chimney.

The project proposes to change the servo motor that control the air and gas cams together, to separate stepper motor for each cam to get the required angle Vs capacity. This change will give the ability to increase or decrease quantity of air and gas separately. A new controller will be added to the main control box of the burner to connect and control the new installed devices.

Table of Content

Title	Page
Cover Page	I
Signature Page	II
Dedication	III
Acknowledgment	IV
Abstract	V
Table of Content	VI
List of Tables	VIII
List of Figures	IX
1. Chapter One – Introduction.	1
1.1 Introduction.	2
1.2 Importance of The Project.	3
1.3 Project Objectives.	3
1.4 Beneficiaries.	3
1.5 General Block Diagram.	4
2. Chapter Two – General Overview of System Components.	5
2.1 Gas Burners.	6
2.2 Feeding gas system.	11
2.3 Steam Boilers.	12
2.4 Difficulties and Operation problems.	14
3. Chapter Three – General Design of System Components.	15
3.1 Air Cam Stepper Motor.	16
3.2 Gas Cam Stepper Motor.	19
3.3 Steam Pressure Transducer.	19
3.4 O2 Sensor.	19
4. Chapter Four – Hardware & Equipment Selection.	20
4.1 Air Cam Stepper Motor Selection.	21
4.2 Gas Cam Stepper Motor Selection.	21
4.3 Steam Pressure Transducer Selection.	22
4.4 O2 Sensor Selection.	22

4.5 New Burner Electrical & Mechanical Layout. 25

5. Chapter Five – Main Controller Selection & Programing. 29

5.1 Main Controller Requirement. 30

5.2 Main Controller Selection. 30

5.3 Main Controller Flow Chart. 32

5.4 Arduino Program Structure. 34

6. Chapter Six – Protection System. 35

6.1 Burner Existing Protection Components. 36

6.2 New Protection Components. 38

7. Chapter Seven – Results. 39

7.1 Main Results. 40

7.2 Main Difficulties. 40

7.3 Recommendations. 40

Conclusion 41

References 42

Appendix 44

List of Tables

Table	Page
Table 2.1 Burner Operation	8
Table 2.2 Parts of Gas Train	11
Table 4.1 Stepper Motor Data	21
Table 5.1 Controller Requirements	30

List of Figures

Figure	Page
Figure 1.1 General Block Diagram	4
Figure 2.1 Gas burner Parts	7
Figure 2.2 Two- stage burner operating mode	9
Figure 2.3 Burner Electrical Layout	10
Figure 2.4 Gas Train	11
Figure 2.5 Reverse Flame Steam Boiler	13
Figure 2.6 Three pass steam boiler	14
Figure 3.1 Stepper Motor	16
Figure 3.2 Stepper motor Electrical coils & Mechanical Parts	17
Figure 3.3 Unipolar Stepper Motor	18
Figure 3.4 Bipolar Stepper Motor	18
Figure 4.1 Stepper motor Nema 23	21
Figure 4.2 Pressure Transducer	22
Figure 4.3 Voltage Characteristic for Lambda Sensor	23
Figure 4.4 Sensor Description	24
Figure 4.5 Burner Mechanical layout	25
Figure 4.6 New Electrical Layout	26
Figure 4.7 Control Box Electrical Layout	27-28
Figure 5.1 Arduino Mega.	31
Figure 5.2 Arduino board overview	31
Figure 5.3 Project Flow Chart	33
Figure 6.1 General block diagram with protections	37
Figure 6.2 Steam boiler with Pressure Transducer and O2 sensor	38

Chapter One

1. Introduction.

1.1 Introduction.

1.2 Importance of The Project.

1.3 Project Objectives.

1.4 Beneficiaries.

1.5 General Block Diagram.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Steam system is considered the main component for many Industrial factories mainly dairy and drinks. The system consists of the steam boiler, burner and steam piping system. Most of the Palestinian factories are working on LPG (Liquefied Petroleum Gas) not Diesel due to saving in running cost and due to the fact that LPG is less harmful to environment.

Steam systems are mainly used to supply steam for Pasteurization system. During Pasteurization, the system required stable quantity of steam with significant Pressure. Usually the factory faces problems in maintaining both quantity and pressure required. If they increase the steam pressure above the required pressure; they will pay more for running cost due to heat losses and they will increase the risk in the system due to high pressure. Also, if the use bigger steam boiler they will pay more for running cost due to the amount of energy required to heat the amount of water Inside it addition to the higher investment cost.

The second main issue is during no –load or smaller load when these boilers serve several applications. In the normal situation, the factory needs to start the boiler regardless the load which cost higher running cost.

The current gas burners installed on steam boilers are two stage burners. That means that burner start and stop at a certain rang of pressure –low pressure- high pressure- regardless the load required. The proposed change from two stages to modulating mode will give the system the ability to react according to the load required. This will be obtained by changing the pressure switch (on- off) to pressure transducer to give continuous reading for pressure to increase and decrease the rating of the burners accordingly.

The challenge when working on modulating mode is to predetermined the ratio between Air and gas. The proposed project will install O2 sensor at chimney. The reading of the sensor will be analyzed by controller which will control two stepper motors for burner Gas and air cams until we reach the right ratio.

This project aims to increase the efficiency of steam system and insure of complete combustion of gas.

1.2 Importance of the project.

- Increase efficiency of steam system.
- Reduce running cost when working on modulating mode instead of two stages mode. In modulating mode the burner capacity will be decided according to the load not on full load as in two stages mode.
- Insure complete combustion of gas to reduce emissions to environment.

1.3 Project objectives.

- Convert two stage gas burners to modulating burner.
- Auto adjustment of gas and air ratio.
- Monitoring of combustion gas flue.

1.4 Beneficiaries – consumers

- All factories that work on gas burners.

1.5 General Block Diagram

The burner contains main control box that control the sequence of operation for the burner. The proposed controller will be connected to the burner control box. The main signal to start the burner and running steam pressure will come from the proposed pressure transducer. The proposed controller will decide the required load according to the pressure reading.

The burner main control box will continue the operation of the burner including starting the fan motor and checking the gas valves. The burner main control box will send signal to start spark ignition and open gas valves and check that the burner flame exists. The proposed controller will operate the gas and air stepper motors which are connected to the burner cams according to pre- Programed angles. The O2 sensor will send the reading to the proposed controller and in case the combustion is not complete, the controller will change the angles of the steppers.

Figure 1.1 shows the general block diagram for the project.

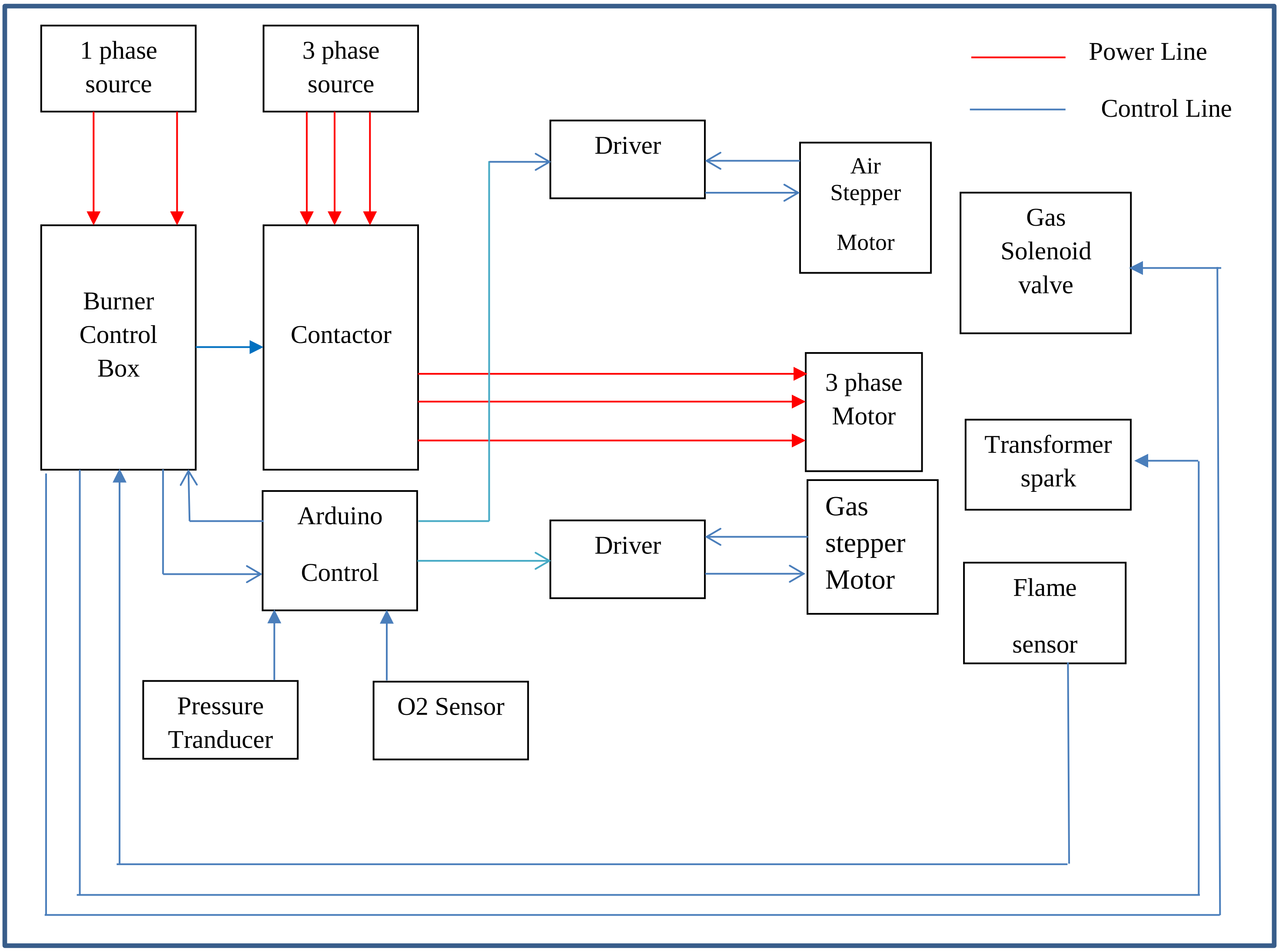


Figure 1.1 General Block Diagram

Chapter Two

General Overview of System Components.

2.1Gas Burners.

2.2Feeding gas system.

2.3Steam Boilers.

2.4Difficulties and Operation problems.

Chapter Two

General Overview of System Components.

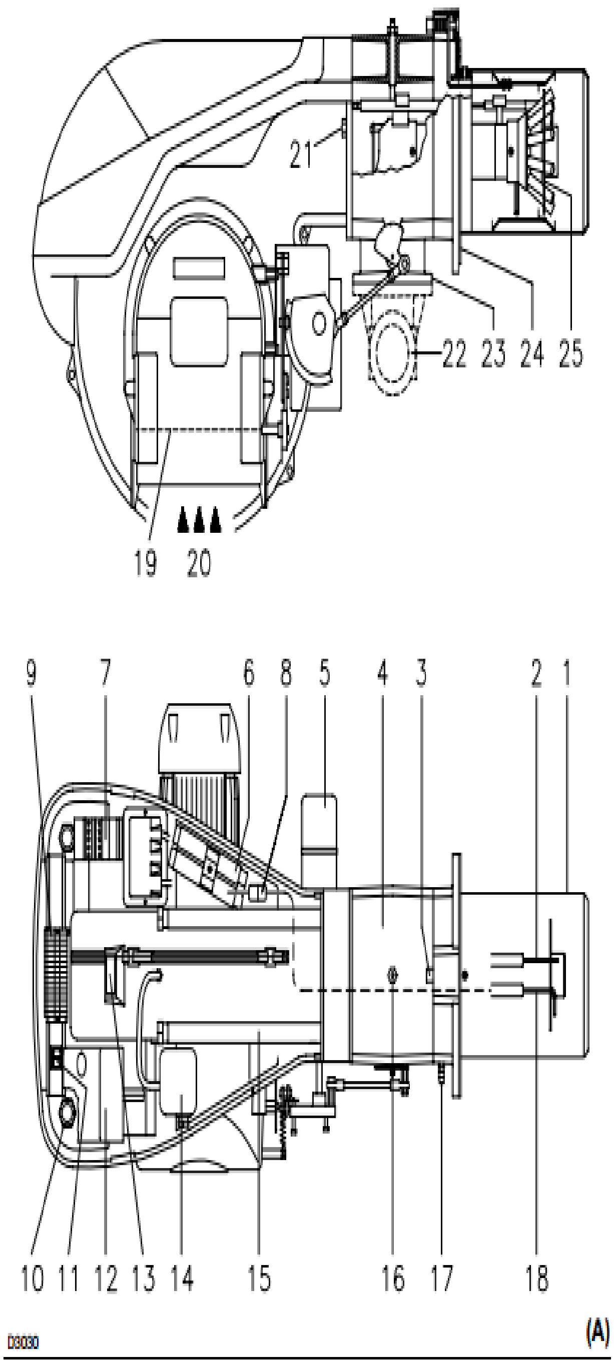
2.1 Gas Burners.

Burners work on the basis of fluid whether its liquid or Gas. For example, it works on diesel, crude oil, woods, natural Gas or industrial Gas (LPG GAS). Some of it operate with one flame to be used domestically at home for heat and some of it (with two stages) two flames operate in industrial facilities. For example, it can be used for heating oil as in food industry or for boiling water or to get steam for sterilization or pasteurization as in dairy products.

Burner consists of 5 components:

1- Air turbo engine
2- Spark for producing flame
3- Flame sensor to identify that there is a flame in order to keep supplying fuel/ gas and stop when there is not (flame)
4- Head mixer to mix the air and fuel
5- Stepper motor or servo motor to move the air gates from stage one to stage two

The burners consist of the following parts as shown in figure 2.1. (Riello RS 70 Catalog)



1 Combustion head

2 Ignition electrode

3 Screw for combustion head adjustment

4 Sleeve

5 Servomotor controlling the gas butterfly valve and of air gate valve

6 Extension for slide bars

7 Motor contactor and thermal cut-out reset button

8 Plug-socket on ionization probe cable

9 Terminal strip

10 Fairleads for electrical connections by installer

11 Two switches:

- one ≈burner off-onΔ
- one for ≈1st - 2nd stage operationΔ

12 Control box with lock-out pilot light and lock out reset button

13 Flame inspection window

14 Minimum air pressure switch

(differential operating type)

15 Slide bars for opening the burner and inspecting the combustion head

16 Gas pressure test point and head fixing screw

17 Air pressure test point

18 Flame sensor probe

19 Air gate valve

20 Air inlet to fan

21 Screws securing fan to sleeve

22 Gas input pipework

23 Gas butterfly valve

24 Boiler mounting flange

25 Flame stability disk

Figure 2.1 Gas burner Parts

Burner Operation

Table 2.1 shows the sequence of burner operation at starting.

Time (Sec)	Activity
	Control device TL closes. Servomotor starts: it rotates during opening up to the angle set on cam with orange lever. After about 3s:
0 s	The control box starting cycle begins.
2 s	Fan motor starts.
3 s	Servomotor starts: it rotates during opening until contact is made on cam with red lever. The air gate valve is positioned to 2nd stage output. Pre-purge stage with air delivery at 2nd stage output. Duration 25 seconds.
28 s	Servomotor starts: it rotates during closing up to the angle set on cam with orange lever.
43 s	The air gate valve and the gas butter-fly are positioned to 1st stage output. Ignition electrode strikes a spark. Safety valve VS and adjustment valve VR (rapid opening) open. The flame is ignited at a low output level, point A. Output is then progressively increased, with the valve opening slowly up to 1st stage output, point B.
45 s	The spark goes out.
53 s	If remote control device TR is closed or if it has been replaced by a jumper, the servomotor will continue to turn until the cam with red lever come into operation, setting the air gate valve and the gas butterfly valve to the 2nd stage operation position, section C-D. The control box starting cycle ends.

Table 2.1 Burner Operation

The two-stage mode burner works as shown in figure 2.2:

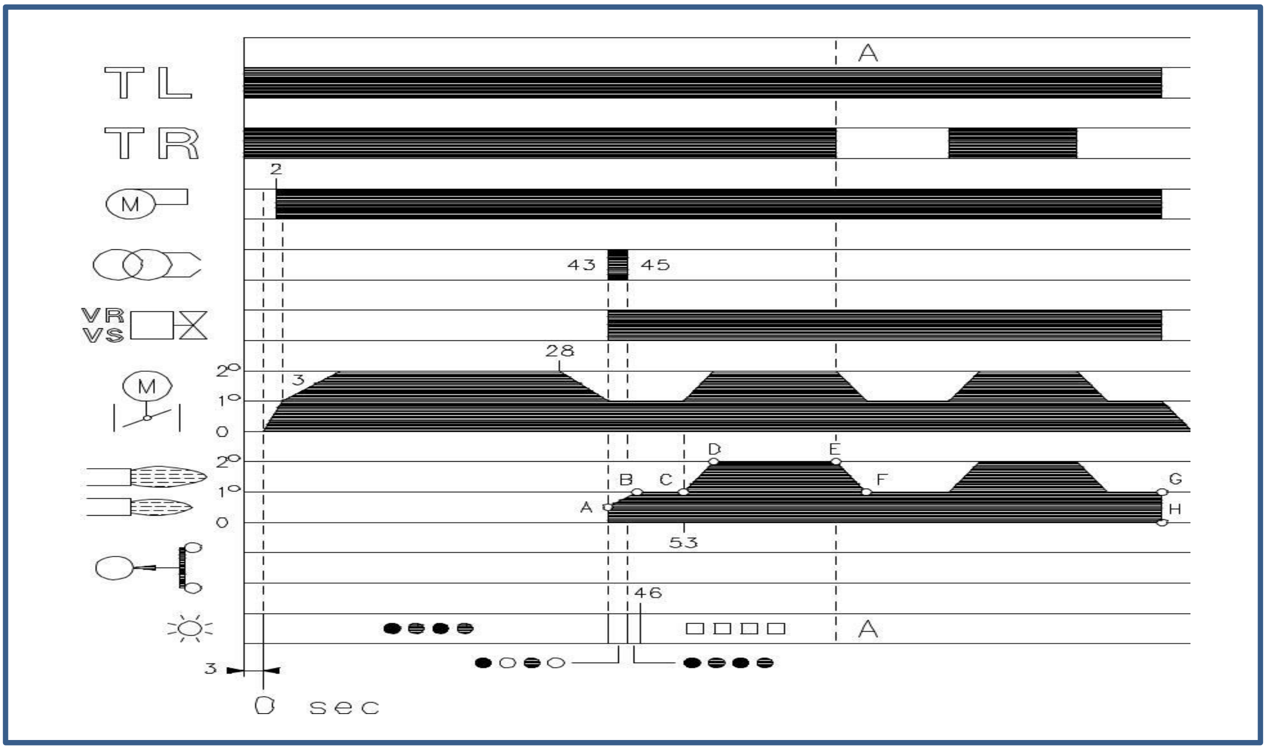


Figure 2.2 Two- stage burner operating mode

Burner Electrical Diagram:

The burner electrical diagram consists of the following:

- Power Supply; the main supply is three phase electrical connection which is connected to main overload protection switch in series to main contactor.
- Main control box; this control box is program to start/ stop the burner and control operation sequence.
- Transformer; the transformer aims to give the required spark for ignition.
- Fan motor; the main motor which is connected to the fan to supply the required air to the burner head.
- Air pressure switch; this switch sense the pressure of air supplied.
- Flame sensor / Ionization probe; this probe senses the existing of flame.

Figure 2.3 shows the main electrical diagram for the burner.

CMV - Motor contactor

DA - Control box (Landis RMG)

F1 - Protection against radio interference

K1 - Relay

I1 - Switch: burner off - on

I2 - Switch: 1st - 2nd stage operation

MB - Burner terminal strip

MV - Fan motor

PA - Air pressure switch

RT - Thermal cut-out

SM - Servomotor

SO - Ionisation probe

SP - Plug-socket

TA - Ignition transformer

TB - Burner ground

XP1 - Connector for STATUS

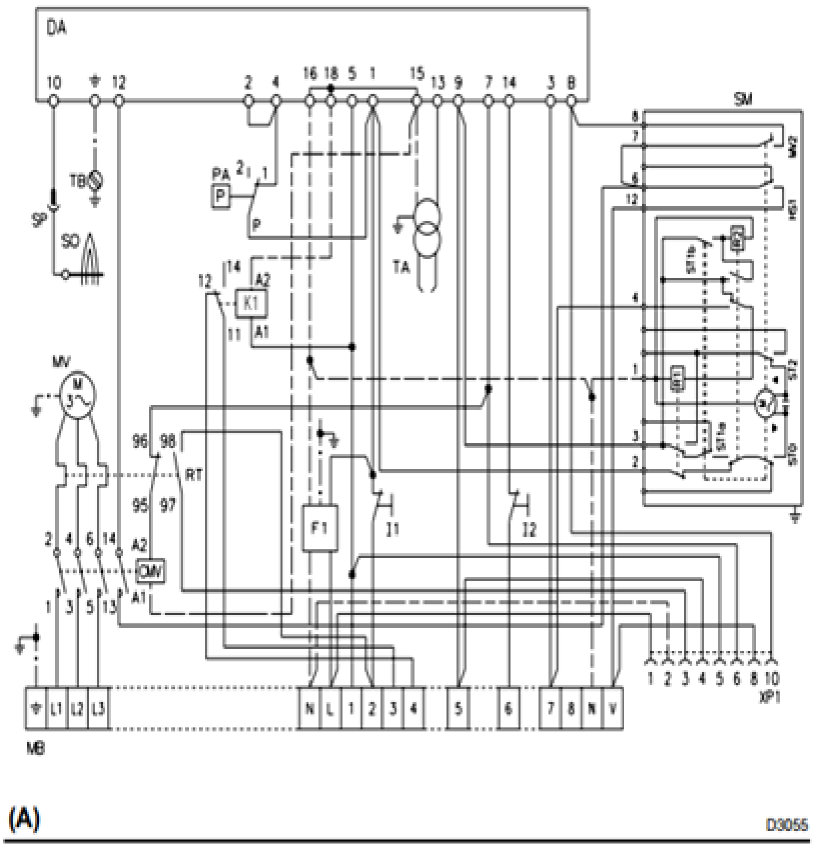


Figure 2.3 Burner Electrical Layout

2.3 Feeding gas system.

The gas system before burner is called gas train. The system should supply enough Quantity of gas with certain pressure according to the burner. The system consists of the following as shown in figure 2.3 and table 2.3.

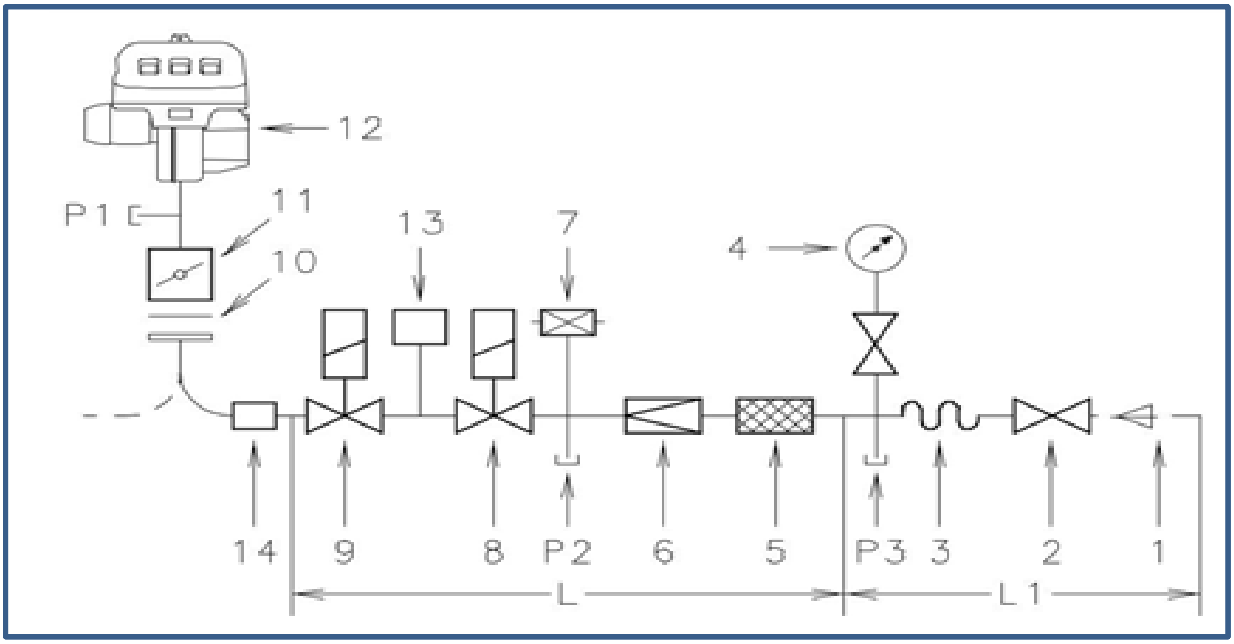


Figure 2.4 Gas Train

Part Number	Description
1	Gas input pipe
2	Manual valve
3	Vibration damping joint
4	Pressure gauge with pushbutton cock
5	Filter
6	Pressure governor
7	Minimum gas pressure switch
8	Safety solenoid
9	Adjustment solenoid

Table 2.2 Parts of Gas Train

2.4 Steam Boilers.

Steam boilers are selected according to the required steam quantity and working Pressure.

2.4.1 Definition of Steam Boiler:

Steam boiler or simply a boiler is basically a closed vessel into which water is heated until the water is converted into steam at required pressure.

2.4.2 Working Principle of Boiler

The basic working principle of boiler is very simple and easy to understand. The boiler is essentially a closed vessel inside which water is stored. Fuel is bunt in a furnace and hot gasses are produced. These hot gasses come in contact with water vessel where the heat of these hot gases transfer to the water and consequently steam is produced in the boiler. Then this steam is piped to the turbine of thermal power plant. There are many different types of boiler utilized for different purposes like running a production unit, sanitizing some area, sterilizing equipment, to warm up the surroundings etc.

2.4.3 Steam Boiler Efficiency

The percentage of total heat exported by outlet steam in the total heat supplied by the fuel is called steam boiler efficiency.

$$Steam\ Boiler\ Efficiency(\%) = \frac{Heat\ exported\ by\ outlet\ steam}{Heat\ supplied\ by\ the\ fuel} \times 100$$

It includes with thermal efficiency, combustion efficiency & fuel to steam efficiency. Steam boiler efficiency depends upon the size of boiler used. A typical efficiency of steam boiler is 80% to 88%. Actually, there are some losses occur like incomplete combustion, radiating loss occurs from steam boiler surrounding wall, defective combustion gas etc. Hence, efficiency of steam boiler gives this result.

2.4.4 Types of Boiler

There are mainly two types of boiler – water tube boiler and fire tube boiler. In fire tube boiler, there are numbers of tubes through which hot gases are passed and water surrounds these tubes. Water tube boiler is reverse of the fire tube boiler. In water tube boiler, the water is heated inside tubes and hot gasses surround these tubes. These are the main two types of boiler but each of the types can be sub divided into many which we will discuss later.

2.4.5 Steam Boilers in the market.

The normal boilers used here in Palestine are fire type boilers; mainly two types:

- Reverse flame boilers.
- Three pass boilers.

- Reverse flame steam boiler:

This is a variation on conventional boiler design. The combustion chamber is in the form of a thimble, and the burner fires down the center. The flame doubles back on itself within the combustion chamber to come to the front of the boiler. Smoke tubes surround the thimble and pass the flue gases to the rear of the boiler and the chimney.

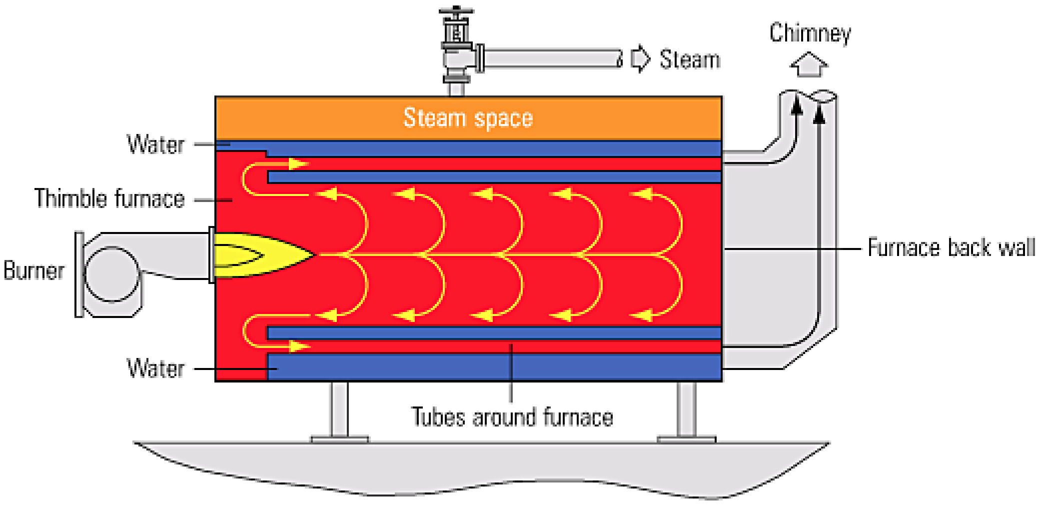


Figure 2.5 Reverse Flame Steam Boiler

- Three pass boiler

Each set of tubes that hot combustion flue gas travels through before making a turn within the boiler, is considered a "pass." A 3-pass fire tube boiler design consists of three sets of horizontal tubes, with the stack outlet located on the rear of the boiler. A downdraft design keeps the cooler water from having an effect on the hot surfaces within the boiler.

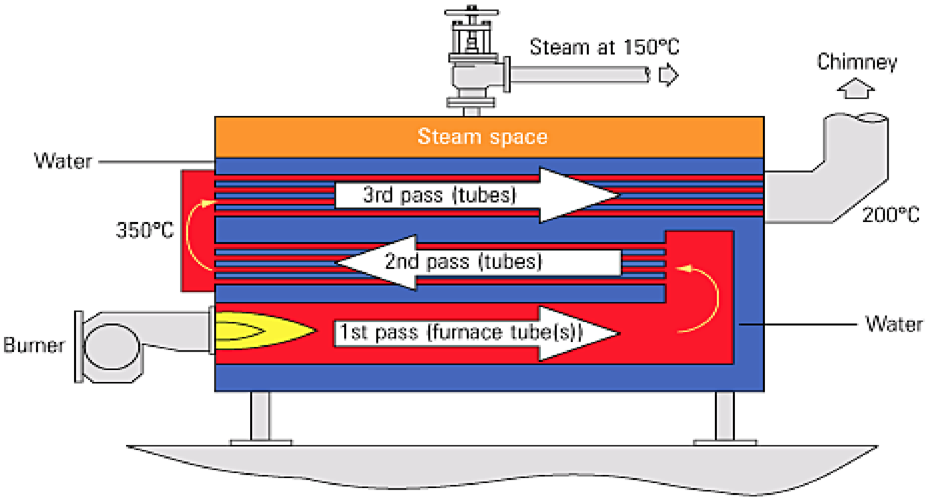


Figure 2.6 Three pass steam boiler

Usually steam boilers have two stage burners with Three pressure switches that control the burner start/stop.

Two of pressure switches will be replaced by pressure transducer.

The third will be used for safety.

2.5 Difficulties and Operation problems.

- Combustion is not complete.
- The burner is not compatible with the load change.

Chapter Three

General Design of The System

3.1 Air Cam Stepper Motor.

3.2 Gas Cam Stepper Motor.

3.3 Steam Pressure Transducer.

3.4 O2 Sensor.

Chapter Three

General Design of The System

The new proposed system consists of three main parts as shown below:

1- Replacing the existing servo motor that control air and gas cams with two stepper motors for each cam alone. This will allow to control each cam alone and get the desired angle for each cam.

2- Replacing the steam pressure switches with pressure transducer. This will allow to get the drop-in pressure according to the steam consumption at the factory and needed load.

3- Adding O 2 sensor at the chimney to measure O2 percentage. This will allow to check that the combustion is complete.

3.1 Air cam stepper motor:

The required servo motor will be installed on the air cam, this cam regulates the Amount of air that enters the burner chamber.

3.1.1 Stepper Motor Construction

A Stepper Motor or a step motor is a brushless, synchronous motor which divides a full rotation into a number of steps. Unlike a brushless DC motor which rotates continuously when a fixed DC voltage is applied to it, a step motor rotates in discrete step angles. The Stepper Motors therefore are manufactured with steps per revolution of 12, 24, 72, 144, 180, and 200, resulting in stepping angles of 30, 15, 5, 2.5, 2, and 1.8 degrees per step. The stepper motor can be controlled with or without feedback. Figure 3.1 shows the stepper motor.

Figure 3.1 Stepper Motor

3.1.2 Stepper motor work principal

Stepper motors work on the principle of electromagnetism. There is a soft iron or magnetic rotor shaft surrounded by the electromagnetic stators. The rotor and stator have poles which may be teethed or not depending upon the type of stepper. When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of a variable reluctance stepper). This way the stators are energized in a sequence to rotate the stepper motor. Figure 3.2 shows stepper motor electrical coil and mechanical part.

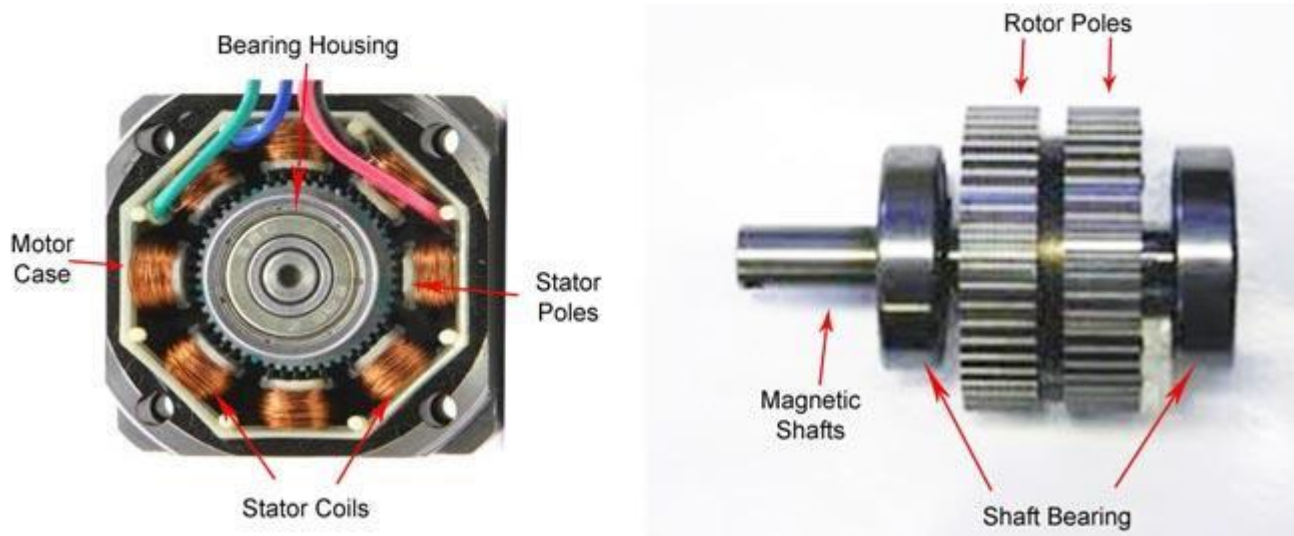


Figure 3.2 Stepper motor Electrical coils & Mechanical Parts

3.1.3 Types of Stepper Motor

By construction the step motors come into three broad classes:

1. Permanent Magnet Stepper
2. Variable Reluctance Stepper
3. Hybrid Step Motor

3.1.4 Types of Winding and Lead-out

The step motors are mostly two-phase motors. These can be unipolar or bipolar. In unipolar step motor, there are two winding per phase. The two winding to a pole may have one lead common i.e. center tapped. The unipolar motor so, have five, six or eight leads. In the designs where the common of two poles are separate but center tapped, motor have six leads. If the center taps of the two poles are internally short, the motor has five leads. Eight lead unipolar facilitates both series and parallel connection whereas five lead and six lead motors have series connection of stator coils. The unipolar motor simplifies the operation because in operating them there is no need to reverse the current in the driving circuit. These are also called bifilar motors. Figure 3.3 shows unipolar stepper motor.

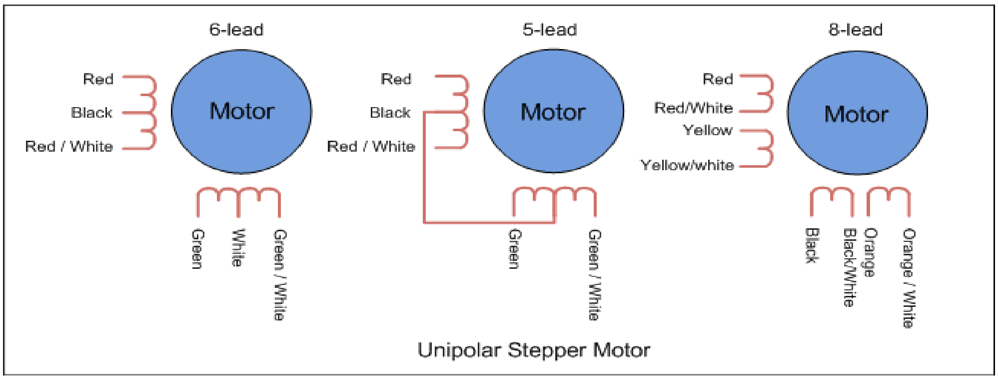


Figure 3.3 Unipolar Stepper Motor

In bipolar stepper, there is single winding per pole. The direction of current need to be changed by the driving circuit so the driving circuit of the bipolar stepper becomes complex. These are also called unifiliar motors. Figure 3.4 shows bipolar stepper motor.

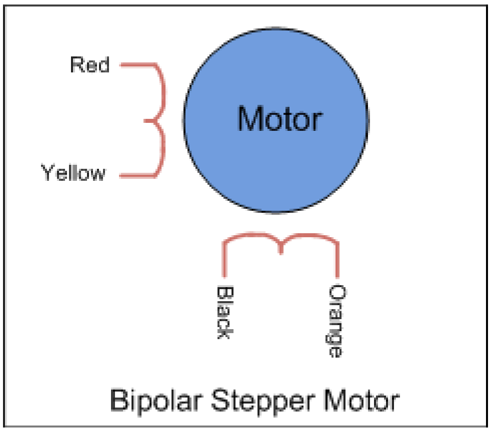


Figure 3.4 Bipolar Stepper Motor

For the required application, we need stepper motor able to produce torque not less than 1.2 -3 N/m.

The maximum only should be 0-90° also it should have holding torque to stable the Opening.

3.2 Gas cam stepper motor:

The required stepper motor will be installed on the gas cam, this cam regulates the Amount of gas that enters the burner chamber.

The stepper should be able to produce torque not less than 1.2 -3 N/m.

The maximum only should be 0-90° also it should have holding torque to stable the Opening.

3.3 Steam pressure transducer:

The pressure transducer should have a measuring range of 0-12 bar and should be for Steam without put of 4-20 mA.

3.4 O2 Sensor:

The sensor will be installed in the chimney, so it should be able to will stand To 450°.

Percentage of O2 from 0-21 % in volume.

Chapter Four

Hardware & Equipment Selection.

4.1.1 Air Cam Stepper Motor Selection.

4.1.2 Gas Cam Stepper Motor Selection.

4.1.3 Steam Pressure Transducer Selection.

4.1.4 O2 Sensor Selection.

4.1.5 New Burner Electrical & Mechanical Layout.

Chapter Four
Hardware & Equipment Selection.

4.1 Air Cam Stepper Motor Selection.

After searching the available models in market; and after matching the required torque to control the air cam according to burner manufacturer. We select Stepper motor Nema 23 double stack, the output torque is 2.3 N/m which suitable to the needed application. The figure 4.1 below shows the stepper motor. The whole stepper data is shown in Appendixes B. Table 4.1 shows the data for the stepper motor.

Phases	2
Steps/Revolution	200
Step Accuracy	±5%
Shaft Load	20,000 Hours at 1000 RPM
Axial	40 N (9 lbs.) Push
	130 N (30 lbs.) Pull
Radial	70 N (15.5 lbs.) At Flat Center
IP Rating	40
Approvals	RoHS
Operating Temp	-20° C to +40° C
Insulation Class	B, 130° C
Insulation Resistance	100 MegOhms

Standard shaft motor shown.

Figure 4.1 Stepper motor Nema 23

Description	Length	Mounted Rated Current	Mounted Holding Torque		Winding Ohms	mH	Detent Torque		Rotor Inertia		Motor Weight	
(Stack)	"L" Max	Amps	Nm Typ.	oz-in Typ.	±10% @ 20°C	Typ.	mNm	oz-in	g cm2	oz-in2	kg	lbs
Single	55.0 mm (2.17 in)	2.2	1.50	210	1.6	6.9	45	6.4	220	1.2	0.6	1.3
Double	77.0 mm (3.03 in)	3	2.30	330	1.1	4.5	75	11	390	2.1	1	2.2
Power Plus (Triple)	77.0 mm (3.03 in)	3	3.30	470	1.1	3.7	150	21	390	2.1	1.1	2.4

Table 4.1 Stepper Motor Data

4.2 Gas Cam Stepper Motor Selection.

The gas cam stepper motor was selected the same as air cam stepper motor.

4.3 Steam Pressure Transducer Selection.

The Pressure transducer was selected according to the available models at the market to match the required pressure and temperature. The Model is Danfoss Pressure transmitter type EMP 2. The measuring range is up to 25 bars and the output is 4-20 milliamp. The figure 4.3 shows the selected transducer. The whole data is shown in Appendixes D.

Figure 4.2 Pressure Transducer

4.4 O2 Sensor Selection.

The O2 sensor was selected to the available models in the market and required measuring range. The selected sensor is Bosch Lambda sensor model VW AG 19 2 031 90662.

An output voltage of 0.2 V (200 mV) DC represents a "lean mixture" of fuel and oxygen, where the amount of oxygen entering the chimney is sufficient to fully oxidize the carbon monoxide (CO), produced in burning the air and fuel, into carbon dioxide(CO_2). An output voltage of 0.8 V (800 mV) DC represents a "rich mixture", one which is high in unburned fuel and low in remaining oxygen. The ideal set point is approximately 0.45 V (450 mV) DC. This is where the quantities of air and fuel are in the optimum ratio, which is ~0.5% lean of the stoichiometric point, such that the exhaust output contains minimal carbon monoxide.

The voltage produced by the sensor is nonlinear with respect to oxygen concentration. The sensor is most sensitive near the stoichiometric point (where $\lambda = 1$) and less sensitive when either very lean or very rich. Figure 4.3 shows the voltage characteristic of the Lambda sensor. Figure 4.4 shows the sensor description.

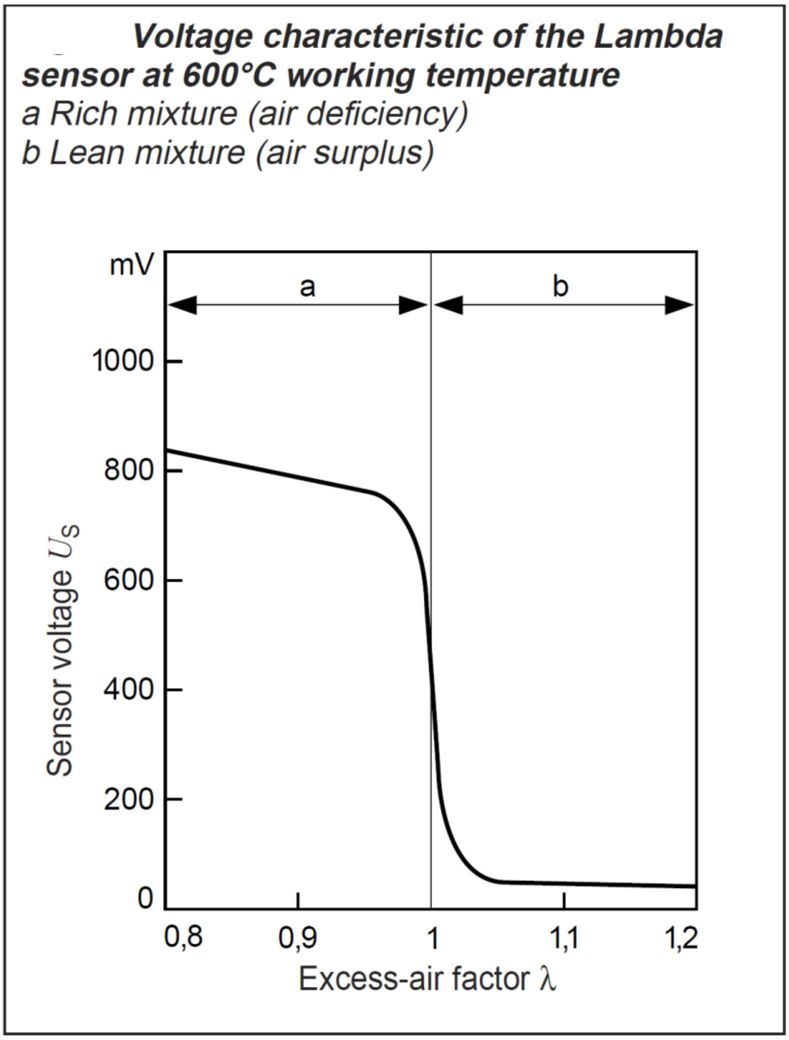


Figure 4.3 Voltage Characteristic for Lambda Sensor

Heated Lambda sensor LSH

1 Connection cable, 2 Disc spring, 3 Ceramic support tube, 4 Protective sleeve, 5 Clamp connection for the heating element, 6 Heating element, 7 Contact element, 8 Sensor housing, 9 Active sensor ceramic, 10 Protective tube.

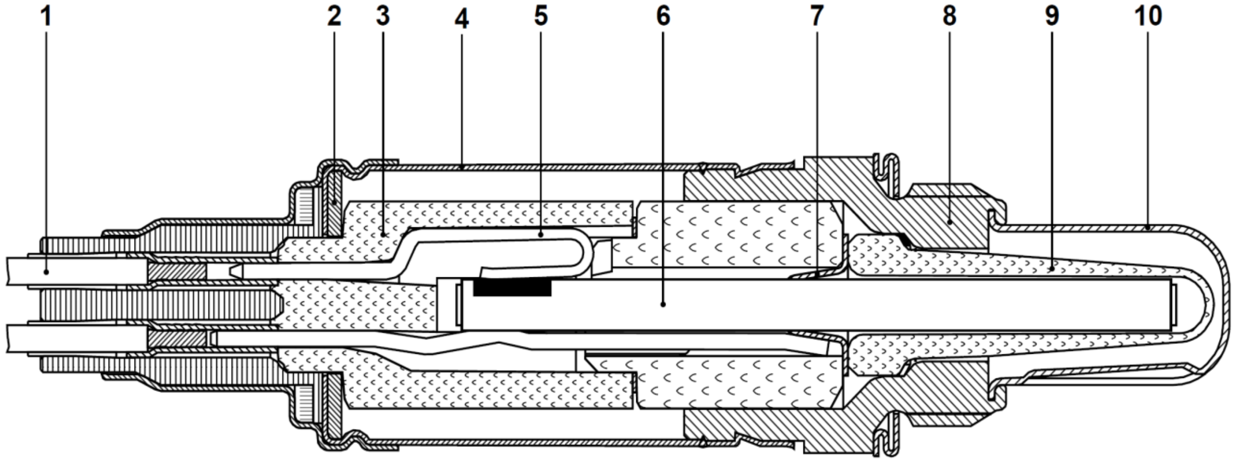


Figure 4.4 Sensor Description

4.5 New Burner Electrical & Mechanical Layout.

- Mechanical Layout:

The main servo motor that controls the air and gas both cams will be replaced by two stepper motors to control each cam alone. Figure 4.5 shows the new burner mechanical layout.

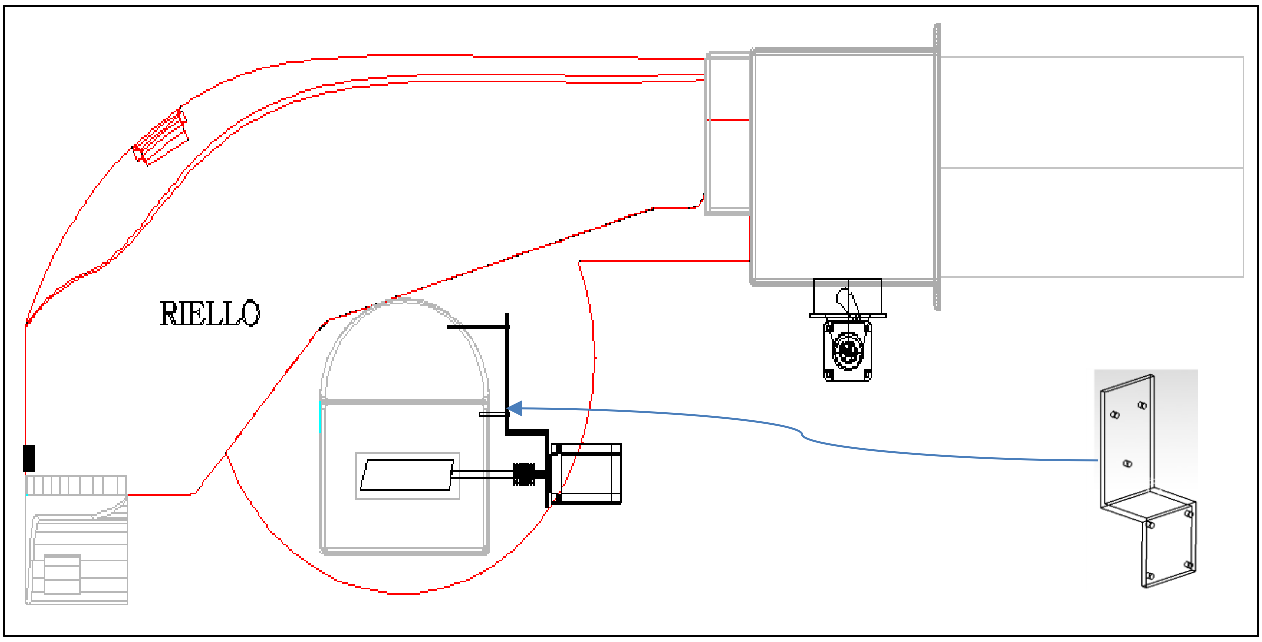
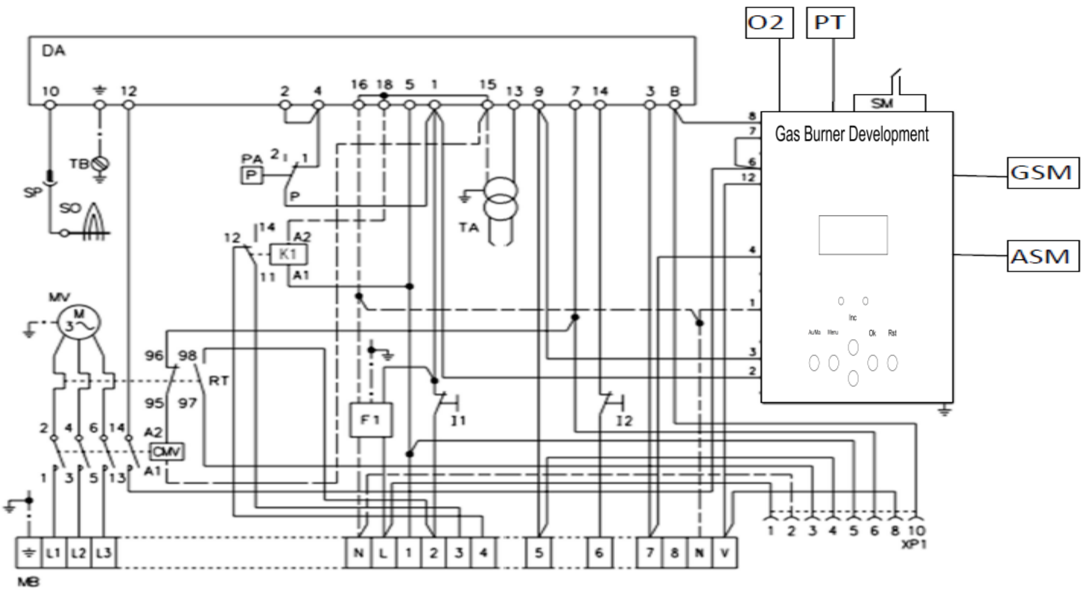


Figure 4.5 Burner Mechanical layout

- Electrical Layout:

The electrical connections of the removed servo motor will be connected to the ports of the Arduino controller. Some of the outputs of the Arduino will be connected to the stepper motors drivers. The O2 sensor and steam pressure transducer will be connected to one of the Arduino ports. Also, a manual selector switch will be connected to the Arduino. Figure 4.6 shows the new electrical layout. Figure 4.7 shows the electrical diagram for the new control box. All drawings were done using Proteus 8 Professional Program.



CMV - Motor contactor

DA - Control box (Landis RMG)

F1 - Protection against radio interference

K1 - Relay

I1 - Switch: burner off - on

I2 - Switch: 1st - 2nd stage operation in manual

MB - Burner terminal strip

MV - Fan motor

PA - Air pressure switch

RT - Thermal cut-out

SM – switch :auto-manual

SO - Ionization probe

SP - Plug-socket

TA - Ignition transformer

TB - Burner ground

XP1 - Connector for STATUS

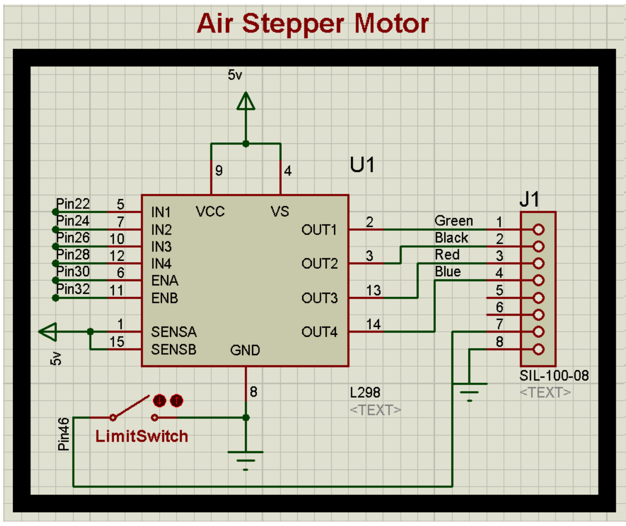
O2 – O2 Sensor

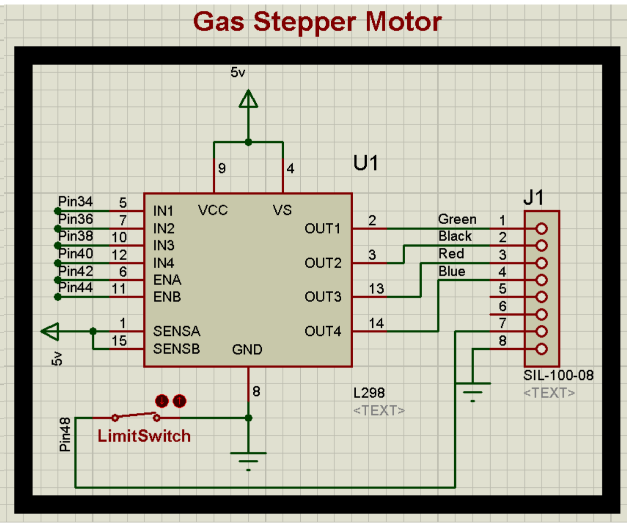
PT – Pressure Transducer

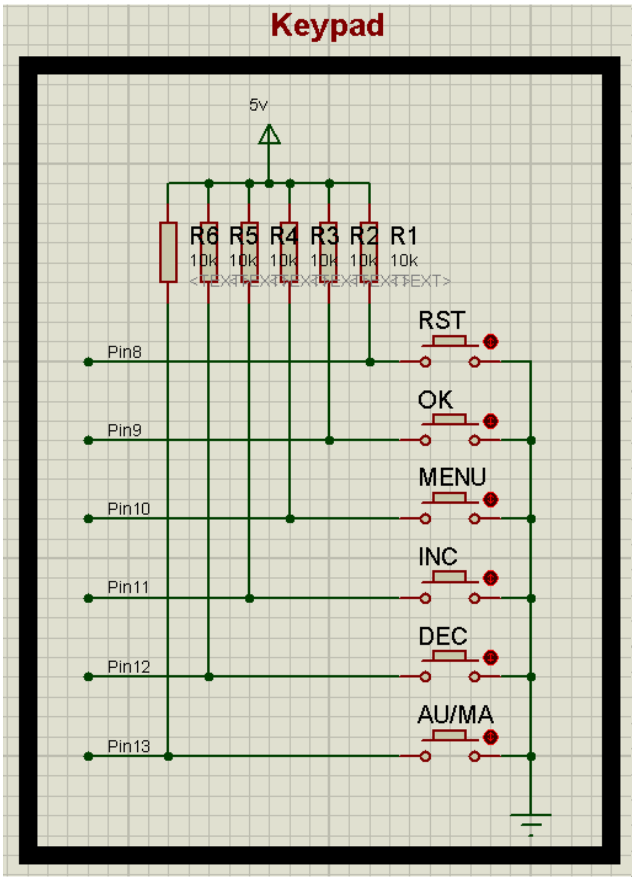
GSM – Gas Stepper Motor

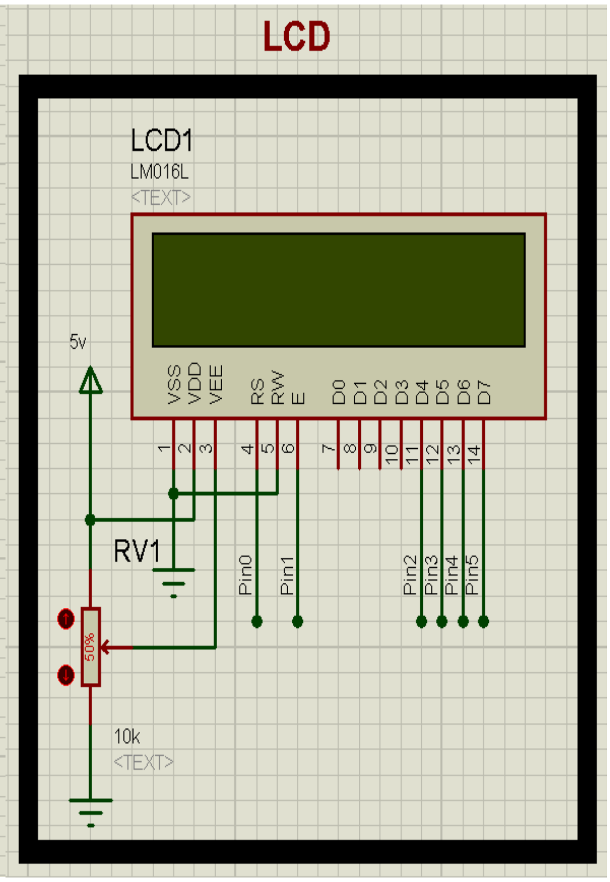
ASM – Air Stepper Motor

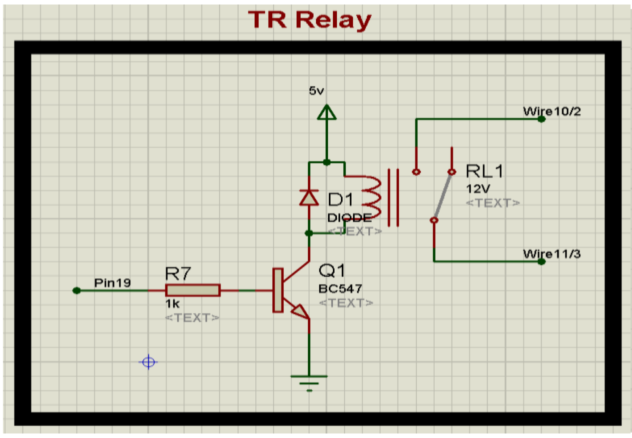
Figure 4.6 New Electrical Layout

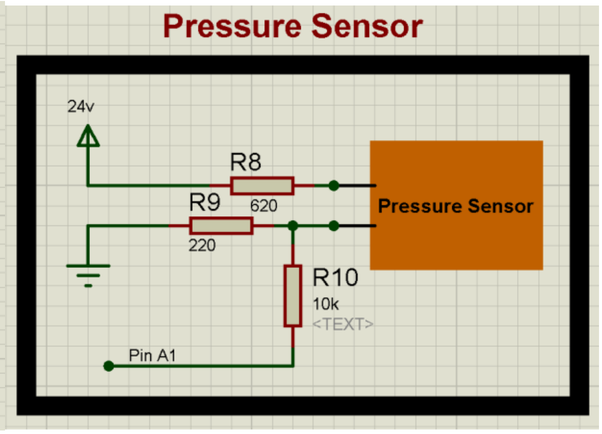

Air Stepper Motor
5v
U1
J1
IN1
IN2
IN3
IN4
ENA
ENB
SENSA
SENSB
VCC
VS
GND
OUT1
OUT2
OUT3
OUT4
Pin22
Pin24
Pin26
Pin28
Pin30
Pin32
Pin46
Green
Black
Red
Blue
L298
SIL-100-08
LimitSwitch


Gas Stepper Motor
5v
U1
J1
IN1
IN2
IN3
IN4
ENA
ENB
SENSA
SENSB
VCC
VS
GND
OUT1
OUT2
OUT3
OUT4
Pin34
Pin36
Pin38
Pin40
Pin42
Pin44
Pin48
Green
Black
Red
Blue
L298
SIL-100-08
LimitSwitch


Keypad
5v
R6
R5
R4
R3
R2
R1
10k
RST
OK
MENU
INC
DEC
AU/MA
Pin8
Pin9
Pin10
Pin11
Pin12
Pin13


LCD
LCD1
LM016L
5v
VSS
VDD
VEE
RS
RW
E
D0
D1
D2
D3
D4
D5
D6
D7
RV1
10k
Pin0
Pin1
Pin2
Pin3
Pin4
Pin5


TR Relay
5v
Wire10/2
Wire11/3
RL1
12V
D1
DIODE
Q1
BC547
R7
1k
Pin19


Pressure Sensor
24v
R8
620
R9
220
R10
10k
Pressure Sensor
Pin A1

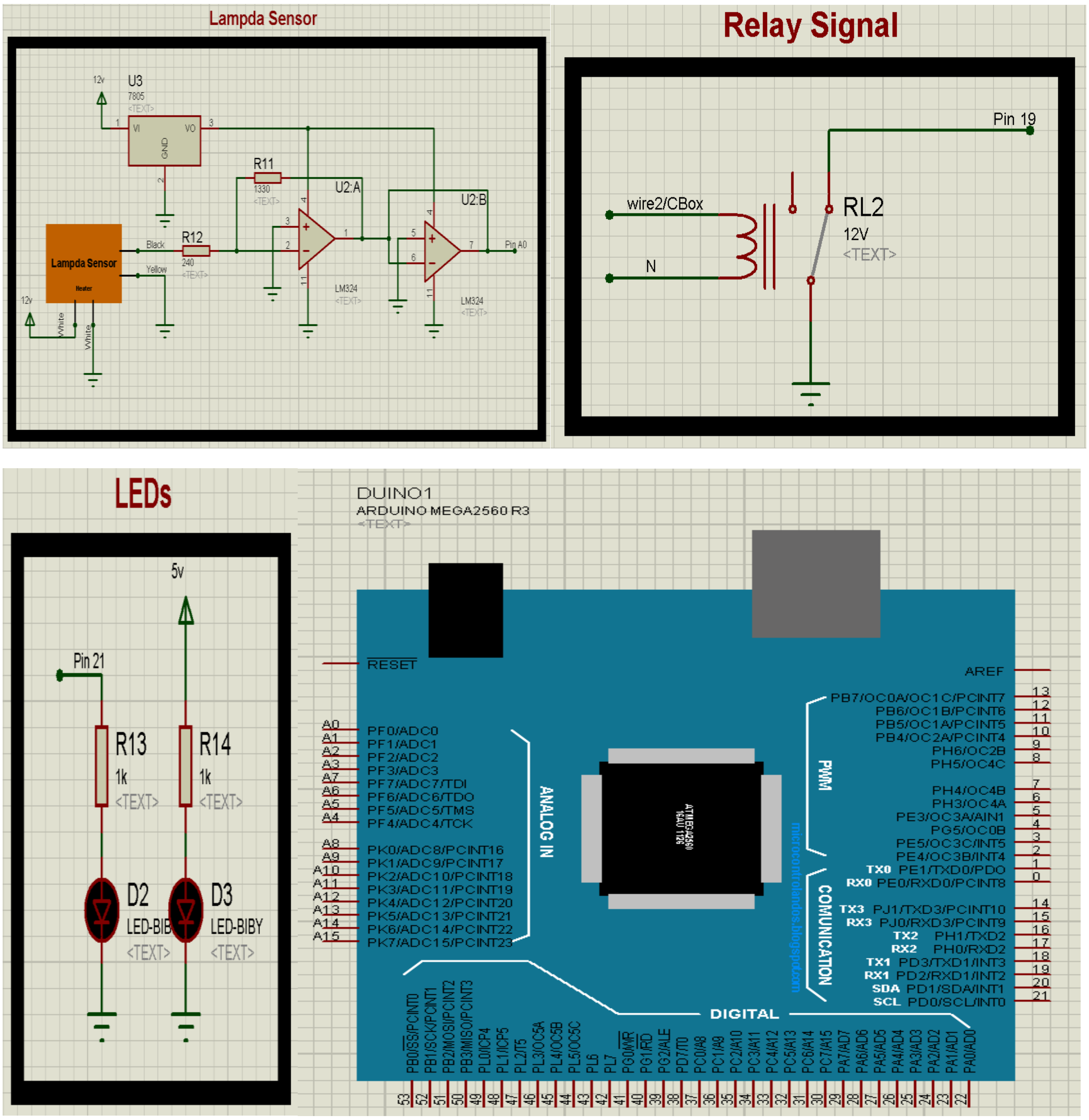


Figure 4.7 Control box Electrical Layout

Chapter Five

Main Controller Selection & Programing

5.1 Main Controller Requirement.

5.2 Main Controller Selection

5.3 Main Controller Flow Chart.

5.4 Arduino Program Structure.

Chapter Five
Main Controller Selection & Programing.

5.1 Main Controller Requirement.

The main controller to be added to the main burner control panel should be able to get readings from the proposed new sensors and to send orders to the new proposed parts. Also, the controller should be able to be connected to the main control panel. The below table 5.1 shows the main inputs and outputs to help in the selection of the controller.

Input Description	Input #	Output #
Air Stepper motor	1	6
Gas stepper motor	1	6
LCD	0	6
TR Relay	0	1
Pressure Transmitter	1	0
O2 Sensor	1	0
Relay signal	1	0
Led	0	2
	Total: 5	Total: 21

Table 5.1 Controller Requirements

5.2 Main Controller Selection.

According to the needs of the inputs and outputs and control features required; and to the available models at market. The model selected is Arduino Microcontroller. Arduino is open-source electronics prototyping platform based on flexible, easy-to-use hardware and software.

Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino have several types according to each application as follows:

- Arduino BT:

The Arduino BT is an Arduino board with built-in bluetooth module, allowing for wireless communication.

- LilyPad Arduino:

The LilyPad Arduino is a microcontroller board designed for wearables and e-textiles. It can be sewn to fabric and similarly mounted power supplies, sensors and actuators with conductive thread.

- Arduino Mega:

Arduino Mega is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila has (electrically) with more analog input pins and onboard +5V AREF jumper.

The selected type is Mega because it matches with our application. Figure 5.2 shows Arduino Mega.

Figure 5.1 Arduino Mega.

The following board overview shows the Arduino board as shown in figure 5.2.

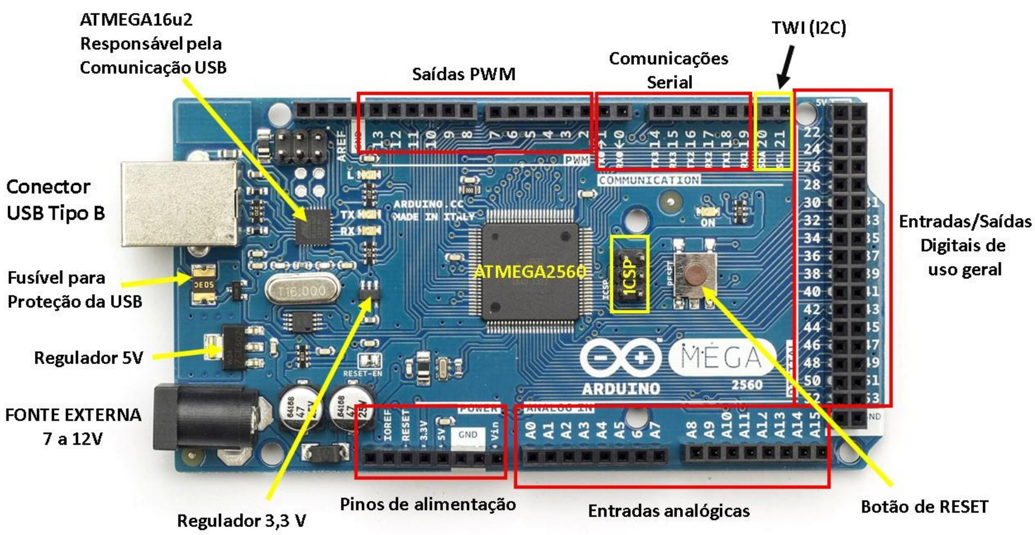


Figure 5.2 Arduino board overview

Data sheet for Arduino Mega is in appendixes F.

5.3 Main Controller Flow Chart.

The main controller flow chart aims to show the sequence of operation for the burner after the add of the new components to the system. After the burner start according to the reading of the steam pressure transducer; the standard checkup should be done as follows:

1. Air stepper motor min & max.
2. Gas stepper motor min & max.
3. Gas pressure switch
4. Air pressure switch.

After the checkup, the burners go to starting cycle including the startup of the fan motor.

After that the air stepper motor is open at max angle to insure sufficient air flow.

The burner then goes to low flame programed angle via opening the air and gas stepper motors. The control box gives signal to start the spark and open the gas solenoid valve.

After the ionization probe sense the existing of flame the spark stop and the burner continue running.

In case there is no flame the burner will stop.

The burner after that start to react according to reading of the steam pressure transducer; in case of low pressure reading it will goes to the max and will continue working proportionally to the load. The burner will decide the angle of both stepper motors according to each pressure reading. At each step the burner will get feedback of the O2 percentage in the chimney and will correct the air stepper motor angel if needed. The burner will stop after the pressure reach the set point and will start again when pressure reading drop.

The below flow chart shows the sequence of operation in figure 5.3.

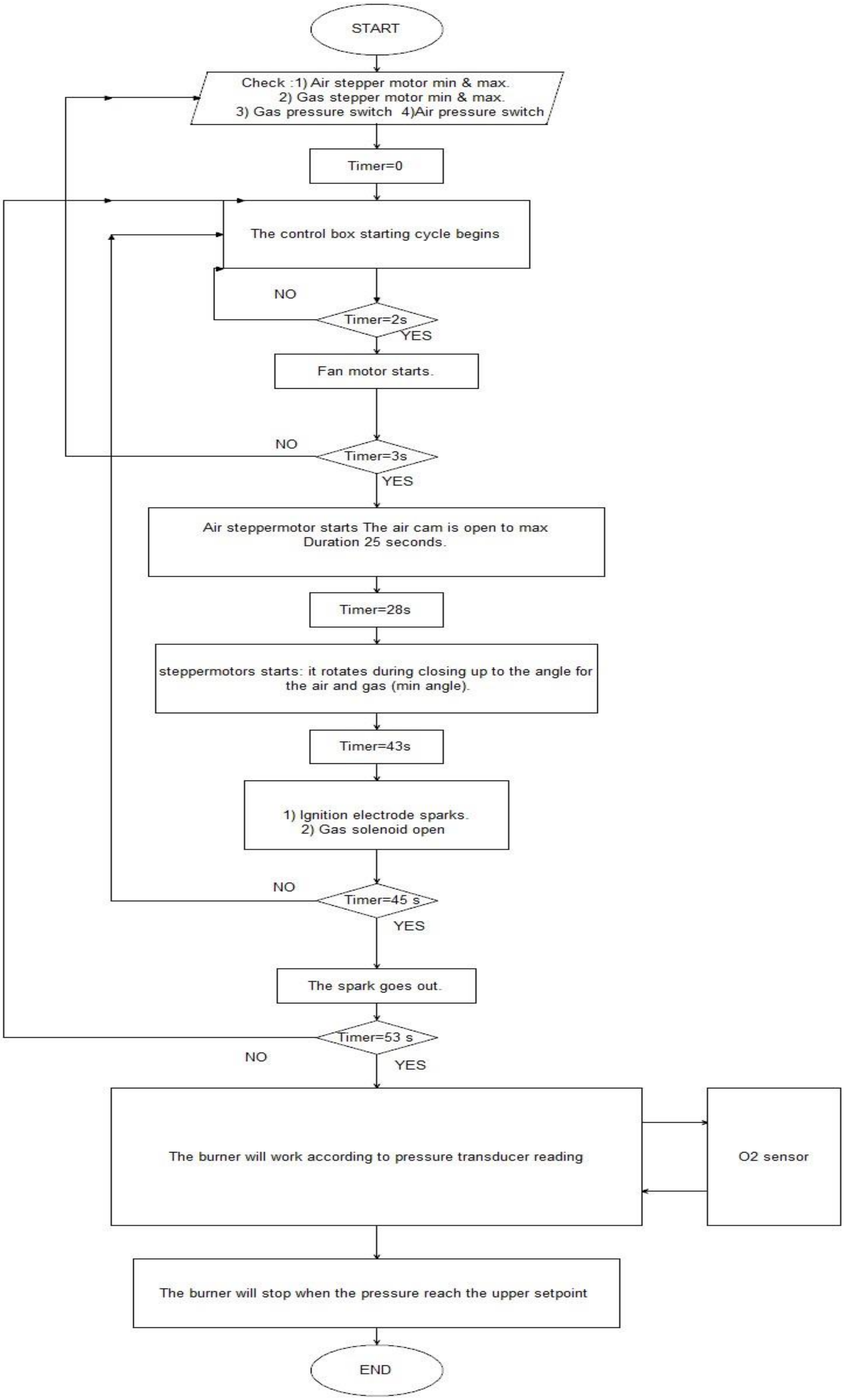


Figure 5.3 Project Flow Chart

5.4 Arduino Program Structure

The program was built with the following aspect:

1- Boiler steam preasure:

The maximum operating pressure is 8 bar.

The intermideiate operating pressure is 7.5 bar.

The second intermidiate operating pressure is 7 bar.

The minumum operating pressure is 6 bar.

The shut off pressure is 12 bar.

2- Gas Stepper motor angels:

The maximum operating angle is 90 degree.

The intermideiate operating angle is 75 degree.

The second intermidiate operating angle is 65 degree.

The minumum operating angle is 30 degree.

The shut off angle is 0 degree.

3- Air Stepper Motor angels:

The maximum operating angle is 90 degree.

The intermideiate operating angle is 75 degree.

The second intermidiate operating angle is 65 degree.

The minumum operating angle is 30 degree.

The shut off angle is 0 degree.

The O2 sensor reading will auto correct the angle if needed.

3- Manual Selection:

In addition to pre stored values there is an option to change the angle manually by inserting the values for both pressure and angle.

The complete code of preogramming is in apendixes G.

Chapter Six

Protection System.

6.1 Burner Existing Protection Components.

6.2 New Protection Components.

Chapter Six

Protection System.

6.1 Burner Existing Protection Components.

The burner has the following protections:

- The pressure of gas at inlet.

  The pressure sensor installed at the main gas valve of the burner sense the pressure of the inlet gas. In case of low pressure, the burner stop working.
- The No flame sensor.

  The flame sensor senses the flame existing. In case of no flame, the burner stop.
- Main fuse at the main control box.

  The main fuse protects the burner from any over current in electrical supply.
- Overload protector.

  The over load sense the over current of the burner blower motor. This is cause due to damage in motor windings or phase failure.
- Max steam pressure.

  This switch turns off the burner in case of max steam pressure in case the running pressure switch fail to stop the burner.
- Max water level.

  This water probe stops the burner in case the boiler is over field with water.
- Low water level.

  This water probe stops the burner in case the boiler has no water inside it.

  Figure 6.1 shows the general block diagram with the above protections.

  Figure 6.2 shows the steam boiler with pressure transducer and O 2 sensor.

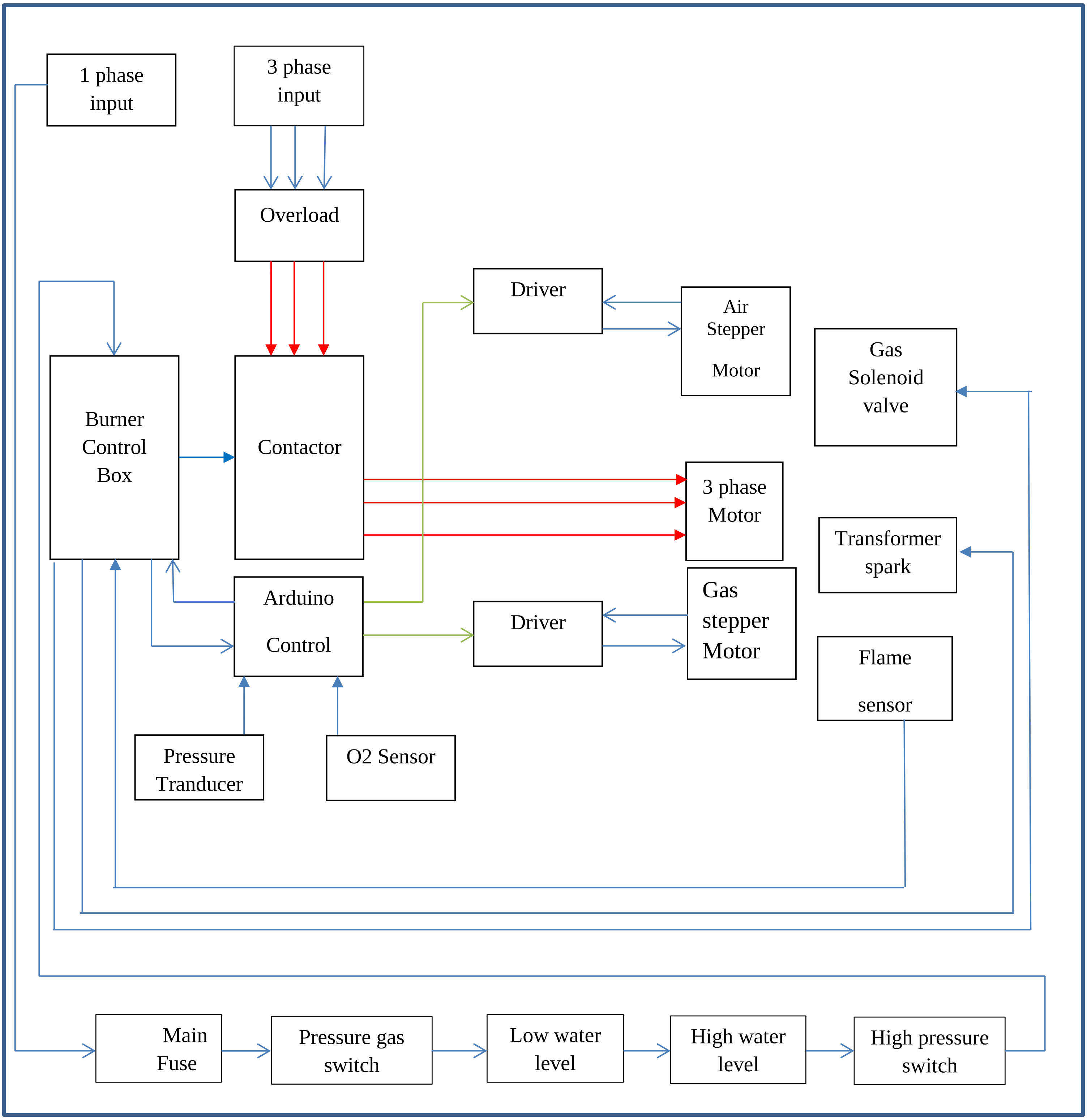


Figure 6.1 General block diagram with protections *(Same as Figure 1.1 with modifications)*

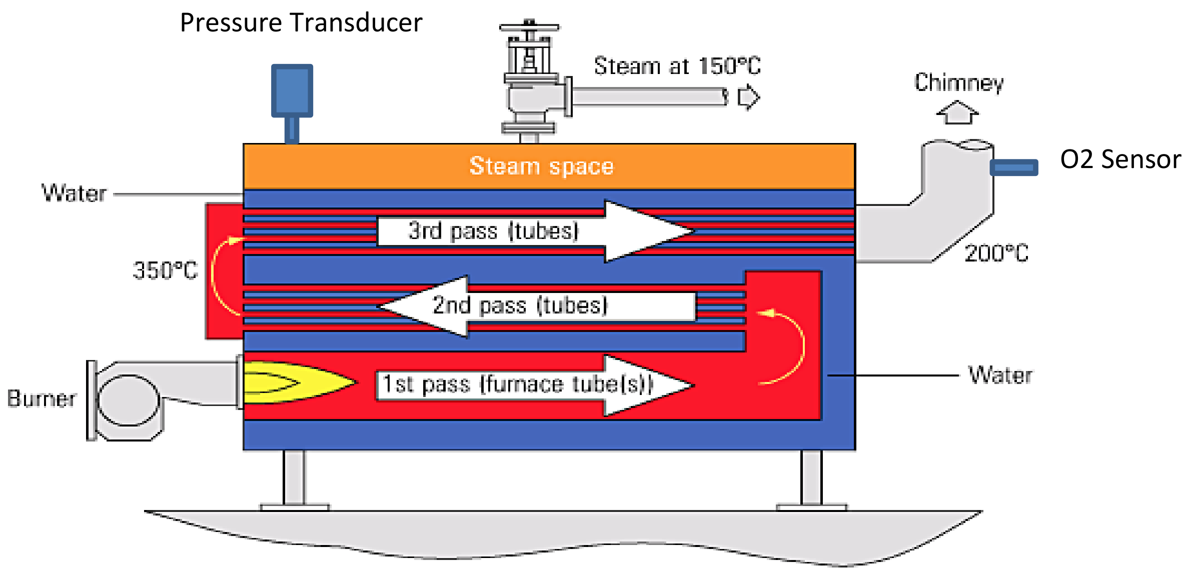


Figure 6.2 Steam boiler with Pressure Transducer and O2 sensor

6.2 New Protection Components.

The main protection to be added is the monitoring of burner combustion flue. In case the burner fails to calibrate itself. This will be cause due to the failure of O2 sensor or a problem in the programing. The burner will stop automatically and gives alarm to the operator. A manual selector switch gives the operator the option to start the burner on two stage mode till the service team came to check the problem.

Chapter Seven

Results.

7.1 Main Results

7.2 Main difficulties.

7.3 Recommendations.

Chapter Seven

Results

7.1 Main Results.

- the change of burner from two stage mode to modulating mode is achievable with auto calibration.
- The implantation of the project will decrease the running costs.
- The implementation of the project will reduce the CO emissions.
- The implementation of the project will reduce the operation problems.

7.2 Main Difficulties.

- To find the required sensors and transducer that match the required application.
- To find the suitable stepper motors with the required torque.

7.3 Recommendations.

The project will introduce several advantages to the Palestinian factories such as cost saving and reducing the emissions to the environment. Also, the project will reduce the problems in the operation of steam systems. Accordingly, this project should be adopted by the Palestinian factories working on LPG gas. In addition to the ability to improve the project components to control more features and get more accurate control and results.

Conclusion

The change of two stage burner to fully modulating burner is possible and can be done with relatively low cost which is around 1000 Usd. The change also allows to monitor the level of O2 in the chimney which will reduce the emissions to the environment. If the factories adopt the system they will save the running cost and operational problems.

References

References:

1. (http:// www.rielloburners.com)
2. (http:// www.spiraxsarco.com)
3. (http:// www.engineersgarage.com)
4. (http:// www.electrozep.ro)
5. (http:// www.jasoceania.co.nz)
6. (https:// www.arduino.cc)

Appendixes

Appendixes:

Appendix A - Riello Burners; Installation, use and maintenance instructions.

Appendix B – Stepper Motor Nema 23.

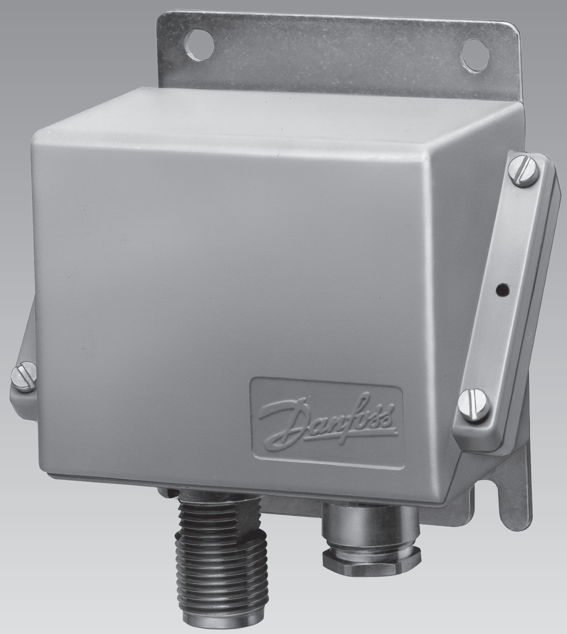
Appendix C - Stepper Motor Driving.

Appendix D – Danfoss Pressure Transmitter.

Appendix E – Bosch O2 Sensor.

Appendix F – Arduino Mega Data Sheet.

Appendix G – Programming Code.



EMP 2 Pressure Transmitters

Technical brochure

Description

Pressure transmitters type EMP 2 convert pressure to an electric signal.

This is proportional to, and linear with, the value of the pressure to which the pressure-sensitive element is subjected by the medium. The units are supplied as two-wire transmitters with an output signal of 4-20 mA.

The transmitters have a zero-point displacement facility for equalizing static pressure.
Span adjustment is also possible.
The EMP 2 series can be used for continuous measurement of liquid, steam of gas pressure.

The transmitters are designed for monitoring and control in marine and industrial applications. They have all necessary marine approvals.

Approvals

Lloyds Register of Shipping, England
Det Norske Veritas, Norway
Nippon Kaiji Kyokai, Japan
American Bureau of Shipping, USA
GL Germanischer Lloyds, BRD
Registro Italiano Navale, Italy
Bereau Veritas, France
China Classification society, China
Korean Register, Korea

Technical data and ordering

(When ordering please state type and code number)

Pressure in bar

Operating pressure p_e bar	Test pressure p_e bar	Min. burst pressure p_e bar	Code no. EMP 2 G ½ A	Code no. EMP 2 G 3/8 A
–1 – 1.5 [2]	5	100	**084G2100**	
–1 – 5 [2]	35	200	**084G2101**	
0.2 – 1	3.2	100	**084G2102**	
0 – 1	3.2	100	**084G2103**	
0 – 1.6	3.2	100	**084G2104**	
0 – 2.5	5	200	**084G2105**	
0 – 4	8	200	**084G2106**	**084G2206**
0 – 6	18	400	**084G2107**	**084G2207**
0 – 6	60 [1]	400	**084G2108**	
0 – 10	20	400	**084G2109**	**084G2209**
0 – 10	60 [1]	400	**084G2110**	
0 – 16	32	400	**084G2111**	**084G2211**
0 – 25	50	400	**084G2112**	
0 – 40	80	400	**084G2113**	**084G2213**
0 – 60	120	400	**084G2114**	
0 – 100	200	400	**084G2115**	
0 – 160	260	640	**084G2116**	
0 – 250	375	1000	**084G2117**	
0 – 400	600	1600	**084G2118**	
–1 – 9 [2]	20	400	**084G2120**	

[1] With pulse snubber
[2] Sealed gauge

Pressure in kp/cm^2

Operating pressure p_e kp/cm^2	Test pressure p_e kp/cm^2	Min. burst pressure p_e kp/cm^2	Code no. EMP 2 G ½ A	Code no. EMP 2 G 3/8 A
–1 – 5 [2]	3.5	200	**084G2131**	
0.2 – 1	3.2	100	**084G2132**	
0 – 1	3.2	100	**084G2133**	
0 – 1.6	3.2	100	**084G2134**	
0 – 2.5	5	200	**084G2135**	**084G2235**
0 – 4	8	200	**084G2136**	**084G2157**
0 – 6	18	400	**084G2137**	**084G2158**
0 – 6	60 [1]	400	**084G2138**	
0 – 10	20	400	**084G2139**	**084G2179**
0 – 10	60 [1]	400	**084G2140**	
0 – 15	32	400	**084G2141**	**084G2159**
0 – 25	50	400	**084G2142**	
0 – 40	80	400	**084G2143**	**084G2169**
0 – 50	120	400	**084G2144**	
0 –100	200	400	**084G2145**	
0 –160	260	640	**084G2146**	
0 – 250	375	1000	**084G2147**	
0 – 400	600	1600	**084G2148**	
0 – 20	50	400	**084G2154**	

Technical data

Operating temperature	–10°C to 70°C, see also fig. 1
Storage temperature	–50°C to 70°C
Temperature of medium	–40°C to 100°C, depending to some extent on ambient temperature (fig. 1)
Media	Water, fuel, oil, lubricating oil, refrigerants, ammonia, gas etc. The media must however be neutral in respect of materials AISI 316L
Voltage supply	Max. 32 V and min. 12 V d.c. between terminals N and P
Load resistance	A. max. 410 Ohm at 24 V d.c. +50%/ –20% B. max. 650 Ohm at 24 V d.c. +50%/ –0%
Zero point adjustment	–5% →20% range span; but max. –1 → 1.5 bar (kp/cm²)
Span adjustment	±5% of range span; but max. ± 5 bar (kp/cm²)
Combination of span and zero point adjustments	–5% →20% of range span
Noise immunity	Complies with the standard for industial apparatus EN 61000-6-2. The Standard contains tests for the following: HF fields, mains transmitted HF, voltage transients, electrostatic immunity, supply voltage variations, low-frequency radiation and transient protection in accordance with Germanischer Lloyd
Noise emission	Complies with standard EN 61000-6-3
Accuracy	Linearity: ± 0.3% in all pressure ranges ± 2.3% FS for -1 to xx bar or kp/cm²
Temperature dependence 1. Thermal zero point shift 2. Thermal sensitivity (span) shift	 1. ± 0.06 % FS/°C 2. ± 0.06 % FS/°C
Voltage dependence	±0.01% FS/ 10V
Vibration stability	3-30 Hz amplitude 1.13 mm and 30-300 Hz acceleration 4G according to IEC 60068-2-6 The requirements of the ship classification societies are up to 100 Hz, acceleration 4 G Extended specifications by prior arrangement
Time constant	Less than 4 ms
Shock stability	500 g for 1 ms to IEC 60068-2-27
Enclosure	IP 67 IEC 529 or DIN 40050. Housings are made of enamelled pressure-die-cast aluminium (GD-AISI 12)
Pressure connection	G ¹/₄, G ½ A standard, G ³/₈ A mano
Weight	approx. 1 kg
Cable entry	Pg 13,5 for cable diameters 5-14 mm

Identification
The type designation and code number of the transmitter is embossed on the side of the housing at the bottom close to the pressure connector.

Installation conditions

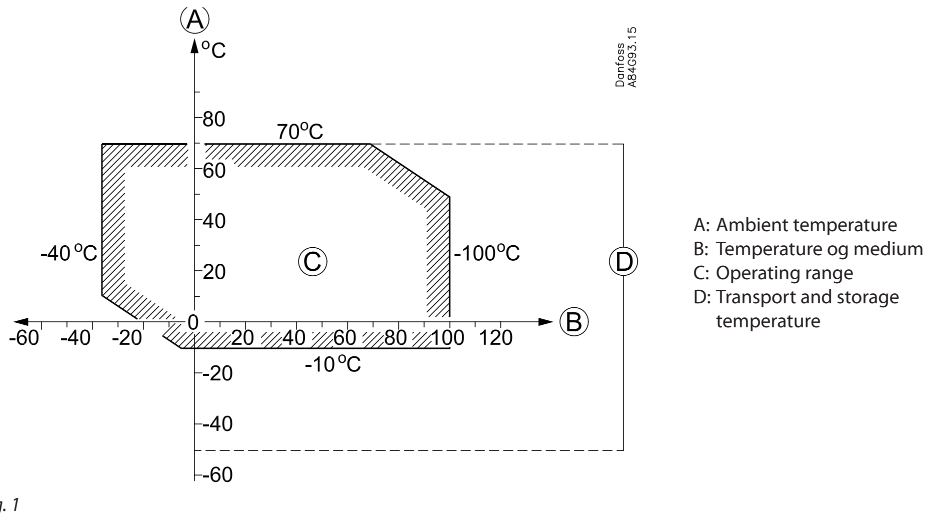


Fig. 1
Permissible ambient temperature depending on temperature of medium

Mounting
Type EMP 2 is equipped with a 3 mm stell bracket for mounting.

Pressure connection
Connector with outside cylindrical thread G ½, some types available with G ³/₈ A mano, and inside cylindrical thread G ¼, to ISO 228.

The primary insertion length of the connector corresponds to EN 837. Connection to the transmitter is made through a connector with a spanner flat, 14 mm across flats.

When fitting or removing pressure lines, the spanner flats on the pressure connector should be used to apply counter-torque.

Installation conditions

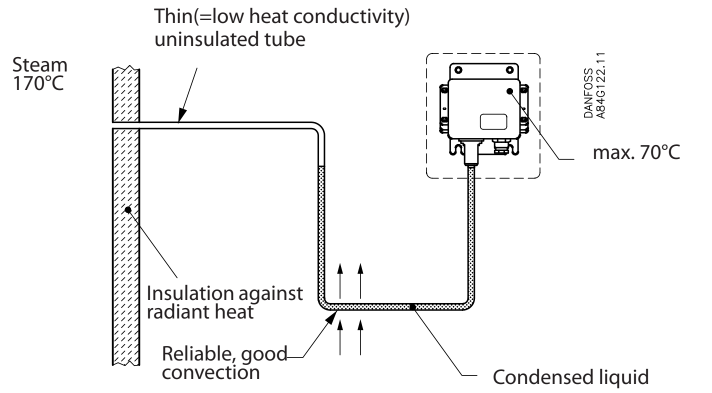


Fig. 2

Water systems
Water in the pressure element is not harmful, but in the event of frost a water-filled pressure element may burst. To prevent this the transmitter should be allowed to operate on an air cushion.

Steam plant
To protect the pressure element against temperatures in excees of the maximum temperature fo the medium (100°C), the insertion of a water-filled loop is recommended. In the example, fig. 2, insulation against radiant heat is also shown.

Surge

Stop damage due to Surge

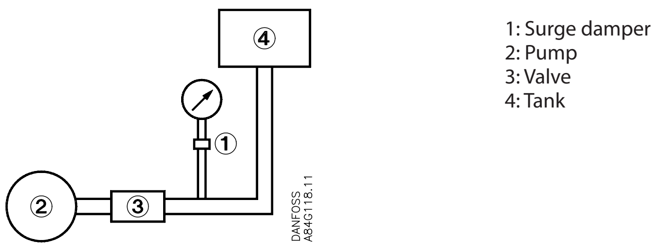


Fig. 3

In cases where valves are closed momentarily, surges af a value in excess of that for which the pressure element is designed can occur. To avoid damage to the pressure element, a damping device should be fitted. The device can consist of a flexible pipe, a throttle, a shock valve, or a combination og these items. The amplitue of surges should never exceed the maximum range pressure of the pressure transmitter.

Electrical connection

The transmitter has a wiring diagram, see fig. 4. Terminals P (positive) and N (negative) are connection terminals for the supply voltage. The same leads are used for supply voltage and output signal.

A function test can be performed between terminals N and T without cutting off the current loop.

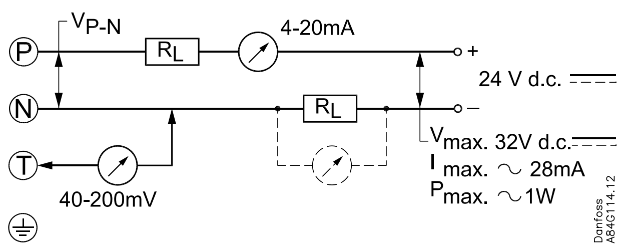


Fig. 4

Pulse snubber

EMP 2 with the pressure range 0 - 6 bar and 0 - 10 bar at extended test pressure is provided with an integrated pulse snubber for protection of the sensor element against cavitations and air bubbles in the media due to extreme pressure peaks and pulsations. Such conditions may be caused by pumps or fast operation valves in both high and low pressure systems.

The integrated pulse snubber is designed as an 0.3 mm orifice mounted in the pressure connection. The medium should not contain particles which may clog up in the orifice. The viscosity has only little effect on the response time. Even at viscosities up to 100 Cst. the response time will not exceed 4 msec.

Sizing

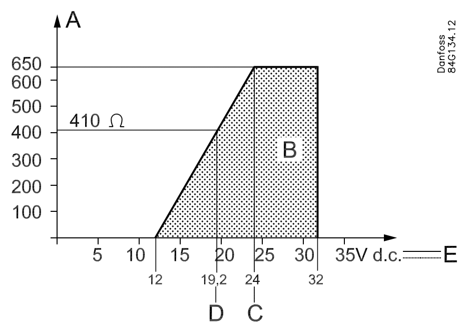
The maximum permissible load resistance R_L for insertion between transmitter and voltage source can be calculated from the formula:

$$R_L\,(\Omega) = \frac{V-12}{20 \times 10^{-3}}$$

The load is the sum of all resistances i both leads.

Any superimposed ripple voltages or voltage changes in a downward direction must be subtracted to find the smallest value of V.

Any superimposed ripple voltages or voltage changes in an upward direction must not result in the stated maximum voltage of 32 V being exceeded.



A: Load in ohms
B: Operating range
C: Rated voltage 24 V d. c.
D: 20% undervoltage
E: Voltage

Fig. 5.
Load as a function of the voltage for EMP 2

The intersection between supply voltage and load resistance graphs must lie within the shaded area (marked B in diagram).

Example
Given:
Supply voltage 24 V ±10%
ripple voltage

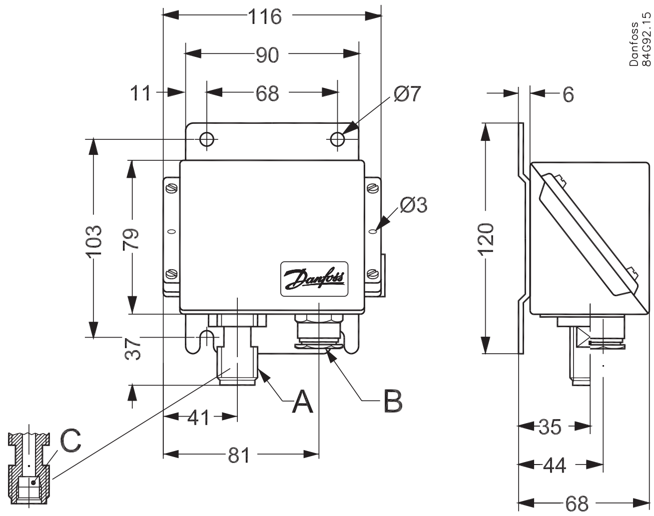
Lead resistance in lead N	10 Ω
Measuring resistance inserted in lead N	270 Ω
Lead resistance in lead P	10 Ω
Measuring resistance inserted in lead P	50 Ω
	R_L = 340 Ω

Calculation
V = 24 V±10% ⇔ V_{upper} = 24 V+10% = 26.4 V
V_{lower} = V -10 % = 21.6

$$R_L\,(\text{permissible}) = \frac{21.6-12}{20 \times 10^{-3}} = 480\ \Omega$$

R_L of 340 Ω is less than 480 Ω
V_{upper} of 26,4 V d.c. is less than $V_{max.}$ of 32 V d.c.
Thus, R_L and V lie within the permissible operating range.

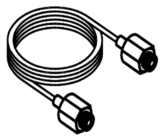
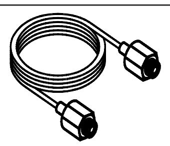
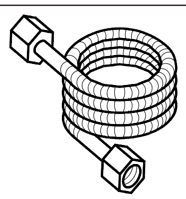
Dimensions and weight



A: G ½ A (G 3/8 A mano)
B: Pg 13.5
C: G ¼
Weight approx. 1 kg

Fig. 6

Accessories

Part	Symbol	Description	Material	**Code no.**
Damping coil		Damping coil with G $^{3}/_{8}$ unions and 1.5 m copper capillary tube.	Copper	**060-104766**
Damping coil		Damping coil with G ½ unions and 1 m capillary tube. Standard washers supplied	Stainless steel	**060-016966**
Damping coil, armoured		Damping coil with G $^{3}/_{8}$ unions and 1 m armoured copper capillary tube. Standard washers supplied	Copper	**060-333366**
Nipple		G¼ A × G $^{3}/_{8}$ A with copper washer	Brass	**060-333266**
		G ¼ A × M10 ext. × 1 with copper washer	Brass	**060-333866**

Conversion table

	Pascal (= Newton per square metre) (N/m^2) Pa	Newton per square mm N/mm^2	bar	Kilopond per square metre (mm H_2O) kp/m^2	Meter water gauge m H_2O	Technical atmosphere (kp/cm^2) at	Physical atmosphere atm	Torr (0°C) mm Hg	Inches Hg (0°C) in Hg	Poundforce per Square inch (lbf/in^2) psi
1 Pa	1	10^{-6}	10^{-5}	0.1020	$1.020 \cdot 10^{-4}$	$1.020 \cdot 10^{-5}$	$9.869 \cdot 10^{-5}$	$7.500 \cdot 10^{-3}$	$2.953 \cdot 10^{-4}$	$1.450 \cdot 10^{-4}$
1 N/mm^2	10^{6}	1	10	$1.020 \cdot 10^{5}$	102.0	10.20	9.869	$7.5 \cdot 10^{3}$	295.3	145.0
1 bar	10^{5}	0.1	1	$10.197 \cdot 10^{3}$	10.20	1.020	0.9869	750	29.53	14.50
1 kp/m^2	9.80665	$9.807 \cdot 10^{-6}$	$9.807 \cdot 10^{-5}$	1	10^{-3}	10^{-4}	$0.9678 \cdot 10^{-4}$	0.07355	$2.896 \cdot 10^{-3}$	$1.422 \cdot 10^{-3}$
1 m H_2O	9806.7	$9.807 \cdot 10^{3}$	0.09807	1000	1	0.1	0.09678	73.55	2.896	1.422
1 at	$98.066 \cdot 10^{3}$	0.09807	0.9807	10^{4}	10	1	0.9678	735.5	28.96	14.22
1 atm	$101.325 \cdot 10^{3}$	0.1013	1.013	$10.333 \cdot 10^{3}$	10.33	1.033	1	760	29.92	14.70
1 mm Hg	133.32	$1.333 \cdot 10^{-4}$	$1.333 \cdot 10^{-3}$	13.60	0.01360	$1.360 \cdot 10^{-3}$	$1.316 \cdot 10^{-3}$	1	0.03937	$1.934 \cdot 10^{-2}$
1 in Hg	3387	$3.387 \cdot 10^{-3}$	0.03387	345.3	0.3453	0.03453	0.03342	25.4	1	0.4912
1 psi	6895	$6.895 \cdot 10^{-3}$	0.06895	703.1	0.7031	0.07031	0.06804	51.71	2.036	1

ISO 9001 quality approval

ISO
9001

Danfoss A/S is certificated in accordance with international standard ISO 9001.
This means that Danfoss fulfils the international standard in respect of product development, design production and sale.

Installation, use and maintenance instructions
Instrucciones de Instalación, Funcionamiento y Mantenimiento
Instruções de Instalação, Funcionamento e Manutenção

RIELLO

GB **Forced draught gas burners**

E **Quemadores de gas**

P **Queimadores a gás**

Progressive two-stage operation
Funcionamiento a dos llamas progresivas
Funcionamento a duas chamas progressivas

CE

CODE - CÓDIGO	MODEL - MODELO	TYPE - TIPO
3785100 - 3785102	RS 70	821 T1
3785101 - 3785103	RS 70	821 T1
3785300 - 3785302	RS 100	822 T1
3785301 - 3785303	RS 100	822 T1
3785500 - 3785502	RS 130	823 T1
3785501 - 3785503	RS 130	823 T1

2915937 (5) - 09/2012

GB **CONTENTS**

TECHNICAL DATA . . . . page **2**
Electrical data. 2
Variants 2
Burner description 3
Packaging - Weight 3
Max. dimensions 3
Standard equipment 3
Firing rates 4
Test boiler. 4
Commercial boilers. 4
Gas pressure 5
INSTALLATION 6
Boiler plate 6
Blast tube length 6
Securing the burner to the boiler 6
Setting the combustion head 7
Gas line 8
Electrical system 9
Adjustments before firing 12
Servomotor. 12
Burner starting 12
Burner firing 12
Burner calibration: 13
1 - Firing output 13
2 - 2nd stage output 13
3 - 1st stage output. 14
4 - Intermediates outputs 14
5 - Air pressure switch 15
6 - Minimum gas pressure switch. 15
Flame present check 15
Burner operation. 16
Final checks 17
Maintenance. 17
Burner start-up cycle diagnostics. 18
Resetting the control box and using diagnostics. 18
Fault - Probable cause - Suggested remedy 19
Accessories 20

N.B.
Figures mentioned in the text are identified as follows:
1)(A) = part 1 of figure A, same page as text;
1)(A)p.3 = part 1 of figure A, page number 3.

TECHNICAL DATA

MODEL			RS 70		RS 100		RS 130	
TYP			821 T1		822 T1		823 T1	
OUTPUT (1)	2nd stage	kW Mcal/h	465 - 814 400 - 700		698 - 1163 600 - 1000		930 - 1512 800 - 1300	
	min. 1st stage	kW Mcal/h	192 165		232 200		372 320	
FUEL			NATURAL GAS: G20 - G21 - G22 - G23 - G25					
			G20	G25	G20	G25	G20	G25
- Net calorific value		kWh/Nm^3 $Mcal/Nm^3$	10 8.6	8.6 7.4	10 8.6	8.6 7.4	10 8.6	8.6 7.4
- Absolute density		kg/Nm^3	0.71	0.78	0.71	0.78	0.71	0.78
- Max. delivery		Nm^3/h	81	94	116	135	151	175
- Pressure at maximum delivery (2)		mbar	10.3	15.2	9.3	13.7	8.6	12.7
OPERATION			• Intermittent (min. 1 stop in 24 hours). • Two-stage (high and low flame) and single-stage (all-nothing)					
STANDARD APPLICATIONS			Boilers: water. steam. diathermic oil					
AMBIENT TEMPERATURE		°C	0 - 40					
COMBUSTION AIR TEMPERATURE		°C max	60					
IN CONFORMITY WITH EEC DIRECTIVES			90/396 - 2004/108 - 2006/95 - 2006/42					
NOISE LEVELS (3)		dBA	75		77		78.5	
APPROVAL		CE	0085AP0944		0085AP0945		0085AP0946	

(1) Reference conditions: Ambient temperature 20°C - Barometric pressure 1000 mbar - Altitude 100 m a.s.l.
(2) Pressure at test point 16)(A)p.3, with zero pressure in the combustion chambre, with open gas ring 2)(B)p.7 an maximum burner output
(3) Sound pressure measured in manufacturers combustion laboratory, with burner operating on test boiler and at maximum rated output.

ELECTRICAL DATA

Motor IE1

MODEL		RS 70	RS 100	RS 130
ELECTRICAL SUPPLY	V Hz	230 - 400 with neutral ~ +/-10% 50 - three-phase		
ELECTRIC MOTOR	rpm W V A	2800 1100 230 / 400 4.7 - 2.7	2830 1500 230 / 400 6.4 - 3.7	2860 2200 230 / 400 8.5 - 4.9
IGNITION TRANSFORMER	V1 - V2 I1 - I2	230 V - 1 x 8 kV 1 A - 20 mA		
ELECTRICAL POWER CONSUMPTION	W max	1400	1800	2600
ELECTRICAL PROTECTION		IP 44		

Motor IE2

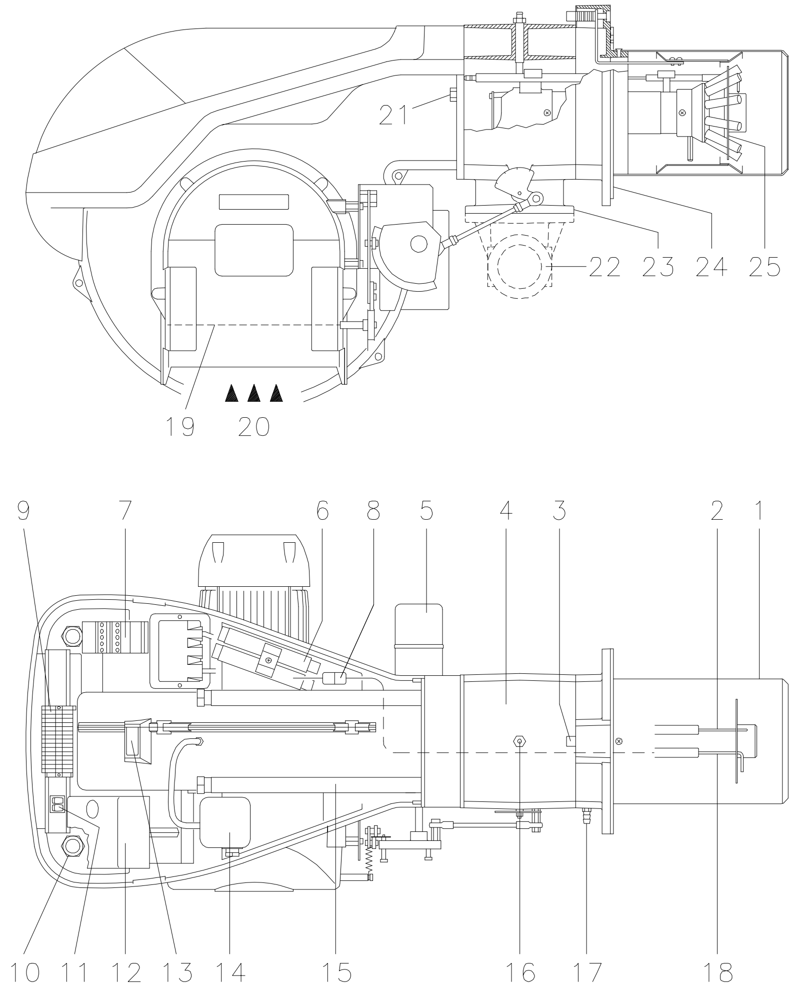
MODEL		RS 70	RS 100	RS 130
ELECTRICAL SUPPLY	V Hz	230 - 400 with neutral ~ +/-10% 50 - three-phase		
ELECTRIC MOTOR	rpm W V A	2860 1100 230 / 400 4.1 - 2.4	2860 1500 230 / 400 5.5 - 3.4	2860 2200 230 / 400 7.9 - 4.6
IGNITION TRANSFORMER	V1 - V2 I1 - I2	230 V - 1 x 8 kV 1 A - 20 mA		
ELECTRICAL POWER CONSUMPTION	W max	1400	1800	2600
ELECTRICAL PROTECTION		IP 44		

VARIANTS

Model	Electrical supply	Blast tube length mm
RS 70	three-phase three-phase	250 385
RS 100	three-phase three-phase	250 385
RS 130	three-phase three-phase	280 415

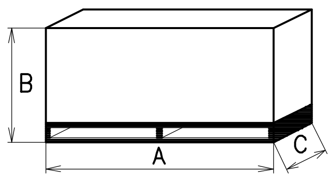
GAS CATEGORY

COUNTRY	CATEGORY
IT - AT - GR - DK - FI - SE	$II_{2H3B / P}$
ES - GB - IE - PT	II_{2H3P}
NL	$II_{2L3B / P}$
FR	II_{2Er3P}
DE	$II_{2ELL3B /P}$
BE	$I_{2E(R)B}$, I_{3P}
LU - PL	$II_{2E 3B/P}$

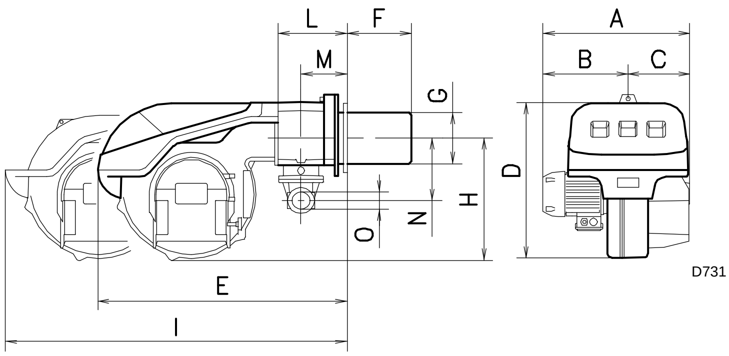


D3030 **(A)**

mm	A	B	C	kg
RS 70	1300	740	682	70
RS 100	1300	740	682	73
RS 130	1300	740	682	76



D36 **(B)**



mm	A	B	C	D	E	F(1)	G	H	I(1)	L	M	N	O
RS 70	511	296	215	555	840	250 - 385	179	430	1161-1296	214	134	221	2”
RS 100	527	312	215	555	840	250 - 385	179	430	1161-1296	214	134	221	2”
RS 130	553	338	215	555	840	280 - 415	189	430	1161-1296	214	134	221	2”

(1) Blast tube: short-lang

(C)

BURNER DESCRIPTION (A)

1 Combustion head
2 Ignition electrode
3 Screw for combustion head adjustment
4 Sleeve
5 Servomotor controlling the gas butterfly valve and of air gate valve (by means of a variable profile cam mechanism).
When the burner is stopped the air gate valve will be completely closed to reduce heat loss due to the flue draught, which tends to draw air from the fan air inlet.
6 Extension for slide bars 15)
7 Motor contactor and thermal cut-out reset button
8 Plug-socket on ionisation probe cable
9 Terminal strip
10 Fairleads for electrical connections by installer
11 Two switches:
- one “burner off-on”
- one for “1st - 2nd stage operation”
12 Control box with lock-out pilot light and lock-out reset button
13 Flame inspection window
14 Minimum air pressure switch (differential operating type)
15 Slide bars for opening the burner and inspecting the combustion head
16 Gas pressure test point and head fixing screw
17 Air pressure test point
18 Flame sensor probe
19 Air gate valve
20 Air inlet to fan
21 Screws securing fan to sleeve
22 Gas input pipework
23 Gas butterfly valve
24 Boiler mounting flange
25 Flame stability disk

Two types of burner failure may occur:
- **Control box lock-out:** if the control box 12)(A) pushbutton (red led) lights up, it indicates that the burner is in lock-out.
To reset, hold the pushbutton down for between 1 and 3 seconds.
- **Motor trip:** release by pressing the pushbutton on thermal cutout 7)(A).

PACKAGING - WEIGHT (B)

Approximate measurements
- The burner stands on a wooden base which can be lifted by fork-lifts.
Outer dimensions of packaging are indicated in (B).
- The weight of the burner complete with packaging is indicated in Table (B).

MAX. DIMENSIONS (C)

Approximate measurements

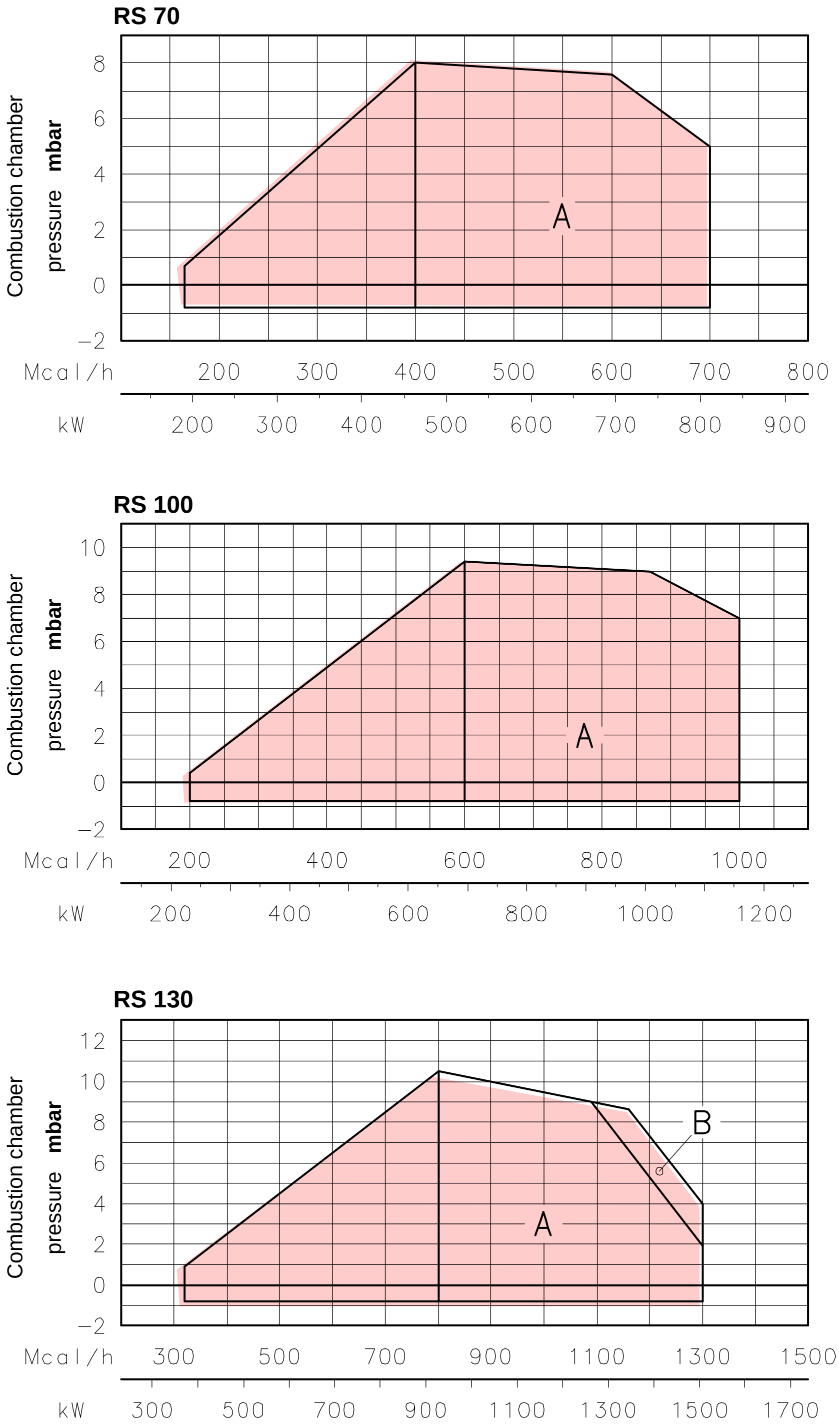
The maximum dimensions of the burner are given in (C).

Bear in mind that inspection of the combustion head requires the burner to be opened by withdrawing the rear part on the slide bars.

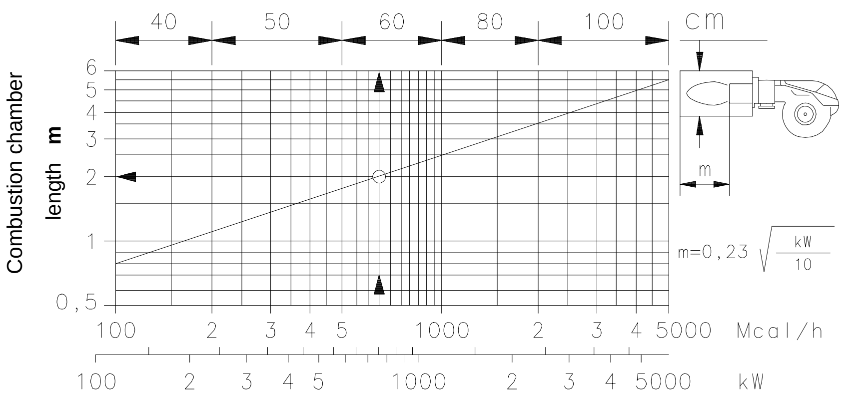
The maximum dimension of the burner when open is give by measurement I.

STANDARD EQUIPMENT

1 - Gas train flange
1 - Flange gasket
4 - Flange fixing screws M 10 x 35
1 - Thermal insulation screen
2 - Extensions 6)(A) for slide bars 15)(A) (for models with 385-415 mm blast tube)
4 - Screws to secure the burner flange to the boiler: M 12 x 35
1 - Instruction booklet
1 - Spare parts list



(A) D950



(B) D715

FIRING RATES (A)

The RS 70-100-130 Model burners can work in two ways: one-stage and two-stage

MAXIMUM OUTPUT must be selected in area A. In order to utilize also area B (RS 130) it is necessary to perform the calibration of the combustion head as explained on page 6.

MINIMUM OUTPUT must not be lower than the minimum limit shown in the diagram.

RS 70 = 192 kW
RS 100 = 232 kW
RS 130 = 372 kW

Important

The FIRING RATE value range has been obtained considering an ambient temperature of 20 °C, and an atmospheric pressure of 1000 mbar (approx. 100 m above sea level) and with the combustion head adjusted as shown on page 7.

TEST BOILER (B)

The firing rates were set in relation to special test boilers, according to EN 676 regulations. Figure (B) indicates the diameter and length of the test combustion chamber.

Example:

Output 756 kW:
diameter = 60 cm; length = 2 m.

COMMERCIAL BOILERS

The burner/boiler combination does not pose any problems if the boiler is CE type-approved and its combustion chamber dimensions are similar to those indicated in diagram (B).

If the burner must be combined with a commercial boiler that has not been CE type-approved and/or its combustion chamber dimensions are clearly smaller than those indicated in diagram (B), consult the manufacturer.

RS 70 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
465	4,2	0,2	11,6	8,5	4,8	5,2	-	-
515	4,8	0,2	13,9	10,0	5,8	6,2	-	-
565	5,6	0,3	16,3	12,0	6,8	7,2	-	-
615	6,4	0,3	18,9	13,5	8,0	8,2	-	-
665	7,3	0,3	21,7	15,0	9,2	9,5	-	-
715	8,3	0,4	24,6	17,2	10,5	10,8	-	-
765	9,3	0,4	27,7	18,5	11,3	11,5	4,4	-
814	10,3	0,4	30,9	20,0	13,2	13,0	5,0	-

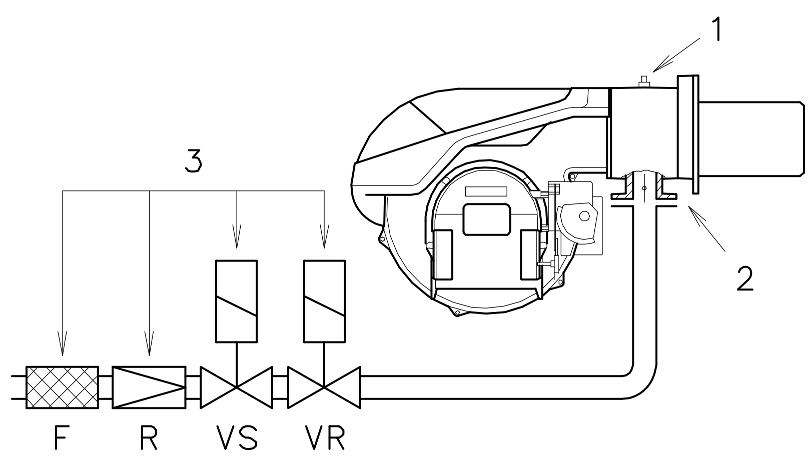
RS 100 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
695	3,7	0,4	23,5	17,0	9,9	10,1	-	-
760	4,2	0,4	27,4	18,5	11,7	11,5	4,4	-
825	5,0	0,5	31,6	20,5	13,6	13,2	5,1	-
890	5,8	0,5	36,1	23,0	15,6	14,0	5,8	-
955	6,5	0,6	40,9	26,0	17,7	16,0	6,6	-
1020	7,3	0,7	45,9	29,0	19,9	18,0	7,5	-
1085	8,3	0,8	51,1	33,0	22,3	20,0	8,4	4,5
1163	9,3	0,8	57,7	38,0	25,3	22,0	9,5	5,0

RS 130 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
930	3,8	1,0	39,0	22,0	16,9	15,0	6,3	-
1010	4,5	1,1	44,9	28,0	19,6	17,0	7,4	-
1090	5,1	1,3	51,5	33,0	22,5	20,0	8,5	4,5
1170	5,8	1,5	58,3	37,0	25,6	22,0	9,6	5,1
1250	6,5	1,7	65,4	40,0	28,8	25,0	10,8	5,7
1330	7,2	1,8	72,9	43,0	32,2	28,0	12,2	6,4
1410	7,9	1,9	80,7	48,0	35,8	31,0	13,6	7,1
1512	8,6	2,0	91,2	53,0	40,6	34,0	15,3	8,0

(A)



(B)

GAS PRESSURE

The adjacent tables show minimum pressure losses along the gas supply line depending on the burner output in 2nd stage operation.

Column 1
Pressure loss at combustion head.
Gas pressure measured at test point 1)(B), with:
- Combustion chamber at 0 mbar
- Burner operating in 2nd stage
- Gas ring 2)(B)p. 7 adjusted as indicated in diagram (C)p. 7.

Column 2
Pressure loss at gas butterfly valve 2)(B) with maximum opening: 90°.

Column 3
Pressure loss of gas train 3)(B) includes: adjustment valve VR, safety valve VS (both fully open), pressure governor R, filter F.

The values shown in the various tables refer to:
natural gas G20 PCI 10 kWh/Nm^3 (8.6 Mcal/Nm^3).
With:
natural gas G25 PCI 8.6 kWh/Nm^3 (7.4 Mcal/Nm^3) multiply tabulated values by 1.3.

Calculate the approximate 2nd stage output of the burner thus:
- subtract the combustion chamber pressure from the gas pressure measured at test point 1)(B).
- Find the nearest pressure value to your result in column 1 of the table for the burner in question.
- Read off the corresponding output on the left.

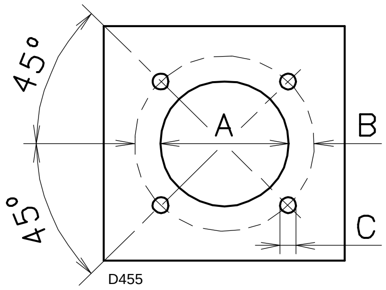
Example - RS 100:
- 2nd stage operation
- Natural gas G20 PCI 10 kWh/Nm^3
- Gas ring 2)(B)p. 7 adjusted as indicated in diagram (C)p. 7.
- Gas pressure at test point 1)(B) = 8 mbar
- Pressure in combustion chamber = 3 mbar
  8 - 3 = 5 mbar

A 2nd stage output of 825 kW shown in Table RS 100 corresponds to 5 mbar pressure, column 1.
This value serves as a rough guide, the effective delivery must be measured at the gas meter.

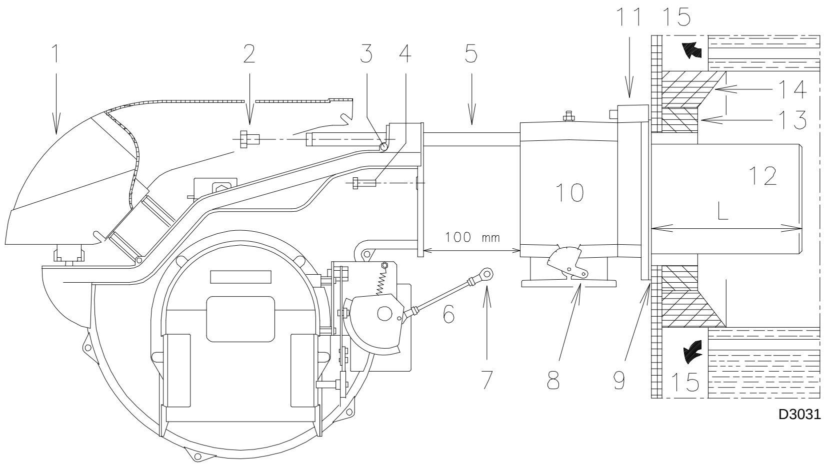
To calculate the required gas pressure at test point 1)(B), set the output required from the burner in 2nd stage operation:
- find the nearest output value in the table for the burner in question.
- Read off the pressure at test point 1)(B) on the right in column 1.
- Add this value to the estimated pressure in the combustion chamber.

Example - RS 100:
- Required burner output in 2nd stage operation: 825 kW
- Natural gas G20 PCI 10 kWh/Nm^3
- Gas ring 2)(B)p.7 adjusted as diagram (C)p.7.
- Gas pressure at burner output of 825 kW, taken from table RS 100, column 1 = 5 mbar
- Pressure in combustion chamber = 3 mbar
  5 + 3 = 8 mbar
  pressure required at test point 1)(B).
  4 + 2 = 6 mbar
  pressure required at test point 1)(B).

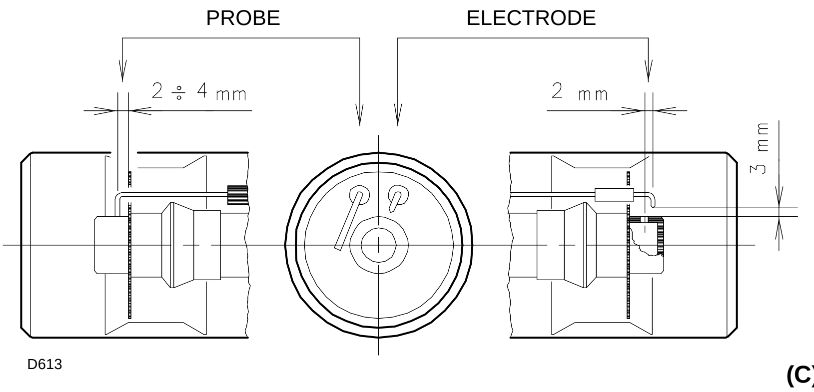
mm	A	B	C
RS 70	185	275 - 325	M 12
RS 100	185	275 - 325	M 12
RS 130	195	275 - 325	M 12



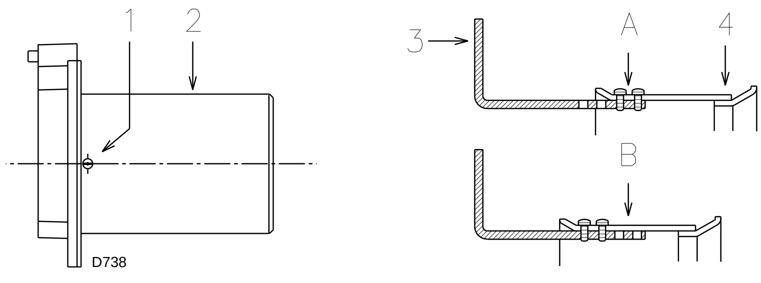
(A)



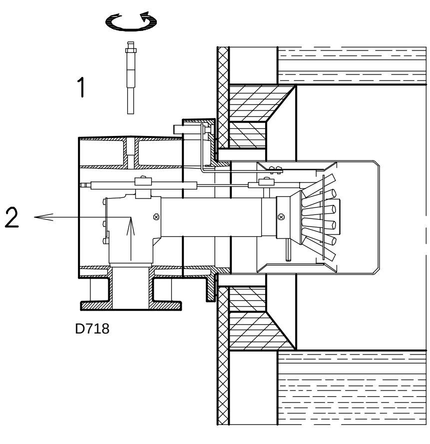
(B)



(C)



(D)



(E)

INSTALLATION

BOILER PLATE (A)

Drill the combustion chamber locking plate as shown in (A). The position of the threaded holes can be marked using the thermal screen supplied with the burner.

BLAST TUBE LENGTH (B)

The length of the blast tube must be selected according to the indications provided by the manufacturer of the boiler, and in any case it must be greater than the thickness of the boiler door complete with its fettling. The range of lengths available, L (mm), is as follows:

Blast tube 12):	**RS 70**	**RS 100**	**RS 130**
• short	250	250	280
• long	385	385	415

For boilers with front flue passes 15) or flame inversion chambers, protective fettling in refractory material 13) must be inserted between the boiler fettling 14) and the blast tube 12).
This protective fettling must not compromise the extraction of the blast tube.
For boilers having a water-cooled front the refractory fettling 13)-14)(B) is not required unless it is expressly requested by the boiler manufacturer.

SECURING THE BURNER TO THE BOILER (B)

Before securing the burner to the boiler, check through the blast tube opening to make sure that the flame sensor probe and the ignition electrode are correctly set in position, as shown in (C).

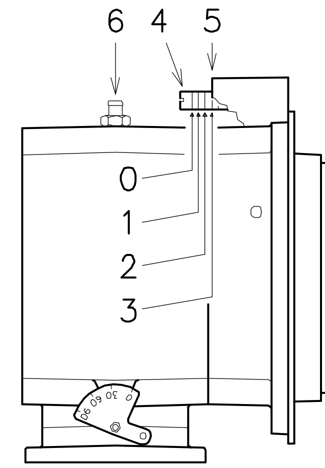
Now detach the combustion head from the burner, fig.(B):
- loosen the 4 screws 3) and remove the cover 1)
- Disengage the articulated coupling 7) from the graduated sector 8).
- Remove the screws 2) from the slide bars 5).
- Remove the two screws 4) and pull the burner back on slide bars 5) by about 100 mm. Disconnect the wires from the probe and the electrode and then pull the burner completely off the slide bars.

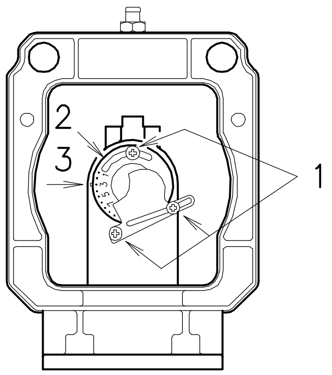
COMBUSTION HEAD CALIBRATION

At this point check, for model RS 130, whether the maximum delivery of the burner in 2nd stage operation is contained in area A or in area B of the firing rate. See page 8.
If it is in area A then no operation is required.
If, on the other hand, it is in area B:
- unscrew the screws 1)(D) and disassemble the blast tube 2).
- Move the fixing of the rod 3)(D) from position A to position B, thereby causing the shutter 4) to retract.
- Now refit the blast tube 2)(D) and the screws 1).

Once this operation has been carried out (if it was required), secure the flange 11)(B) to the boiler plate, interposing the thermal insulating screen 9)(B) supplied with the burner. Use the 4 screws, also supplied with the unit, after first protecting the thread with an anti-locking product.
The seal between burner and boiler must be airtight.

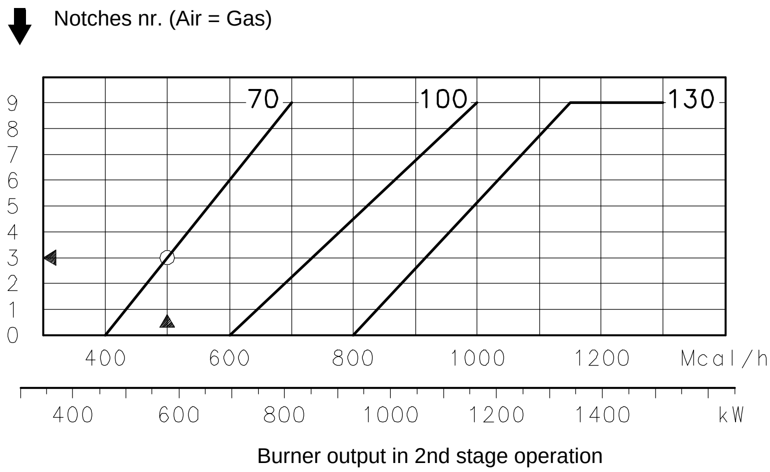
If you noticed any irregularities in positions of the probe or ignition electrode during the check mentioned above, remove screw 1)(E), extract the internal part 2)(E) of the head and proceed to set up the two components correctly.
Do not attempt to turn the probe. Leave it in the position shown in (C) since if it is located too close to the ignition electrode the control box amplifier may be damaged.



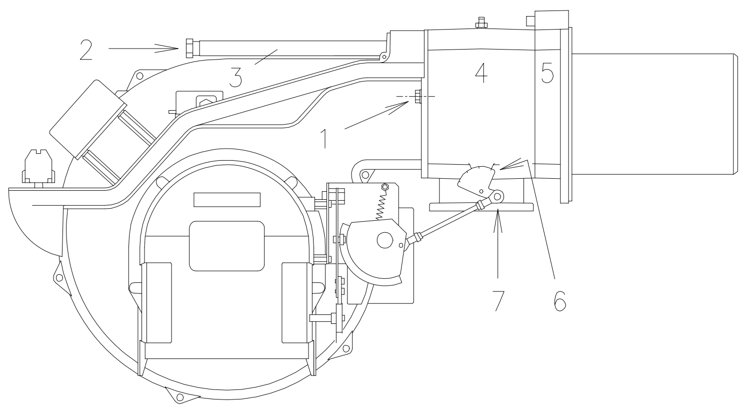


D719

(A) (B)



(C) D720



(D) D3032

SETTING THE COMBUSTION HEAD

Installation operations are now at the stage where the blast tube and sleeve are secured to the boiler as shown in fig. (A). It is now a very simple matter to set up the combustion head, as this depends solely on the output developed by the burner in 2nd stage operation.
It is therefore essential to establish this value before proceeding to set up the combustion head.
There are two adjustments to make on the head:
air and gas deliveries.

In diagram (C) find the notch to use for adjusting the air and the gas, and then proceed as follows:

Air adjustment (A)
Turn screw 4)(A) until the notch identified is aligned with the front surface 5)(A) of the flange.
Gas adjustment (B)
Loosen the 3 screws 1)(B) and turn ring 2) until the notch identified is aligned with index 3). Tighten the 3 screws 1) fully down.

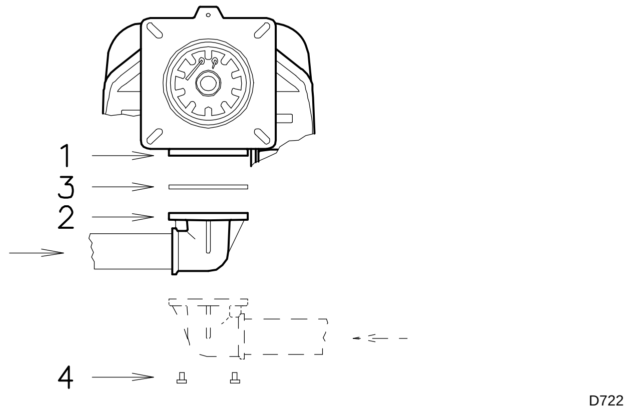
Example RS 70:
Burner output = 581 kW (500 Mcal/h).
If we consult diagram (C) we find that for this output, air and gas must be adjusted using notch 3, as shown in figs.(A) and (B).

Note
Diagram (C) shows the ideal settings for the combustion head. If the gas mains pressure is too low to reach the 2nd stage operation pressure indicated on page 5, and if the ring 2)(B) is not fully open, it can be opened wider by 1 or 2 notches.

Continuing with the previous example, page 5 indicates that for burner RS 70 with output of 581 kW (500 Mcal/h) a pressure of approximately 6 mbar is necessary at test point 6)(A). If this pressure cannot be reached, open the ring 2)(B) to notch 4 or 5.
Make sure that the combustion characteristics are satisfactory and free of pulsations.

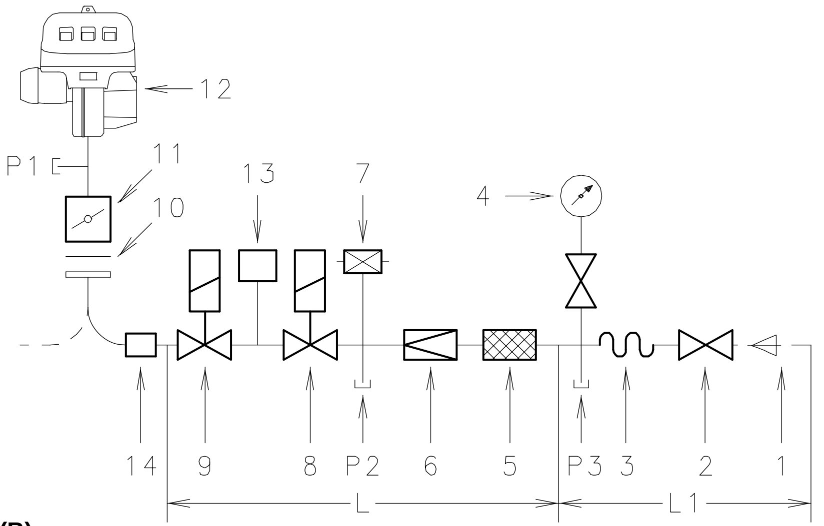
Once you have finished setting up the head, refit the burner to the slide bars 3)(D) at approximately 100 mm from the sleeve 4)(D) - burner positioned as shown in fig.(B)p.6 - insert the flame detection probe cable and the ignition electrode cable and then slide the burner up to the sleeve so that it is positioned as shown in fig.(D).
Refit screws 2) on slide bars 3).
Secure the burner to the sleeve by tightening screw 1).
Reconnect the articulation 7) to the graduated sector 6).

Important
When fitting the burner on the two slide bars, it is advisable to gently draw out the high tension cable and flame detection probe cable until they are slightly stretched.



(A)

D722



(B)

D953

GAS BURNERS AND RELEVANT GAS TRAINS APPROVED ACCORDING TO EN 676

Gas train L			Burner			13	14
Ø	C.T.	Code	RS 70	RS 100	RS 130	Code	Code
1"1/2	-	3970145	•	•	•	3010123	3000843
1"1/2	-	3970180	•	•	•	3010123	3000843
2"	-	3970146	•	•	•	3010123	-
2"	♦	3970160	•	•	•	-	-
2"	-	3970181	•	•	•	3010123	-
2"	♦	3970182	•	•	•	-	-
DN 65	-	3970147	•	•	•	3010123	3000825
DN 65	♦	3970161	•	•	•	-	3000825
DN 80	–	3970148	-	-	•	3010123	3000826
DN 80	♦	3970162	-	-	•	-	3000826

(C)

GAS TRAIN COMPONENTS

Code	Components		
	Filter 5	Pressure governor 6	Solenoids 8 - 9
3970145	GF 515/1	FRS 515	DMV-DLE 512/11
3970180	Multiblock MB DLE 415		
3970146 3970160	GF 520/1	FRS 520	DMV-DLE 520/11
3970181 3970182	Multiblock MB DLE 420		
3970147 3970161	GF 40065/3	FRS 5065	DMV-DLE 5065/11
3970148 3970162	GF 40080/3	FRS 5080	DMV-DLE 5080/11

GAS LINE

- The gas train must be connected to the gas attachment 1)(A), using flange 2), gasket 3) and screws 4) supplied with the burner.
- The gas train can enter the burner from the right or left side, depending on which is the most convenient, see fig.(A).
- Gas solenoids 8)-9)(B) must be as close as possible to the burner to ensure gas reaches the combustion head within the safety time range of 3 s.
- Make sure that the pressure governor calibration range (colour of the spring) comprises the pressure required by the burner.

GAS TRAIN (B)

It is type-approved according to EN 676 Standards and is supplied separately from the burner with the code indicated in Table (C).

KEY (B)

1 - Gas input pipe
2 - Manual valve
3 - Vibration damping joint
4 - Pressure gauge with pushbutton cock
5 - Filter
6 - Pressure governor (vertical)
7 - Minimum gas pressure switch
8 - Safety solenoid VS (vertical)
9 - Adjustment solenoid VR (vertical)
Two adjustments:
• ignition delivery (rapid opening)
• maximum delivery (slow opening)
10 - Standard issue burner gasket with flange
11 - Gas adjustment butterfly valve
12 - Burner
13 - Gas valve 8)-9) leak detection control device.
In accordance with EN 676 Standards, gas valve leak detection control devices are compulsory for burners with maximum outputs of more than 1200 kW; therefore only for model RS 130.
14 - Gas train/burner adaptor.

P1 - Pressure at combustion head
P2 - Pressure down-line from the pressure governor
P3 - Pressure up-line from the filter

L - Gas train supplied separately with the code indicated in Table (C)
L1 - The responsibility of the installer

KEY TO TABLE (C)

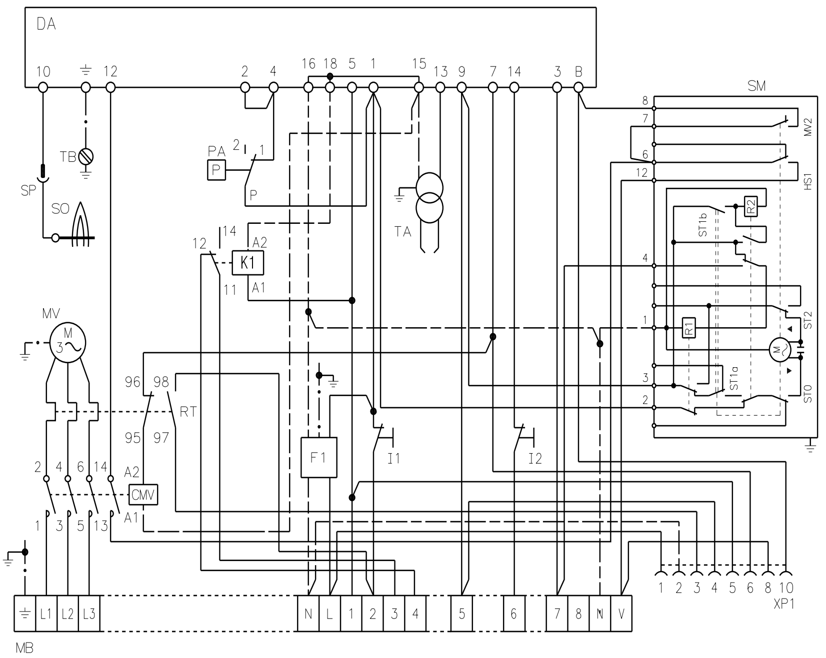
C.T.=Gas valves 8) - 9) leak detection control devices:
- = Gas train without gas valve leak detection control device; device that can be ordered separately and assembled subsequently (see Column 13).
♦= Gas train with assembled VPS valve leak detection control device.

13 = VPS valve leak detection control device. Supplied separately from gas train on request.
14 = Gas train/burner adaptor. Supplied separately from gas train on request.

Note

See the accompanying instructions for the adjustment of the gas train.

ELECTRICAL EQUIPMENT FACTORY-SET
RS 70 - RS 100 - RS 130



(A) D3055

ELECTRICAL SYSTEM

ELECTRICAL SYSTEM as set up by the manufacturer

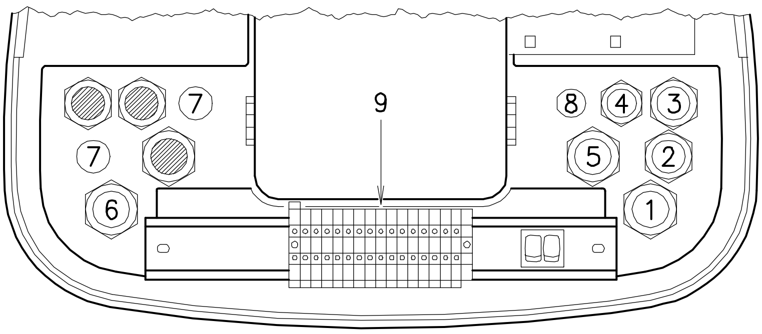
LAYOUT (A)
Burners RS 70 - RS 100 - RS 130

- Models RS 70 - RS 100 - RS 130 leave the factory preset for **400 V** power supply.
- If **230 V** power supply is used, change the motor connection from star to delta and change the setting of the thermal cut-out as well.

Key to Layout (A)

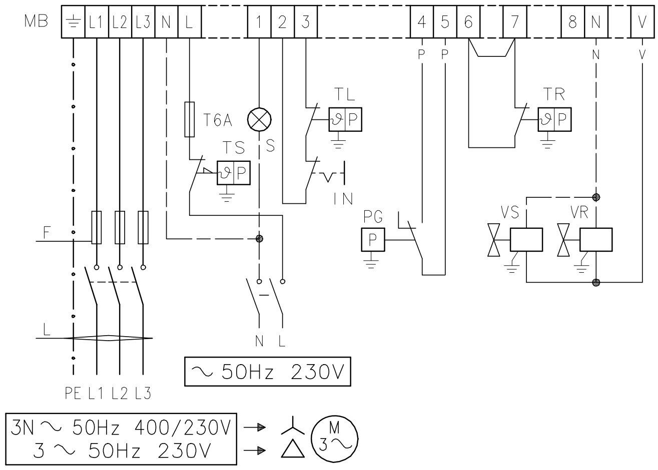
CMV	- Motor contactor
DA	- Control box (Landis RMG)
F1	- Protection against radio interference
K1	- Relay
I1	- Switch: burner off - on
I2	- Switch: 1st - 2nd stage operation
MB	- Burner terminal strip
MV	- Fan motor
PA	- Air pressure switch
RT	- Thermal cut-out
SM	- Servomotor
SO	- Ionisation probe
SP	- Plug-socket
TA	- Ignition transformer
TB	- Burner ground
XP1	- Connector

ATTENTION
In the case of phase-phase feed, a bridge must be fitted on the control box terminal strip between terminal 6 and the earth terminal.



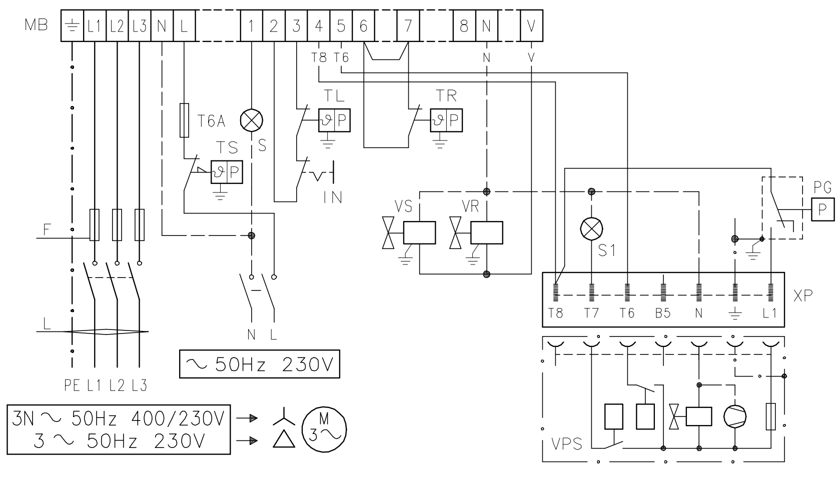
(A) D955

RS 70 - RS 100 - RS 130 without leak detection control device



(B) D956

RS 70 - RS 100 - RS 130 with leak detection control device VPS



(C) D957

		RS 70		RS 100		RS 130	
		230 V	400 V	230 V	400 V	230 V	400 V
F	A	T10	T6	T16	T10	T16	T10
L	mm^2	1,5	1,5	1,5	1,5	1,5	1,5

(D)

ELECTRICAL CONNECTIONS

Use flexible cables according to EN 60 335-1 Regulations:

- if in PVC sheath, use at least H05 VV-F
- if in rubber sheath, use at least H05 RR-F.

All the wires to connect to the burner terminal strip 9)(A) must enter through the supplied fairleads.

The fairleads and hole press-outs can be used in various ways; the following lists show one possible solution:

1 - Pg 13,5 Three-phase power supply
2 - Pg 11 Single-phase power supply
3 - Pg 11 Remote control device TL
4 - Pg 9 Remote control device TR
5 - Pg 13,5 Gas valves
6 - Pg 13,5 Gas pressure switch or gas valve leak detection control device
7 - Pg 11 Open the hole, if a pipe union is to be added
8 - Pg 9 Open the hole, if a pipe union is to be added

LAYOUT (B)

Electrical connection RS 70 - 100 - 130 burners without leak detection control device.

LAYOUT (C)

Electrical connection RS 70 - 100 - 130 burners with VPS leak detection control device.

Gas valve leak detection control takes place immediately before every burner start-up.

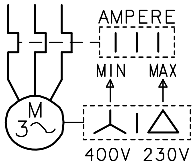
Fuses and cables cross-section layouts (B) and (C), see table (D).

Cross-section when not indicated: 1,5 mm^2.

KEY TO LAYOUTS (B - C)

IN - Burner manual stop switch
XP - Plug for leak detection control device
MB - Burner terminal strip
PG - Min. gas pressure switch
S - Remote lock-out signal
S1 - Remote lock-out signal of leak detection control device
TR - High-low mode load remote control system: controls operating stages 1 and 2.
If the burner is to be set up for single stage operation, replace of remote control device TR with a jumper.
TL - Load limit remote control system:
shuts down the burner when the boiler temperature or pressure reaches the preset value.
TS - Safety load control system:
operates when TL is faulty
VR - Adjustment valve
VS - Safety valve

CALIBRATION OF THERMAL RELAY



(A)

D867

LAYOUT (A)

Calibration of thermal cut-out 7)(A)p. 3

This is required to avoid motor burn-out in the event of a significant increase in power absorption caused by a missing phase.

- If the motor is star-powered, **400 V**, the cursor should be positioned to "MIN".
- If the motor is delta-powered, **230 V**, the cursor should be positioned to "MAX".

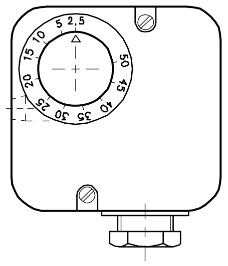
Even if the scale of the thermal cut-out does not include rated motor absorption at 400 V, protection is still ensured in any case.

N.B.

- The RS 70-100-130 burners leave the factory preset for 400 V power supply. If 230 V power supply is used, change the motor connection from star to delta and change the setting of the thermal cut-out as well.
- The RS 70-100-130 burners have been type-approved for intermittent operation. This means they should compulsorily be stopped at least once every 24 hours to enable the control box to check its own efficiency at start-up. Burner halts are normally provided for automatically by the boiler load control system.
  If this is not the case, a time switch should be fitted in series to IN to provide for burner shut-down at least once every 24 hours.
- The RS 70-100-130 burners are factory set for two-stage operation and must therefore be connected to control device TR.
  Alternatively, if single stage operation is required, instead of control device TR install a jumper lead between terminals 6 and 7 of the terminal strip.

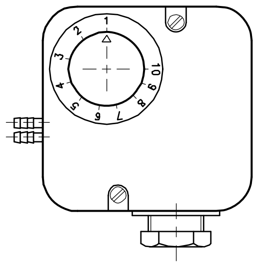
WARNING: Do not invert the neutral with the phase wire in the electricity supply line. Inverting the wires will make the burner go into lock-out because of firing failure.

MIN GAS PRESSURE SWITCH



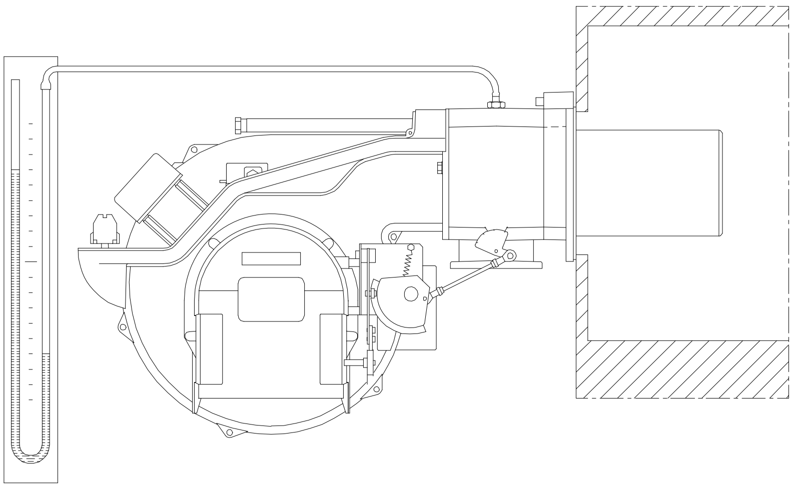
(A)

AIR PRESSURE SWITCH



(B)

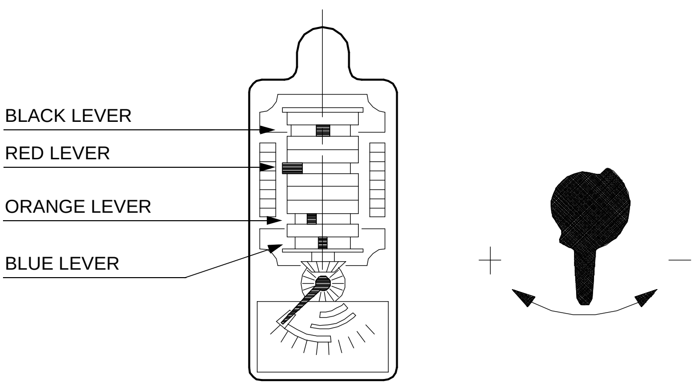
D897



(C)

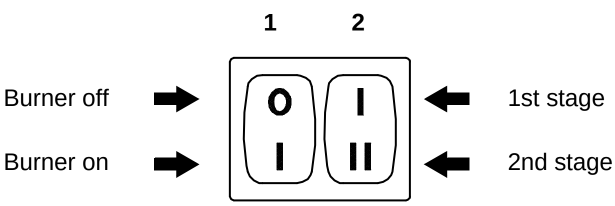
D3033

SERVOMOTOR



(D)

D728



(E)

D469

ADJUSTMENTS BEFORE FIRST FIRING

Adjustment of the combustion head, and air and gas deliveries has been illustrated on page 7.
In addition, the following adjustments must also be made:
- open manual valves up-line from the gas train.
- Adjust the minimum gas pressure switch to the start of the scale (A).
- Adjust the air pressure switch to the zero position of the scale (B).
- Purge the air from the gas line.
  Continue to purge the air (we recommend using a plastic tube routed outside the building) until gas is smelt.
- Fit a U-type manometer (C) to the gas pressure test point on the sleeve.
  The manometer readings are used to calculate the 2nd stage operation burner power using the tables on page 5.
- Connect two lamps or testers to the two gas line solenoid valves VR and VS to check the exact moment at which voltage is supplied.
  This operation is unnecessary if each of the two solenoid valves is equipped with a pilot light that signals voltage passing through.

Before starting up the burner it is good practice to adjust the gas train so that ignition takes place in conditions of maximum safety, i.e. with gas delivery at the minimum.

SERVOMOTOR (D)

The servomotor provides simultaneous adjustment of the air gate valve, by means of the variable profile cam, and the gas butterfly valve.
The angle of rotation of the servomotor is equal to the angle on the graduated sector controlling the gas butterfly valve. The servomotor rotates through 90 degrees in 15 seconds.
Do not alter the factory setting for the 4 levers; simply check that they are set as indicated below:

RED LEVER : 90°
Limits rotation toward maximum position. When the burner is in 2nd stage operation the gas butterfly valve must be fully open: 90°.

BLUE LEVER : 0°
Limits rotation toward the minimum position. When the burner is shut down the air gate valve and the gas butterfly valve must be closed: 0°.

ORANGE LEVER : 15°
Adjusts the ignition position and the output in 1st stage operation.

BLACK LEVER : 85°
Lights up the 2nd stage LED.

A graduated plate with 4 coloured sectors marks the lever operation point.

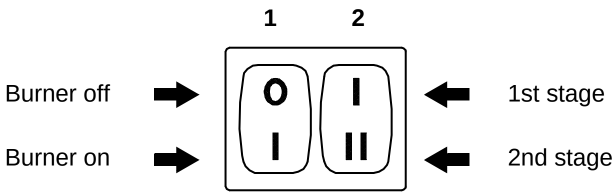
BURNER STARTING

Close the control devices and set:
- switch 1)(E) to "Burner ON" position;
- switch 2)(E) to "1st STAGE" position.

As soon as the burner starts check the direction of rotation of the fan blade, looking through the flame inspection window 13)(A)p.3.
Make sure that the lamps or testers connected to the solenoids, or pilot lights on the solenoids themselves, indicate that no voltage is present. If voltage is present, then **immediately** stop the burner and check electrical connections.

BURNER FIRING

Having completed the checks indicated in the previous heading, the burner should fire. If the motor starts but the flame does not appear and the control box goes into lock-out, reset and wait for a new firing attempt.
If firing is still not achieved, it may be that gas is not reaching the combustion head within the safety time period of 3 seconds.
In this case increase gas firing delivery.
The arrival of gas at the sleeve is indicated by the U-type manometer (C).
Once the burner has fired, now proceed with global calibration operations.



(A)

D469

BURNER CALIBRATION

The optimum calibration of the burner requires an analysis of the flue gases at the boiler outlet.

Adjust successively:
1 - First firing output
2 - 2nd stage burner output
3 - 1st stage burner output
4 - Intermediate outputs between 1st and 2nd stage
5 - Air pressure switch
6 - Minimum gas pressure switch

1 - FIRING OUTPUT

According to EN 676 Regulations:

Burners with max. output up to 120 kW
Firing can be performed at the maximum operation output level. Example:
• Max. operation output : 120 kW
• Max. firing output : 120 kW

Burners with max. output above 120 kW
Firing must be performed at a lower output than the max. operation output. If the firing output does not exceed 120 kW, no calculations are required. If firing output exceeds 120 kW, the regulations prescribe that the value be defined according to the control box safety time "ts":
- for "ts" = 2s, firing output must be equal to or lower than 1/2 of max. operation output.
- For "ts" = 3s, firing output must be equal to or lower than 1/3 of max. operation output.

Example: MAX operation output of 600 kW.
Firing output must be equal to or lower than:
• 300 kW with "ts" = 2s
• 200 kW with "ts" = 3s

In order to measure the firing output:
- disconnect the plug-socket 8)(A)p.3 on the ionization probe cable (the burner will fire and then go into lock-out after the safety time has elapsed).
- Perform 10 firings with consecutive lock-outs.
- On the meter read the quantity of gas burned. This quantity must be equal to or lower than the quantity given by the formula, for ts = 3s:

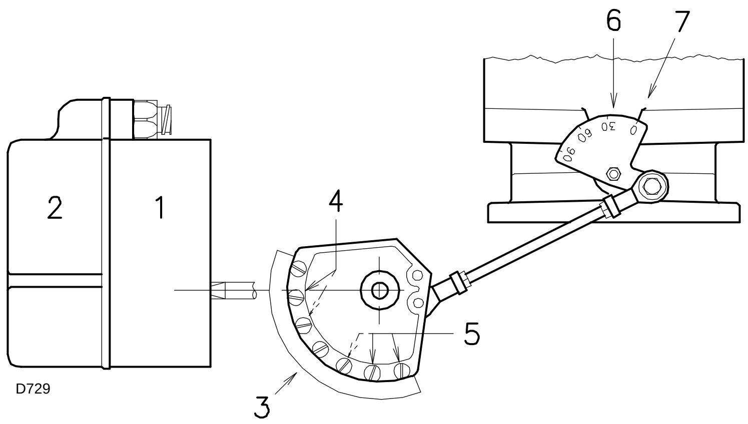
$$\frac{\mathbf{Nm^3/h}\ \text{(max. burner delivery)}}{\mathbf{360}}$$

Example: for G 20 gas (10 kWh/Nm^3):
Max. operation output: 600 kW corresponding to 60 Nm^3/h.
After 10 firings with lock-outs, the delivery read on the meter must be equal to or lower than:
60 : 360 = 0,166 Nm^3.

2 - 2ND STAGE OUTPUT

2nd stage output of the burner must be set within the firing rate range shown on page 4.
In the above instructions we left the burner running in 1st stage operation. Now set switch 2)(A) to the 2nd stage position: the servomotor will open, simultaneously, the air gate valve and the gas butterfly valve to 90°.

Gas calibration
Measure the gas delivery at the meter.
A guideline indication can be calculated from the tables on page 5, simply read off the gas pressure on the U-type manometer, see fig.(C) on page 12, and follow the instructions on page 5.
- If delivery needs to be reduced, diminish outlet gas pressure and, if it is already very low, slightly close adjustment valve VR.
- If delivery needs to be increased, increase outlet gas pressure.



1 Servomotor

2 Cam cover

3 Adjustable profile cam

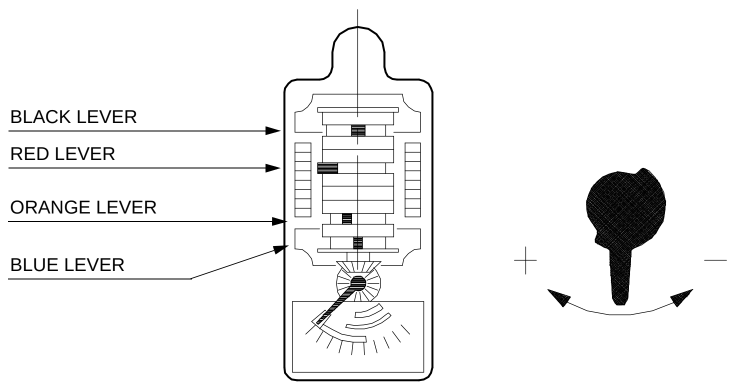
4 Cam starting profile adjustment screws

5 Cam end profile adjustment screws

6 Graduated sector for gas butterfly valve

7 Index for graduated sector 6

(A)



(B)

Adjusting air delivery

Progressively adjust the end profile of cam 3)(A) by turning the screws 5).
- Turn the screws clockwise to increase air delivery.
- Turn the screws counter-clockwise to reduce air delivery.

3 - 1ST STAGE OUTPUT

Burner power in 1st stage operation must be selected within the firing rate range shown on page 4.

Set the switch 2)(A)p.13 to the 1st stage position: the servomotor 1)(A) will close the air gate valve and, at the same time, closes the gas butterfly valve down to 15°, i.e. down to the original factory setting.

Adjusting gas delivery

Measure the delivery of gas from the gas meter.
- If this value is to be reduced, decrease the angle of the orange lever (B) slightly by proceeding a little at a time until the angle is changed from 15° to 13° or 11°....
- If it is necessary to increase the mains pressure, move to 2nd stage operation by altering the setting of switch 2)(A)p.13 and increase the angle of the orange lever, proceeding a little at a time until the angle is changed from 15° to 17° - 19°....
  At this point return to 1st stage operation and measure gas delivery.

Note

The servomotor follows the adjustment of the orange lever only when the angle is reduced.

If, however the angle must be increased, switch to 2nd stage operation, increase the angle and then return to 1st stage operation to check the effect of the adjustment.

Adjustment of air delivery

Progressively adjust the starting profile of cam 3)(A) by turning the screws 4). It is preferable not to turn the first screw since this is used to set the air gate valve to its fully-closed position.

4 - INTERMEDIATE OUTPUTS

Adjustment of gas delivery

No adjustment of gas delivery is required.

Adjustment of air delivery

Switch off the burner using switch 1)(A)p.13 and turn the central screws of the cam so that the cam offers a progressive gradient.

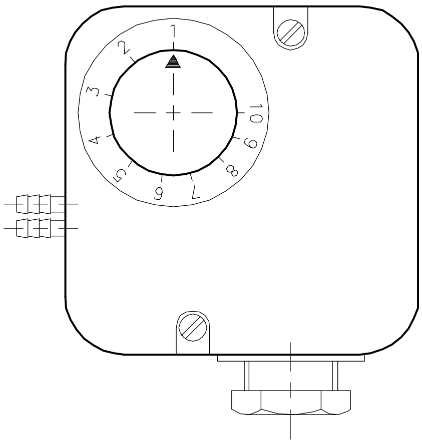
Do not alter the position of the screws at each end of the cam track, which have already been adjusted for 1st and 2nd stage air gate valve control.

Note

Once you have finished adjusting outputs 2ND STAGE - 1ST STAGE - INTERMEDIATE, check ignition once again: noise emission at this stage must be identical to the following stage of operation.

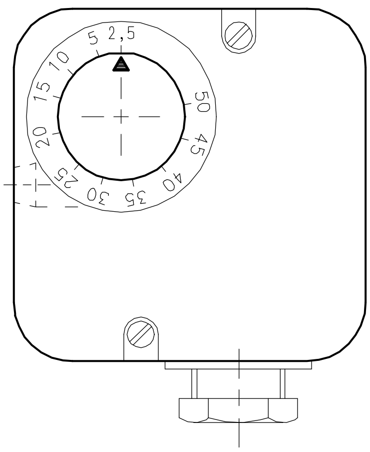
If you notice any sign of pulsations, reduce the ignition stage delivery.

AIR PRESSURE SWITCH 14)(A)p. 3

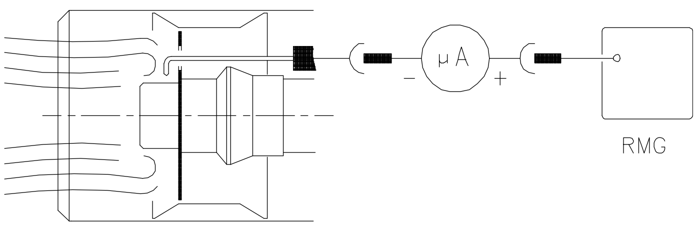


(A) D521

MIN GAS PRESSURE SWITCH 7)(B)p. 8



(B) D896



(C) D3023

5 - AIR PRESSURE SWITCH (A)

Adjust the air pressure switch after having performed all other burner adjustments with the air pressure switch set to the start of the scale (A).
With the burner operating in 1st stage, increase adjustment pressure by slowly turning the relative knob clockwise until the burner locks out.
Then turn the knob anti-clockwise by about 20% of the set point and repeat burner starting to ensure it is correct.
If the burner locks out again, turn the knob anti-clockwise a little bit more.

Attention

As a rule, the air pressure switch must limit the CO in the fumes to less than 1% (10,000 ppm).
To check this, insert a combustion analyser into the chimney, slowly close the fan suction inlet (for example with cardboard) and check that the burner locks out, before the CO in the fumes exceeds 1%.

The air pressure switch may operate in "differential" operation in two pipe system. If a negative pressure in the combustion chamber during pre-purging prevents the air pressure switch from switching, switching may be obtained by fitting a second pipe between the air pressure switch and the suction inlet of the fan. In such a manner the air pressure switch operates as differenzial pressure switch.

Warning

The use of the air pressure switch with differential operation is allowed only in industrial applications and where rules enable the air pressure switch to control only fan operation without any reference to CO limit.

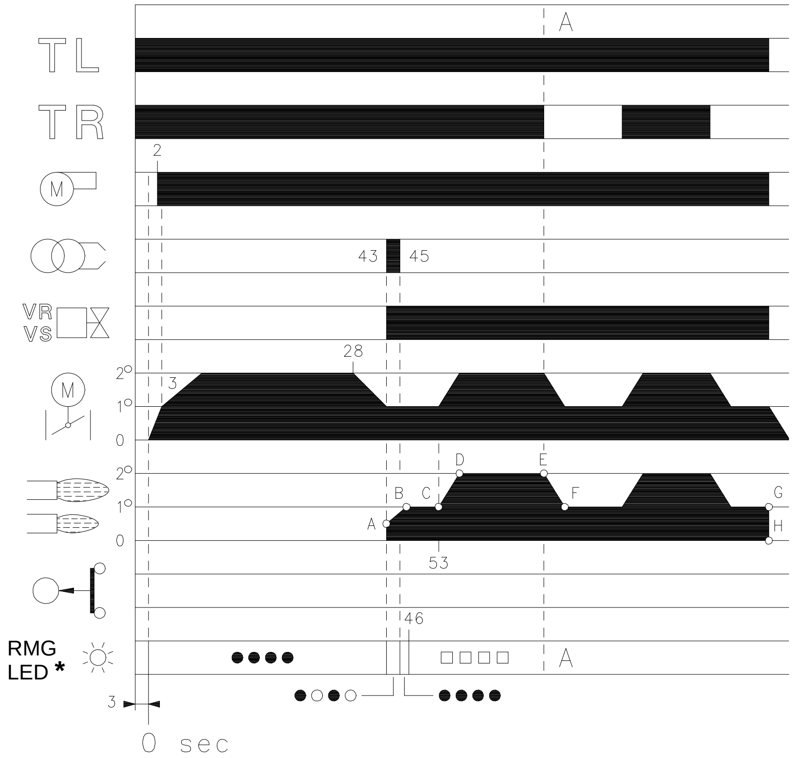
6 - MINIMUM GAS PRESSURE SWITCH (B)

Adjust the minimum gas pressure switch after having performed all the other burner adjustments with the pressure switch set at the start of the scale (B).
With the burner operating in 2nd stage, increase adjustment pressure by slowly turning the relative knob clockwise until the burner locks out.
Then turn the knob anti-clockwise by 2 mbar and repeat burner starting to ensure it is uniform.
If the burner locks out again, turn the knob anti-clockwise again by 1 mbar.

FLAME PRESENT CHECK (C)

The burner is fitted with an ionisation system which ensures that a flame is present. The minimum current for plant operation is 5 μA.
The burner provides a much higher current, so that controls are not normally required. However, if it is necessary to measure the ionisation current, disconnect the plug-socket 8)(A)p.3 on the ionisation probe cable and insert a direct current microamperometer with a base scale of 100 μA.
Carefully check polarities!

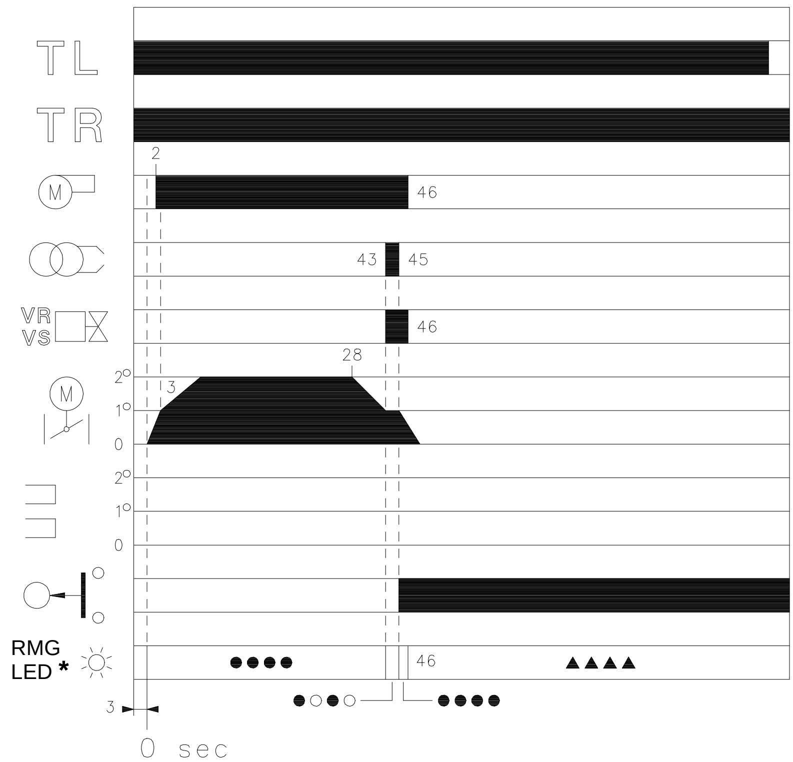
NORMAL FIRING
(n° = seconds from instant 0)



* ○ Off ● Yellow □ Green ▲ Red
For further details see page 18.

(A) D3051

NO FIRING



* ○ Off ● Yellow ▲ Red
For further details see page 18.

(B) D3052

BURNER OPERATION

BURNER STARTING (A)

- : Control device TL closes.
  Servomotor starts: it rotates during opening up to the angle set on cam with orange lever.
  After about 3s:
- 0 s : The control box starting cycle begins.
- 2 s : Fan motor starts.
- 3 s : Servomotor starts: it rotates during opening until contact is made on cam with red lever.
  The air gate valve is positioned to 2nd stage output.
  Pre-purge stage with air delivery at 2nd stage output.
  Duration 25 seconds.
- 28 s : Servomotor starts: it rotates during closing up to the angle set on cam with orange lever.
- 43 s : The air gate valve and the gas butterfly are positioned to 1st stage output.
  Ignition electrode strikes a spark.
  Safety valve VS and adjustment valve VR (rapid opening) open. The flame is ignited at a low output level, point A. Output is then progressively increased, with the valve opening slowly up to 1st stage output, point B.
- 45 s : The spark goes out.
- 53 s : If remote control device TR is closed or if it has been replaced by a jumper, the servomotor will continue to turn until the cam with red lever come into operation, setting the air gate valve and the gas butterfly valve to the 2nd stage operation position, section C-D.
  The control box starting cycle ends.

STEADY STATE OPERATION (A)

System equipped with one control device TR.
Once the starting cycle has come to an end, control of the servomotor passes on to the control device TR that controls boiler temperature or pressure, point D.
(The control box will continue, however, to monitor flame presence and the correct position of the air pressure switch).

- When the temperature or the pressure increases until the control device TR opens, the servomotor closes the gas butterfly valve and the air gate valve and the burner passes from the 2nd to the 1st stage of operation, section E-F.
- When the temperature or pressure decreases until the control device TR closes, the servomotor opens the gas butterfly valve and the air gate valve and the burner passes from the 1st to the 2nd stage of operation, and so on.
- The burner stops when the demand for heat is less than the amount of heat delivered by the burner in the 1st stage, section G-H. Control device TL now opens, the servomotor returns toward the 0° position, limited in this movement by cam with blue lever. The air gate valve closes completely to reduce heat losses to a minimum.

Systems not equipped with control device TR (jumper wire installed)
The burner is fired as described in the case above. If the temperature or pressure increase until control device TL opens, the burner shuts down (Section A-A in the diagram).

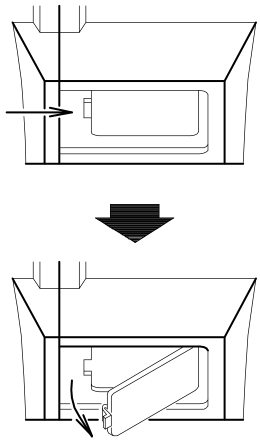
FIRING FAILURE (B)

If the burner does not fire, it goes into lock-out within 3 s of the opening of the gas solenoid valve and 49 s after the closing of control device TL. The control box red pilot light will light up.

BURNER FLAME GOES OUT DURING OPERATION

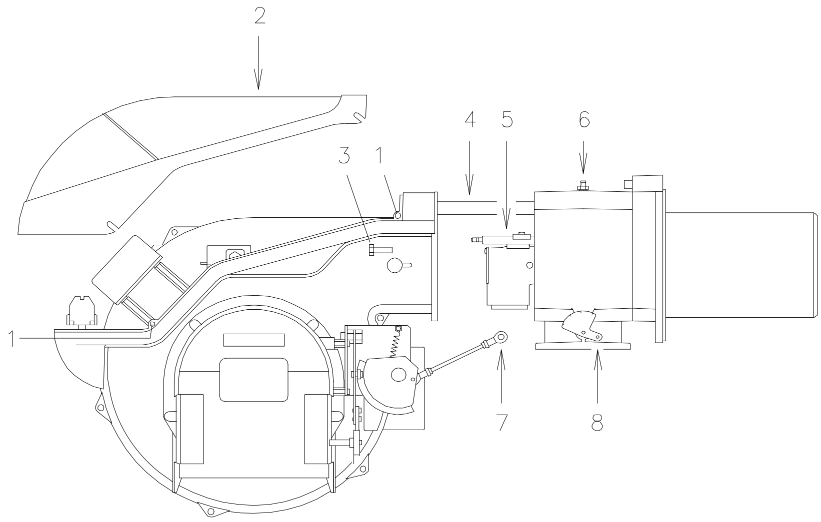
If the flame should accidentally go out during operation, the burner will lock out within 1s.

FLAME INSPECTION WINDOW



(A) D709

OPENING THE BURNER



(B) D3034

FINAL CHECKS (with burner running)

- Disconnect one of the wires on the minimum gas pressure switch:
- Open remote control device TL:
- Open remote control device TS:

the burner must stop

- Disconnect the common wire P from the air pressure switch:
- Disconnect the ionisation probe lead:

the burner must lock out

- Make sure that the mechanical locking systems on the various adjustment devices are fully tightened.

MAINTENANCE

Combustion

The optimum calibration of the burner requires an analysis of the flue gases. Significant differences with respect to the previous measurements indicate the points where more care should be exercised during maintenance.

Gas leaks

Make sure that there are no gas leaks on the pipework between the gas meter and the burner.

Gas filter

Change the gas filter when it is dirty.

Flame inspection window

Clean the flame inspection window (A).

Combustion head

Open the burner and make sure that all components of the combustion head are in good condition, not deformed by the high temperatures, free of impurities from the surroundings and correctly positioned. If in doubt, disassemble the elbow fitting 5)(B).

Burner

Check for excess wear or loose screws in the mechanisms controlling the air gate valve and the gas butterfly valve. Also make sure that the screws securing the electrical leads in the burner terminal strip are fully tightened.

Clean the outside of the burner, taking special care with the transmission joints and cam 3)(A)p.14.

Combustion

Adjust the burner if the combustion values found at the beginning of the operation do not comply with the regulations in force, or at any rate, do not correspond to good combustion. Use the appropriate card to record the new combustion values; they will be useful for subsequent controls.

TO OPEN THE BURNER (B):

- switch off the electrical power.
- Loosen screws 1) and withdraw cover 2).
- Disengage the articulated coupling 7) from the graduated sector 8).
- Fit the two standard supplied extensions onto the slide bars 4) (models with 385-415 mm blast tube).
- Remove screws 3), and pull the burner back by about 100 mm on the slide bars 4). Disconnect the probe and electrode leads and then pull the burner fully back.

Now extract the gas distributor 5) after having removed the screw 6).

TO CLOSE THE BURNER (B):

- push the burner until it is about 100 mm from the sleeve.
- Re-connect the leads and slide in the burner until it comes to a stop.
- Refit screws 3), and pull the probe and electrode leads gently out until they are slightly stretched.
- Re-couple the articulated coupling 7) to the graduated sector 8).
- Remove the two extensions from the slide bars 4).

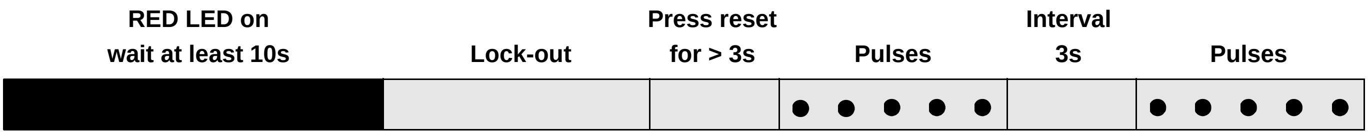
BURNER START-UP CYCLE DIAGNOSTICS

During start-up, indication is according to the followin table:

COLOUR CODE TABLE	
Sequences	**Colour code**
Pre-purging	● ● ● ● ● ● ● ● ●
Ignition phase	● ○ ● ○ ● ○ ● ○ ●
Operation, flame ok	□ □ □ □ □ □ □ □ □
Operating with weak flame signal	□ ○ □ ○ □ ○ □ ○ □
Electrical supply lower than ~ 170V	● ▲ ● ▲ ● ▲ ● ▲ ●
Lock-out	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲
Extraneous light	▲ □ ▲ □ ▲ □ ▲ □ ▲
Key: ○ Off ● Yellow □ Green ▲ Red	

RESETTING THE CONTROL BOX AND USING DIAGNOSTICS

The control box features a diagnostics function through which any causes of malfunctioning are easily identified (indicator: **RED LED**).
To use this function, you must wait at least 10 seconds once it has entered the safety condition (**lock-out**), and then press the reset button.
The control box generates a sequence of pulses (1 second apart), which is repeated at constant 3-second intervals.
Once you have seen how many times the light pulses and identified the possible cause, the system must be reset by holding the button down for between 1 and 3 seconds.



The methods that can be used to reset the control box and use diagnostics are given below.

RESETTING THE CONTROL BOX

To reset the control box, proceed as follows:

- Hold the button down for between 1 and 3 seconds.
  The burner restarts after a 2-second pause once the button is released.
  If the burner does not restart, you must make sure the limit thermostat is closed.

VISUAL DIAGNOSTICS

Indicates the type of burner malfunction causing lock-out.
To view diagnostics, proceed as follows:

- Hold the button down for more than 3 seconds once the red LED (burner lock-out) remains steadily lit.
  A yellow light pulses to tell you the operation is done.
  Release the button once the light pulses. The number of times it pulses tells you the cause of the malfunction, according to the coding system indicated in the table on page 19.

SOFTWARE DIAGNOSTICS

Reports burner life by means of an optical link with the PC, indicating hours of operation, number and type of lock-outs, serial number of control box etc ...
To view diagnostics, proceed as follows:

- Hold the button down for more than 3 seconds once the red LED (burner lock-out) remains steadily lit.
  A yellow light pulses to tell you the operation is done.
  Release the button for 1 second and then press again for over 3 seconds until the yellow light pulses again.
  Once the button is released, the red LED will flash intermittently with a higher frequency: only now can the optical link be activated.

Once the operations are done, the control box's initial state must be restored using the resetting procedure described above.

BUTTON PRESSED FOR	CONTROL BOX
Between 1 and 3 seconds	Control box reset without viewing visual diagnostics.
More than 3 seconds	Visual diagnostics of lock-out condition: (LED pulses at 1-second intervals).
More than 3 seconds starting from the visual diagnostics condition	Software diagnostics by means of optical interface and PC (hours of operation, malfunctions etc. can be viewed)

The sequence of pulses issued by the control box identifies the possible types of malfunction, which are listed in the table on page 19.

SIGNAL	FAULT	PROBABLE CAUSE	SUGGESTED REMEDY
2 x blinks ● ●	After pre-purge and safety time, the burner goes tolock-out and the flame does not appear	1 - The solenoid VR allows little gas through 2 - Solenoid valves VR or VS fail to open 3 - Gas pressure too low 4 - Ignition electrode wrongly adjusted 5 - Electrode grounded due to brocken insulation 6 - High voltage cable defective 7 - High voltage cable deformed by high temperature 8 - Ignition trasformer defective 9 - Erroneous valve or trasformer electrical connections 10 - Control box defective 11 - A cock down-line of the gas train is closed 12 - Air in pipework 13 - VS and VR gas valves unconnected or with interrupted coil	Increase Renew the coil or rectifier panel Increase pressure at governor Adjust, see fig. (C)p. 6 Replace Replace Replace and protect Replace Check Replace Open Bleed air Check connections or replace coil
3 x blinks ● ● ●	The burner does not start and lock-out warning appears	14 - Air pressure switch in operating position	Adjust or replace
	The burner starts and then locks out	Air pressure switch inoperative due to insufficient air pressure: 15 - Air pressure switch adjusted badly 16 - Pressure switch pressure point pipe blocked 17 - Head wrongly adjusted 18 - High negative draft in chamber	 Adjust or replace Clean Adjust Connect air pressure switch to fan suction inlet
	Lock-out during pre-purging	19 - Defective motor remote control switch 20 - Defective electrical motor 21 - Motor protection tripped	Replace Replace Reset thermal cut-out when third phase is re-connected
4 x blinks ● ● ● ●	The burner starts and then locks out	22 - Flame simulation	Replace control box
	Lock out when burner stops	23 - Flame remains in combustion head or flame simulation	Eliminate persistence of flame or replace control box
7 x blinks ● ● ● ● ● ● ●	The burner goes to lock-out right after flame appearance	24 - The solenoid VR allows little gas through 25 - Ionisation probe wrongly adjusted 26 - Insufficient ionisation (less than 5 μA) 27 - Probe grounded 28 - Burner poorly grounded 29 - Phase and neutral wires inverted 30 - Defective control box	Increase Adjust, see fig. (C)p. 6 Check probe position Withdraw or replace cable Check grounding Correct by interventing Replace
	Burner locks out at transition between 1st and 2nd stage or between 2nd and 1st stage	31 - Too much air or too little gas	Adjust air and gas
	During operation, the burner stops in lock out	32 - Probe or ionisation cable grounded 33 - Fault on air pressure switch	Replace worn parts Replace
10 x blinks ● ● ● ● ● ● ● ● ● ●	The burner does not start and lock-out warning appears	34 - Erroneous electrical connections	Check connections
	The burner goes to lock-out	35 - Control box defective 36 - Presence of electromagnetic disturbance	Replace Use the radio disturbance protection kit
No blink	The burner does not start	37 - No electrical power supply 38 - A limiter or safety control device is open 39 - Control box fuses blown 40 - Control box lock-out 41 - No gas supply 42 - Mains gas pressure insufficient 43 - Minimum gas pressure switch fails to close	Close all switches - Check connections Adjust or replace Replace Reset control box Open the manual valves between meter and train Contact your GAS COMPANY Adjust or replace
	The burner repeats the starting cycle without lock out	44 - Mains gas pressure is near the value to which the min. gas pressure switch gas is adjusted. The repeated drop in pressure which follows valve opening causes temporary opening of the pressure switch itself, the valve immediately closes and the burner comes to a halt. Pressure increases again, the pressure switch closes again and the firing cycle is repeated. The sequence repeats endlessly.	Reduce operating pressure of minimum gas pressure switch. Replace gas filter
	Ignition with pulsation	45 - Poorly adjusted head 46 - Ignition electrode wrongly adjusted 47 - Poorly adjusted fan air gate: too much air 48 - Output during ignition phase is too high	Adjust, see p. 7 Adjust, see fig. (C)p. 6 Adjust Reduce
	The burner does not pass to 2nd stage	49 - Remote control device TR does not close 50 - Defective control box 51 - Servomotor faulty	Adjust oe replace Replace Replace
	Burner stops with air gate valve open	52 - Sevomotor faulty	Replace

ACCESSORIES (optional):

- **RADIO DISTURBANCEPROTECTION KIT**

If the burner is installed in places particularly subject to radio disturbance (emission of signals exceeding 10 V/m) owing to the presence of an INVERTER, or in applications where the length of the thermostat connections exceeds 20 metres, a protection kit is available as an interface between the control box and the burner.

BURNER	**RS 70 - RS 100 - RS 130**
Code	3010386

- **KIT LONG HEAD**

BURNER	**RS 70**	**RS 100**	**RS 130**
Code	3010117	3010118	3010119

- **KIT FOR LPG OPERATION:** The kit allows the RS 70-100-130 burners to operate on LPG.

BURNER	**RS 70**		**RS 100**		**RS 130**	
Output kW	242 ÷ 814		349 ÷ 1163		466 ÷ 1512	
Blast tube length mm	250	385	250	385	280	415
Code	3010097	3010098	3010099	3010100	3010101	3010102

- **VIBRATION REDUCTION KIT**

BURNER	**RS 70**		**RS 100**		**RS 130**	
Output kW	192 ÷ 814		232 ÷ 1163		185 ÷ 1461	
Blast tube length mm	250	385	250	385	280	415
Code	3010201		3010202		3010373	3010374

- **GROUND FAULT INTERRUPTER:** code **3010329**
- **GAS TRAIN ACCORDING TO REGULATION EN 676 (with valves, pressure governor and filter)**: see page 8.

Important: The installer is responsible for the addition of any safety device not forseen in the present manual.

E **ÍNDICE**

CARACTERÍSTICAS TÉCNICAS . . . . página Nº **2**
Datos eléctricos 2
Versiones constructivas 2
Descripción del quemador 3
Embalaje - Peso 3
Dimensiones 3
Forma de suministro 3
Gráficos Caudal, Potencia-Sobrepresión 4
Caldera de prueba 4
Calderas comerciales 4
Presión del gas 5

INSTALACIÓN **6**
Placa de caldera 6
Longitud tubo llama 6
Fijación del quemador a la caldera 6
Regulación del cabezal de combustión 7
Línea alimentación gas 8
Instalación eléctrica 9
Regulación previa al encendido 12
Servomotor 12
Puesta en marcha del quemador 12
Encendido del quemador 12
Regulación del quemador: 13
1 - Potencia de encendido 13
2 - Potencia en 2.ª llama 13
3 - Potencia en 1.ª llama 14
4 - Potencias intermedias 14
5 - Presostato de aire 15
6 - Presostato gas de mínima 15
Control presencia llama 15
Funcionamiento del quemador 16
Control final 17
Mantenimiento 17
Diagnóstico del programa de puesta en marcha 18
Desbloqueo de la caja de control y uso de la función
de diagnóstico 18
Anomalía - Causa Probable - Solución 19
Accesorios 20

Nota

Las figuras que se mencionan en el texto se identifican del modo siguiente:

1)(A) = Detalle 1 de la figura A, en la misma página que el texto;
1)(A)p.3 = Detalle 1 de la figura A, página N° 3.

CARACTERÍSTICAS TÉCNICAS

MODELO			RS 70		RS 100		RS 130	
TIPO			821 T1		822 T1		823 T1	
POTÊNCIA (1)	2.ª llama	kW Mcal/h	465 - 814 400 - 700		698 - 1163 600 - 1000		930 - 1512 800 - 1300	
	min. 1ª llama	kW Mcal/h	192 165		232 200		372 320	
COMBUSTIBLE			GAS NATURAL: G20 - G21 - G22 - G23 - G25					
			G20	G25	G20	G25	G20	G25
- Poder Calorífico Inferiorr		kWh/Nm^3 $Mcal/Nm^3$	10 8,6	8,6 7,4	10 8,6	8,6 7,4	10 8,6	8,6 7,4
- Densidad absoluta		kg/Nm^3	0,71	0,78	0,71	0,78	0,71	0,78
- Caudal máximo		Nm^3/h	81	94	116	135	151	175
- Presión al máximo caudal (2)		mbar	10,3	15,2	9,3	13,7	8,6	12,7
FUNCIONAMIENTO			• Intermitente (mín. 1 paro en 24 horas). • 2 llamas (2.ª y 1.ª) o 1 llama (todo - nada)					
UTILIZACIÓN			Calderas: de agua, a vapor y aceite térmico					
TEMPERATURA AMBIENTE		°C	0 - 40					
TEMPERATURA AIRE COMBURENTE		°C max	60					
CONFORMIDAD DIRECTIVAS CEE			90/396 - 2004/108 - 2006/95 - 2006/42					
NIVEL SONORO (3)		dBA	75		77		78,5	
HOMOLOGACIÓN		CE	0085AP0944		0085AP0945		0085AP0946	

(1) Condiciones de referencia: Temperatura ambiente 20ºC - Presión barométrica 1000 mbar - Altitud sobre el nivel del mar 100 metros.
(2) Presión en la toma 16)(A)p.3, con presión cero en la cámara de combustión, con el disco del gas 2)(B)p.7 abierto y a la potencia máxima del quemador.
(3) Presión acústica medida en el laboratorio de combustión del constructor, con quemador funcionando en caldera de prueba a la máxima potencia.

DATOS ELÉCTRICOS

Motor IE1

MODELO		RS 70	RS 100	RS 130
ALIMENTACIÓN ELÉCTRICA	V Hz	230 - 400 com neutro ~ +/-10% 50 - trifásica		
MOTOR ELÉCTRICO	rpm W V A	2800 1100 230 / 400 4,7 - 2,7	2830 1500 230 / 400 6,4 - 3,7	2860 2200 230 / 400 8,5 - 4,9
TRANSFORMADOR DE ENCENDIDO	V1 - V2 I1 - I2	230 V - 1 x 8 kV 1 A - 20 mA		
POTENCIA ELÉCTRICA ABSORBIDA	W max	1400	1800	2600
GRADO DE PROTECCIÓN		IP 44		

Motor IE2

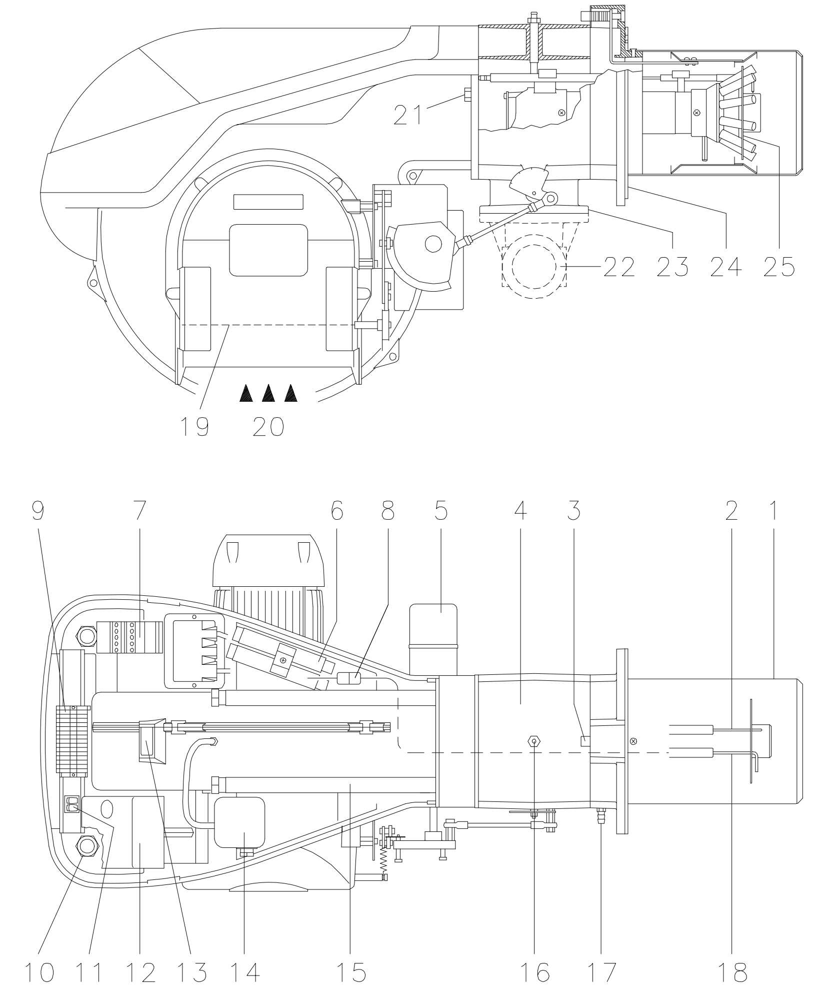
MODELO		RS 70	RS 100	RS 130
ALIMENTACIÓN ELÉCTRICA	V Hz	230 - 400 com neutro ~ +/-10% 50 - trifásica		
MOTOR ELÉCTRICO	rpm W V A	2860 1100 230 / 400 4,1 - 2,4	2860 1500 230 / 400 5,5 - 3,4	2860 2200 230 / 400 7,9 - 4,6
TRANSFORMADOR DE ENCENDIDO	V1 - V2 I1 - I2	230 V - 1 x 8 kV 1 A - 20 mA		
POTENCIA ELÉCTRICA ABSORBIDA	W max	1400	1800	2600
GRADO DE PROTECCIÓN		IP 44		

VERSIONES CONSTRUCTIVAS

Modelo	Alimentación eléctrica	Longitud tubo llama mm
RS 70	trifásico trifásico	250 385
RS 100	trifásico trifásico	250 385
RS 130	trifásico trifásico	280 415

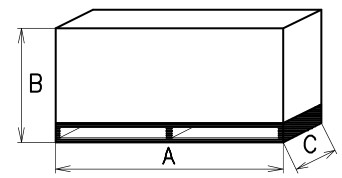
CATEGORÍA GAS

PAÍS	CATEGORÍA
IT - AT - GR - DK - FI - SE	$II_{2H3B / P}$
ES - GB - IE - PT	II_{2H3P}
NL	$II_{2L3B / P}$
FR	II_{2Er3P}
DE	$II_{2ELL3B /P}$
BE	$I_{2E(R)B}$, I_{3P}
LU - PL	$II_{2E 3B/P}$

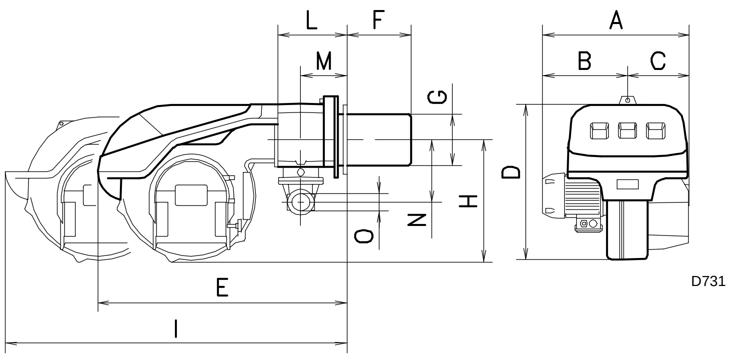


D3030 **(A)**

mm	A	B	C	kg
RS 70	1300	740	682	70
RS 100	1300	740	682	73
RS 130	1300	740	682	76



D36 **(B)**



mm	A	B	C	D	E	$F_{(1)}$	G	H	$I_{(1)}$	L	M	N	O
RS 70	511	296	215	555	840	250 - 385	179	430	1161-1296	214	134	221	2”
RS 100	527	312	215	555	840	250 - 385	179	430	1161-1296	214	134	221	2”
RS 130	553	338	215	555	840	280 - 415	189	430	1161-1296	214	134	221	2”

(1) Tubo llama: Normal - Alargado

(C)

DESCRIPCIÓN DEL QUEMADOR (A)

1 Cabezal de combustión
2 Electrodo de encendido
3 Tornillo regulación cabezal de combustión
4 Manguito unión grupo ventilador-cabezal de combustión
5 Servomotor, para el control de la válvula de mariposa del gas y, mediante una leva de perfil variable, el registro del aire.
Cuando el quemador está parado, el registro del aire está completamente cerrado para reducir al mínimo la dispersión térmica de la caldera debido al tipo del conducto de humos que toma aire de la boca de aspiración del ventilador.
6 Prolongadores guías
7 Contactor motor y relé térmico con botón de rearme
8 Conector cable sonda de ionización
9 Regleta conexiones quemador
10 Pasacables para el conexionado eléctrico, a efectuar por el instalador
11 Dos interruptores:
- uno de “marcha-paro”
- uno para “1.ª llama - 2.ª llama”
12 Caja de control con piloto luminoso de bloqueo y pulsador de desbloqueo
13 Visor llama
14 Presostato de aire (tipo diferencial)
15 Guías para abertura del quemador e inspección del cabezal de combustión
16 Toma de presión de gas y tornillo fijación cabezal
17 Toma de presión de aire
18 Sonda de ionización
19 Registro de aire
20 Entrada aire del ventilador
21 Tornillo fijación del ventilador al soporte quemador
22 Conducto entrada gas
23 Válvula mariposa gas
24 Brida para fijación a la caldera
25 Disco estabilizador de llama

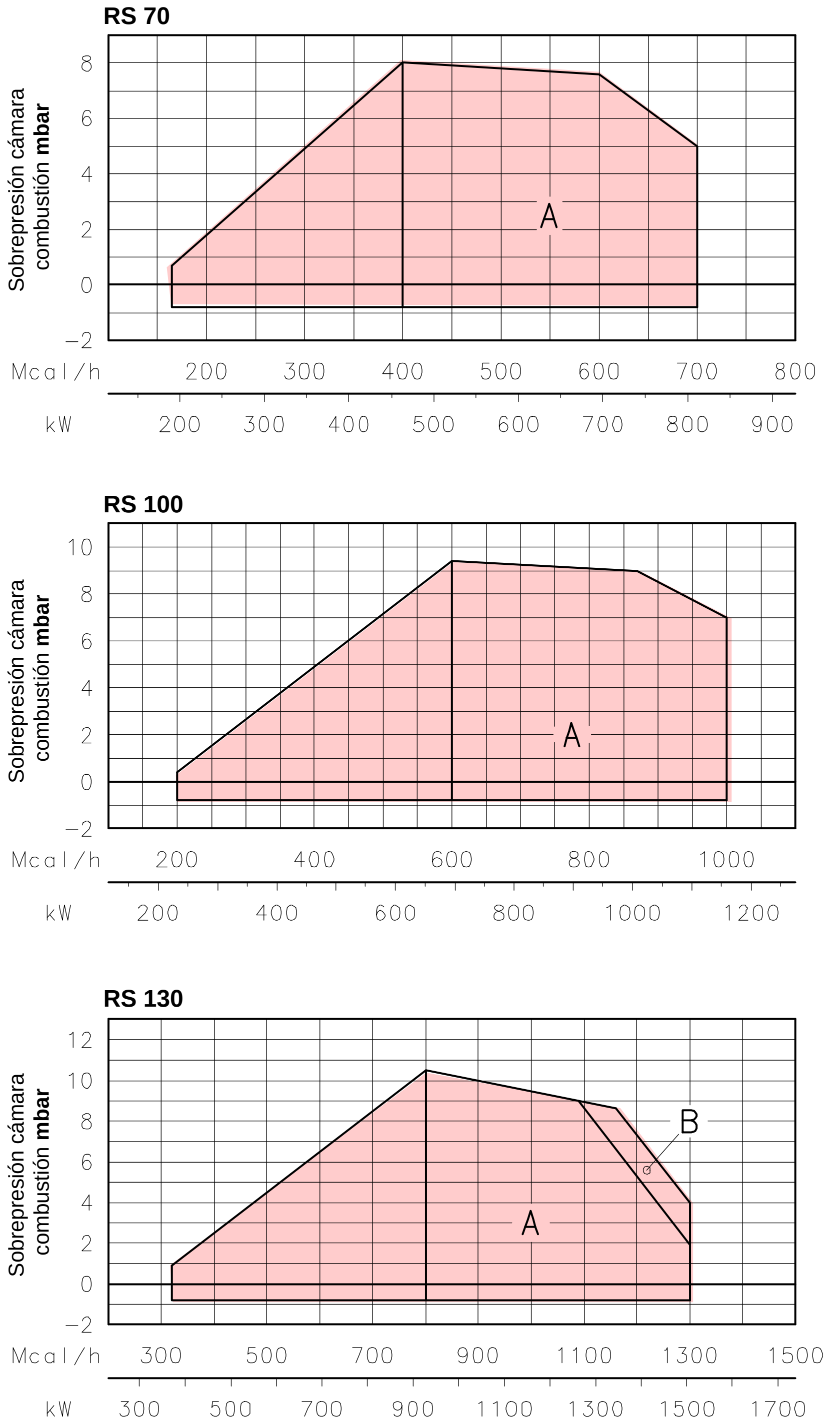
Hay dos posibilidades de bloqueo del quemador:
- **BLOQUEO CAJA DE CONTROL:**
La iluminación del pulsador (**led rojo**) de la caja 12)(A) indica que el quemador está bloqueado.
Para desbloquear, oprimir el pulsador durante un tiempo comprendido entre 1 y 3 segundos.
- **BLOQUEO MOTOR**:
Para desbloquear, oprimir el pulsador del relé térmico 7)(A).

EMBALAJE - PESO (B) - medidas aproximadas
- El embalaje del quemador se apoya en un soporte de madera adaptado para una carretilla elevadora. Las dimensiones exteriores del embalaje se indican en la tabla (B).
- El peso del quemador completo con embalaje se indica en la tabla (B).

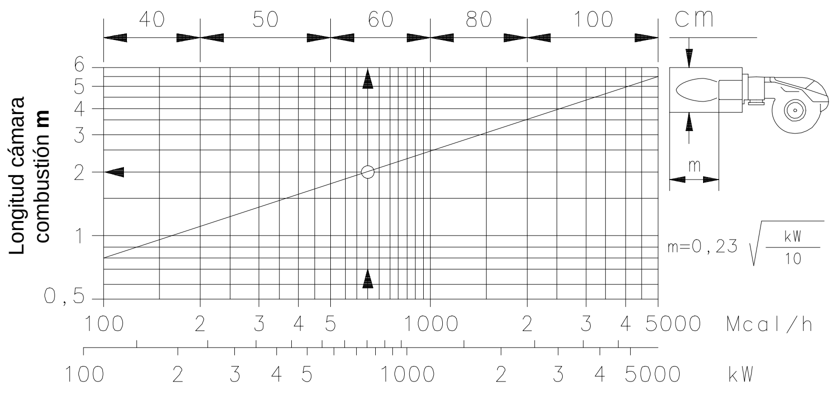
DIMENSIONES MÁXIMAS (C) - medidas aproximadas
Las dimensiones máximas del quemador se indican en (C).
Tener en cuenta que para inspeccionar el cabezal de combustión, el quemador debe abrirse desplazando la parte posterior por las guías.
La longitud máxima del quemador abierto, sin envolvente, está indicada por la cota I.

FORMA DE SUMINISTRO

1 - Brida conexión rampa de gas
1 - Junta brida
4 - Tornillos M10 x 35 fijación brida
1 - Junta aislante
2 - Prolongadores 6)(A) para guías 15)(A) (modelos con tubo llama 385 - 415 mm)
4 - Tornillos M12 x 35 para fijar la brida del quemador a la caldera
1 - Instrucciones
1 - Lista de recambios



(A) D950



(B) D715

GRÁFICOS CAUDAL, POTENCIA-SOBRE-PRESIÓN (A)

Los quemadores RS 70 - 100 - 130 pueden funcionar en dos modos: Monollama y Billama.

La **POTENCIA MÁXIMA** se sitúa en la zona A.
Para utilizar también la zona B (RS 130) hay que preajustar el cabezal de combustión explicado en la pág. 6.

La **POTENCIA MÍNIMA** no debe ser inferior al límite mínimo del gráfico:

RS 70 = 192 kW
RS 100 = 232 kW
RS 130 = 372 kW

Atención
El CAMPO DE TRABAJO se ha calculado considerando una temperatura ambiente de 20°C, una presión barométrica de 1000 mbar (aprox. 100 metros sobre el nivel del mar) y con el cabezal de combustión regulado como se indica en la página 7.

CALDERA DE PRUEBA (B)
Los gráficos se han obtenido con calderas de prueba especiales, según la norma EN 676.
En la figura (B) se indica el diámetro y longitud de la cámara de combustión de la caldera de prueba.
Ejemplo:
Potencia 756 kW:
diámetro 60 cm - longitud 2 m.

CALDERAS COMERCIALES
En el acoplamiento quemador-caldera no hay ningún problema si la caldera tiene la homologación CE y si las dimensiones de la cámara de combustión se aproximan a las indicadas en el gráfico (B).

Si por el contrario el quemador debe instalarse en una caldera comercial no homologada CE o con dimensiones de cámara de combustión mucho más pequeñas que las indicadas en el gráfico (B), se debe consultar al fabricante.

RS 70 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
465	4,2	0,2	11,6	8,5	4,8	5,2	-	-
515	4,8	0,2	13,9	10,0	5,8	6,2	-	-
565	5,6	0,3	16,3	12,0	6,8	7,2	-	-
615	6,4	0,3	18,9	13,5	8,0	8,2	-	-
665	7,3	0,3	21,7	15,0	9,2	9,5	-	-
715	8,3	0,4	24,6	17,2	10,5	10,8	-	-
765	9,3	0,4	27,7	18,5	11,3	11,5	4,4	-
814	10,3	0,4	30,9	20,0	13,2	13,0	5,0	-

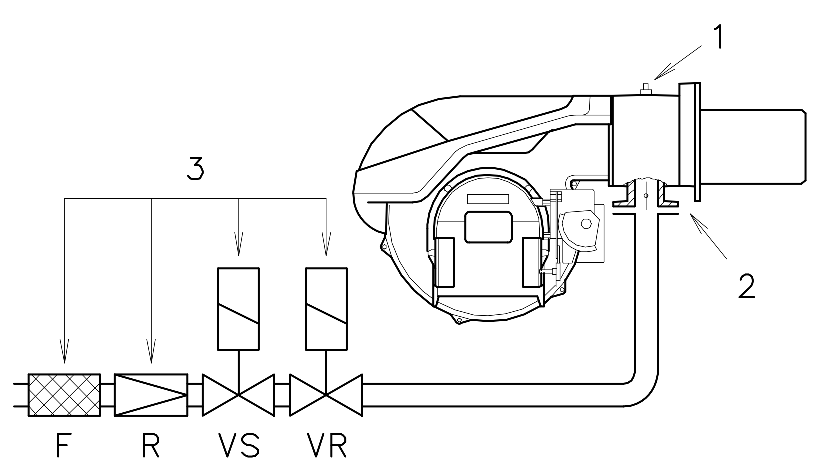
RS 100 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
695	3,7	0,4	23,5	17,0	9,9	10,1	-	-
760	4,2	0,4	27,4	18,5	11,7	11,5	4,4	-
825	5,0	0,5	31,6	20,5	13,6	13,2	5,1	-
890	5,8	0,5	36,1	23,0	15,6	14,0	5,8	-
955	6,5	0,6	40,9	26,0	17,7	16,0	6,6	-
1020	7,3	0,7	45,9	29,0	19,9	18,0	7,5	-
1085	8,3	0,8	51,1	33,0	22,3	20,0	8,4	4,5
1163	9,3	0,8	57,7	38,0	25,3	22,0	9,5	5,0

RS 130 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
930	3,8	1,0	39,0	22,0	16,9	15,0	6,3	-
1010	4,5	1,1	44,9	28,0	19,6	17,0	7,4	-
1090	5,1	1,3	51,5	33,0	22,5	20,0	8,5	4,5
1170	5,8	1,5	58,3	37,0	25,6	22,0	9,6	5,1
1250	6,5	1,7	65,4	40,0	28,8	25,0	10,8	5,7
1330	7,2	1,8	72,9	43,0	32,2	28,0	12,2	6,4
1410	7,9	1,9	80,7	48,0	35,8	31,0	13,6	7,1
1512	8,6	2,0	91,2	53,0	40,6	34,0	15,3	8,0

(A)



D963 **(B)**

PRESIÓN DEL GAS

Las tablas que hay al margen indican las pérdidas de carga mínimas de la línea de alimentación de gas en función de la potencia del quemador en 2.ª llama.

Columna 1
Pérdida de carga cabezal de combustión.
Presión de gas en la toma 1)(B), con:
- Cámara de combustión a 0 mbar
- Quemador funcionando en 2.ª llama
- Disco del gas 2)(B)p.7 regulado como se indica en el gráfico (C)p.7.

Columna 2
Pérdida de carga registro mariposa gas 2)(B) con abertura máxima: 90°.

Columna 3
Pérdida de carga rampa de gas 3)(B) comprende: válvula de regulación VR, válvula de seguridad VS (ambas con la máxima abertura), regulador de presión R, filtro F.

Los valores indicados en las tablas se refieren a:
gas natural G 20 PCI 10 kWh/Nm^3 (8,6 Mcal/Nm^3)
Con:
gas natural G 25 PCI 8,6 kWh/Nm^3 (7,4 Mcal/Nm^3)
multiplicar los valores de las tablas por 1,3.

Para conocer la potencia aproximada a la que está funcionando el quemador en 2.ª llama:
- Restar a la presión del gas en la toma 1)(B) la sobrepresión de la cámara de combustión.
- Hallar en la tabla relativa al quemador que se considere, columna 1, el valor de presión más cercano al resultado obtenido en la resta.
- Leer a la izquierda la potencia correspondiente.

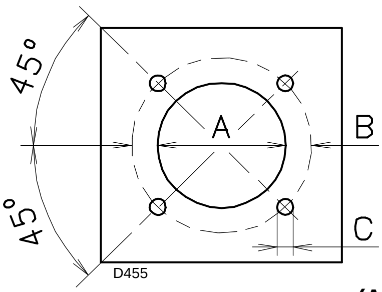
Ejemplo - RS 100:
- Funcionamiento en 2.ª llama
- Gas natural G 20 PCI 10 kWh/Nm^3
- Disco del gas 2)(B)p.7 regulado como se indica en el gráfico (C)p.7
- Presión de gas en la toma 1)(B) = 8 mbar
- Presión en la cámara de combustión = 3 mbar
  8 - 3 = 5 mbar

A la presión de 5 bar, columna 1, corresponde en la tabla del RS 100 una potencia en 2.ª llama de 825 kW.
Este valor sirve como primera aproximación; el real se determinará a través del contador.

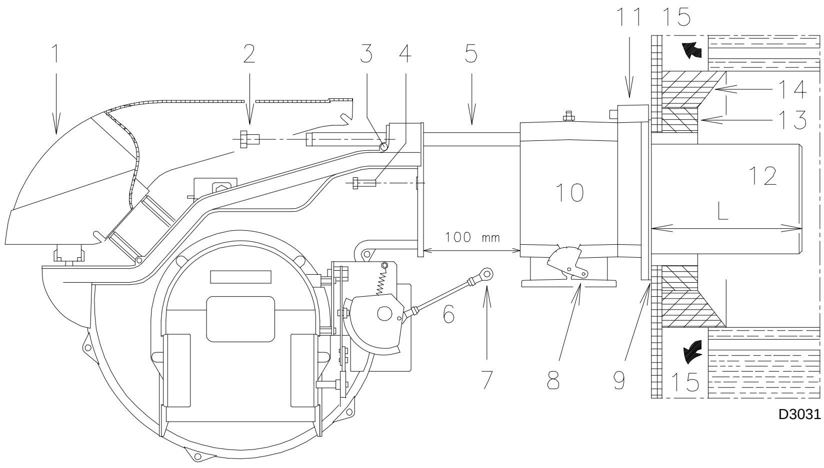
En cambio, para conocer la presión de gas necesaria en la toma 1)(B), una vez fijada la potencia en 2.ª llama a la que se desea que funcione el quemador:
- Hallar la potencia más cercana al valor deseado, en la tabla relativa al quemador que se considere.
- Leer a la derecha, columna 1, la presión en la toma 1)(B).
- Sumar a este valor la sobrepresión estimada de la cámara de combustión.

Ejemplo - RS 100:
- Potencia deseada en 2.ª llama: 825 kW
- Gas natural G 20 PCI 10 kWh/Nm^3
- Disco del gas 2)(B)p.7 regulado como se indica en el gráfico (C)p.7
- Presión del gas a la potencia de 825 kW, en la tabla del RS 100, columna 1 = 5 mbar
- Presión en la cámara de combustión= 3 mbar
  5 + 3 = 8 mbar
  presión necesaria en la toma 1)(B).

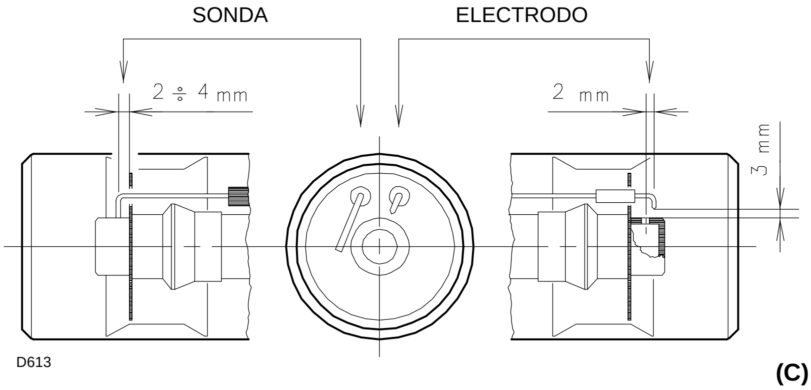
mm	A	B	C
RS 70	185	275 - 325	M 12
RS 100	185	275 - 325	M 12
RS 130	195	275 - 325	M 12



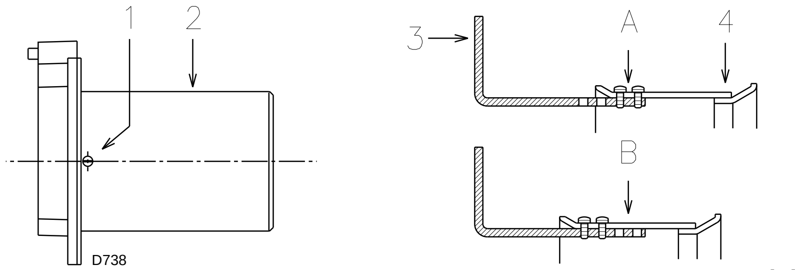
(A)



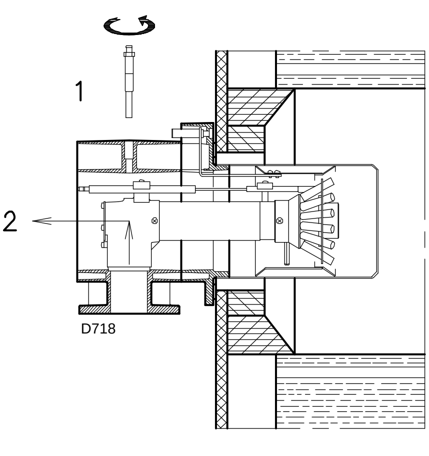
(B)



(C)



(D)



(E)

INSTALACIÓN

PLACA DE CALDERA (A)

Taladrar la placa de cierre de la cámara de combustión tal como se indica en (A). Puede marcarse la posición de los orificios roscados utilizando la junta aislante que se suministra con el quemador.

LONGITUD TUBO LLAMA (B)

La longitud del tubo de llama debe seleccionarse de acuerdo con las indicaciones del fabricante de la caldera y, en cualquier caso, debe ser mayor que el espesor de la puerta de la caldera completa, con el material refractario incluido. Las longitudes, L (mm), disponibles son:

Tubo llama 12):	RS 70	RS 100	RS 130
• corto	250	250	280
• largo	385	385	415

Para calderas con pasos de humos delanteros 15) o con cámara de inversión de llama, colocar una protección de material refractario 13) entre el refractario de la caldera 14) y el tubo de llama 12). Esta protección debe permitir el desplazamiento del tubo de llama.
En calderas con frontal refrigerado por agua, no es necesario el revestimiento refractario 13)-14)(B), salvo que lo indique el fabricante de la caldera.

FIJACIÓN DEL QUEMADOR A LA CALDERA (B)

Antes de fijar el quemador a la caldera, verificar (a través de la abertura del tubo de llama) si la sonda y el electrodo de encendido están correctamente posicionados como se muestra en la figura (C).

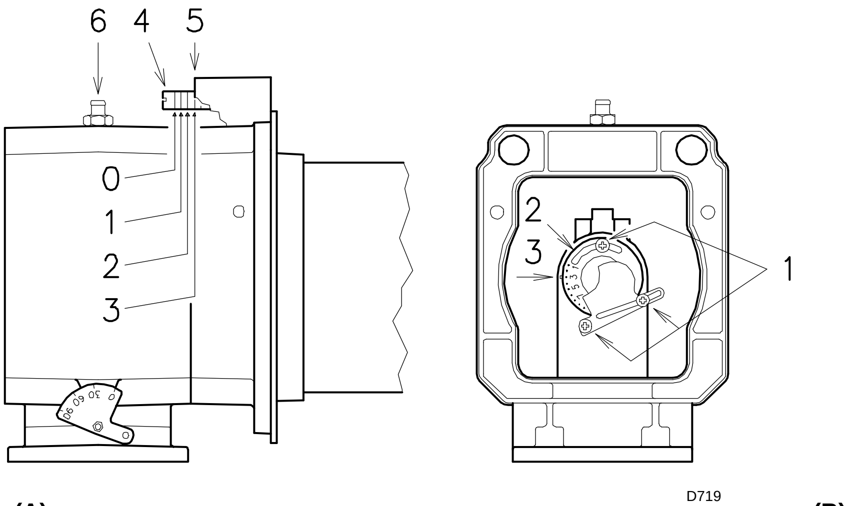
Luego separar el cabezal de combustión del resto del quemador, fig. (B):
- Desenroscar los 4 tornillos 3) y extraer la envolvente 1);
- Desenganchar la articulación 7) del sector graduado 8);
- Desenroscar los tornillos 2) de las dos guías 5);
- Desenroscar los 2 tornillos 4) y desplazar el quemador por las guías 5) unos 100 mm;
- Desconectar los cables de la sonda y del electrodo y a continuación extraer por completo el quemador de las guías.

PREAJUSTE DEL CABEZAL DE COMBUSTIÓN

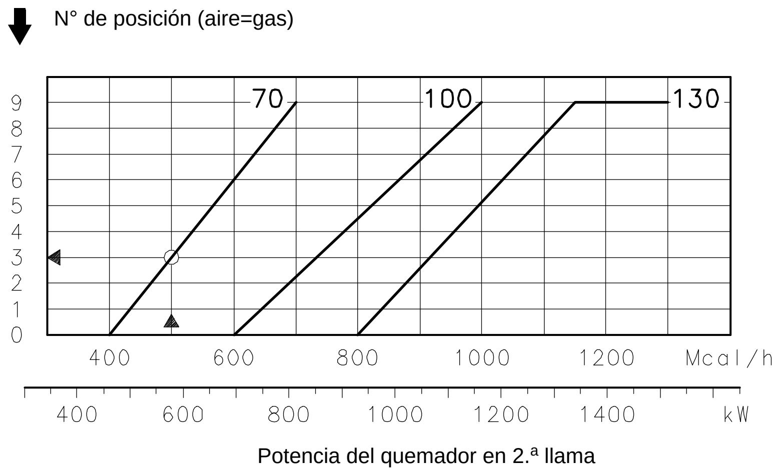
Ahora, para el modelo RS 130 controlar que el caudal máximo del quemador en 2° llama esté comprendido dentro de la zona A o dentro de la B del campo de trabajo. Véase pág. 4.
Si está en la zona A, no hay que hacer ningún ajuste.
Por el contrario, en la zona B:
- Desenroscar los tornillos 1)(D) y desmontar el tubo llama 2).
- Desplazar la fijación de la varilla 3)(D) desde la posición A a la B, así retrocediendo el obturador 4).
- Volver a montar el tubo llama 2)(D) y los tornillos 1).

Una vez concluida la operación, fijar la brida 11)(B) a la placa de la caldera, intercalando la junta 9)(B) que se suministra. Utilizar los 4 tornillos que se suministran, después de haber protegido la rosca con algún producto antibloqueo.
El acoplamiento del quemador con la caldera debe ser hermético.

Si en la verificación anterior, la posición de la sonda o del electrodo no era correcta, desenroscar el tornillo 1)(E), extraer la parte interior 2)(E) del cabezal y proceder a su calibración.
No hacer girar la sonda, sino dejarla como se indica en (C), ya que si se sitúa demasiado cerca del electrodo de encendido podría dañar el amplificador de la caja de control.

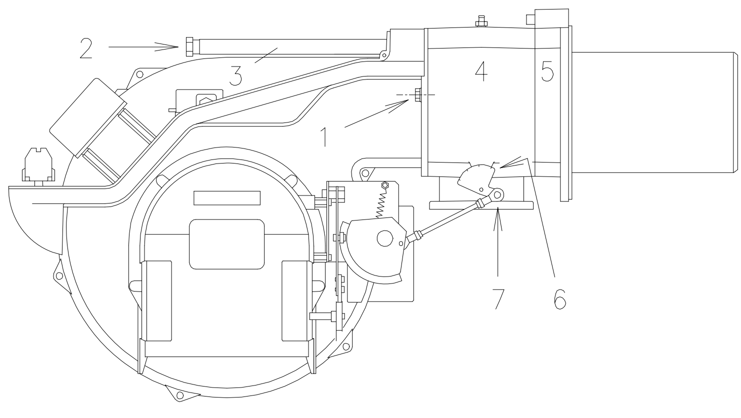


(A) (B)



(C)

D720



(D)

D3032

REGULACIÓN DEL CABEZAL DE COMBUSTIÓN

En este punto de la instalación, el tubo de llama y el soporte quemador se fijan a la caldera como se indica en la Fig. (A). Así pues, resulta particularmente fácil efectuar el reglaje del cabezal de combustión; esta regulación depende unicamente de la potencia que desarollará el quemador en 2.ª llama.
Por tanto, antes de efectuar esta regulación se debe conocer este valor.
En el cabezal se deben efectuar dos regulaciones, la del aire y la del gas.

Hallar en el gráfico (C) la posición a la cual regular el aire y el gas, del modo siguiente:

Regulación aire (A)
Girar el tornillo 4)(A) hasta que coincida el número de posición hallada con el plano anterior 5)(A) de la brida.

Regulación gas (B)
Aflojar los tres tornillos 1)(B) y girar el disco 2) hasta que coincida el número de posición hallada con el índice 3). Apretar bien los tres tornillos 1).

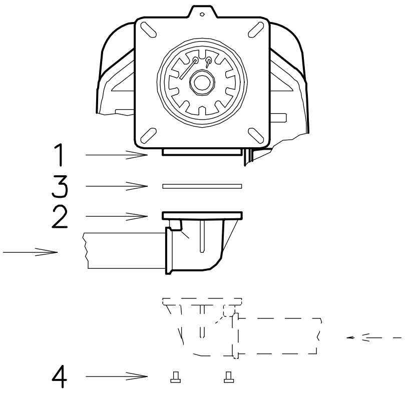
Ejemplo:
Quemador RS 70,
potencia quemador = 581 kW (500 Mcal/h)
En el grafico (C), para esta potencia el número de posición de regulación del aire y del gas es la 3, tal como está en los dibujos Fig.(A) y Fig. (B).

NOTA
El gráfico (C) indica la regulación óptima del cabezal. Si la presión de la red de alimentación de gas es muy baja y no permite que se alcance la presión que se indica en la pág. 5 en 2.ª llama, y si el disco 2)(B) está sólo parcialmente abierto, aún es posible abrir el disco 1 ó 2 posiciones.

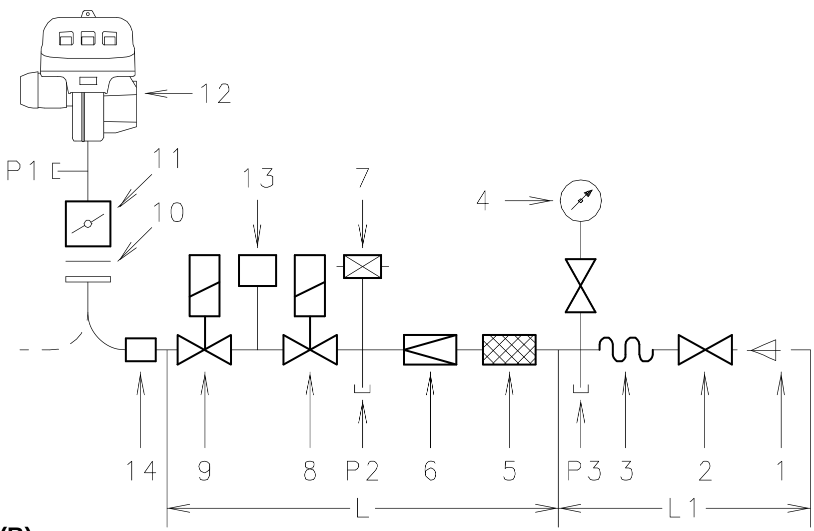
Siguiendo el ejemplo anterior, en la pág. 5 se ve que para un quemador RS 70 con una potencia de 581 kW (500 Mcal/h), se necesita una presión aproximada de 6 mbar en la toma 6)(A). Si no se dispone de dicha presión, abrir el disco 2)(B) hasta la posición 4-5.
Verificar que la combustión sea satisfactoria y sin pulsaciones.

Finalizada la regulación del cabezal, volver a montar el quemador en las guías 3)(D) a unos 100 mm del soporte quemador 4)(D) (quemador en la posición que muestra la Fig. (B) p.6); conectar los cables de la sonda y del electrodo y a continuación desplazar el quemador hasta el soporte (quemador en la posición que muestra la Fig. (D).
Volver a colocar los tornillos 2) en las guías 3).
Fijar el quemador al soporte mediante los tornillos 1).
Montar la articulación 7) en el sector graduado 6).

Atención
En el momento de cerrar el quemador en las guías, es conveniente tirar suavemente hacia afuera del cable de alta tensión y del de la sonda de ionización hasta que estén ligeramente tensados.



(A)



(B)

QUEMADORES Y RAMPAS DE GAS HOMOLOGADAS SEGÚN NORMA EN 676

Rampa de gas L			Quemador			13	14
Ø	C.T.	Nº de Ref	RS 70	RS 100	RS 130	Nº de Ref	Nº de Ref
1"1/2	-	3970145	•	•	•	3010123	3000843
1"1/2	-	3970180	•	•	•	3010123	3000843
2"	-	3970146	•	•	•	3010123	-
2"	♦	3970160	•	•	•	-	-
2"	-	3970181	•	•	•	3010123	-
2"	♦	3970182	•	•	•	-	-
DN 65	-	3970147	•	•	•	3010123	3000825
DN 65	♦	3970161	•	•	•	-	3000825
DN 80	–	3970148	-	-	•	3010123	3000826
DN 80	♦	3970162	-	-	•	-	3000826

(C)

COMPONENTES RAMPA DE GAS L

Nº de Ref	Componentes		
	Filtro 5	Regulador de presión 6	Válvulas 8 - 9
3970145	GF 515/1	FRS 515	DMV-DLE 512/11
3970180	Multiblock MB DLE 415		
3970146 3970160	GF 520/1	FRS 520	DMV-DLE 520/11
3970181 3970182	Multiblock MB DLE 420		
3970147 3970161	GF 40065/3	FRS 5065	DMV-DLE 5065/11
3970148 3970162	GF 40080/3	FRS 5080	DMV-DLE 5080/11

LÍNEA ALIMENTACIÓN DE GAS

- La rampa de gas va acoplada a la conexión de gas 1)(A), mediante la brida 2), la junta 3) y los tornillos 4, que se suministran con el quemador.
- La rampa puede llegar por la derecha o por la izquierda, según convenga. Ver Fig. (A).
- Las electroválvulas 8)-9)(B) del gas deben estar lo más cerca posible del quemador, para asegurar la llegada del gas al cabezal de combustión en el tiempo de seguridad de 3 segundos.
- Asegurarse de que el campo de tarado del regulador de presión (color del muelle) abarque la presión de gas que necesita el quemador.

RAMPA DE GAS (B)

Está homologada según la norma EN 676 y se suministra por separado, con el número de referencia que se indica en la tabla (C).

LEYENDA (B)

1 - Conducto llegada gas
2 - Válvula manual
3 - Junta antivibratoria
4 - Manómetro con válvula de pulsador
5 - Filtro
6 - Regulador de presión (vertical)
7 - Presostato gas de mínima
8 - Electroválvula seguridad VS (vertical)
9 - Electroválvula regulación VR (vertical)
Tiene dos regulaciones:
• caudal de encendido (abertura rápida)
• caudal máximo (abertura lenta)
10 - Junta y brida, suministradas con el quemador
11 - Registro mariposa de gas
12 - Quemador
13 - Dispositivo para el control de estanqueidad de las electroválvulas 8)-9). Según la norma EN 676, el control de estanqueidad es obligatorio para quemadores con potencia máxima superior a 1200 kW.
14 - Adaptador rampa de gas-quemador

P1 - Presión en el cabezal de combustión
P2 - Presión a la salida del regulador
P3 - Presión antes del filtro

L - Rampa de gas suministrada por separado, con el Nº de Ref. que se indica en la tabla (C).
L1 - A cargo del instalador

LEYENDA TABLA (C)

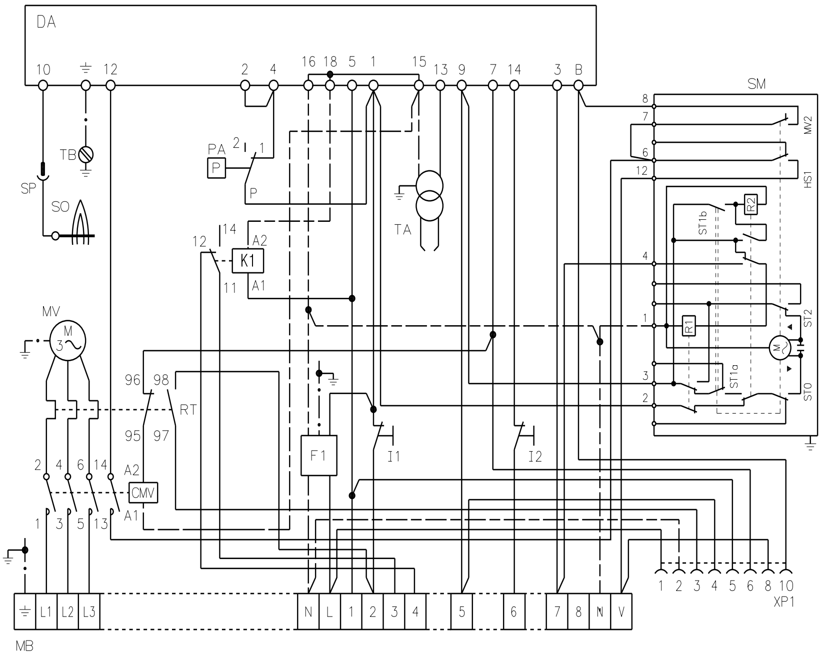
C.T.= Dispositivo de control de estanqueidad válvulas gas 8) - 9):
- = Rampa sin dispositivo de control de estanqueidad; dispositivo que se puede pedir por separado, véase columna 13, y ser montado sucesivamente.
♦= Rampa con dispositivo de control de estanqueidad VPS montado.

13 = Dispositivo de control de estanqueidad válvula VPS.
Se suministra aparte de la rampa de gas, sobre demanda.
14 = Adaptador rampa-quemador.
Se suministra aparte de la rampa de gas, sobre demanda.

Nota

Para la regulación de la rampa de gas, ver las instrucciones que acompañan a la misma.

CONEXIONADO ELÉCTRICO DE FÁBRICA
RS 70 - RS 100 - RS 130



(A) D3055

INSTALACIÓN ELÉCTRICA

INSTALACIÓN ELÉCTRICA de fábrica

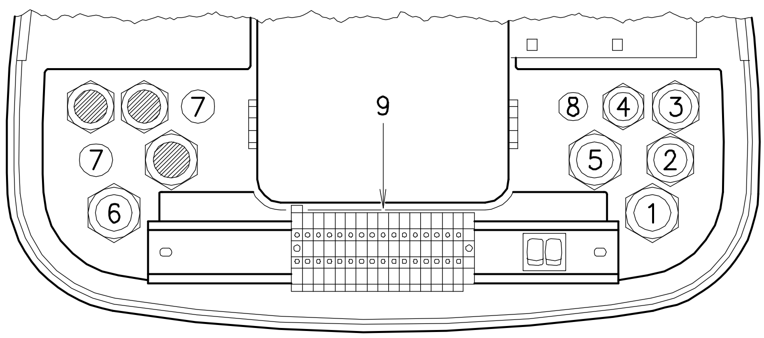
ESQUEMA (C)
Quemador RS 70 - RS 100 - RS 130
- Los modelos RS 70 - RS 100 - RS 130, salen de fábrica previstos para una alimentación eléctrica a **400 V**.
- Si la alimentación es a **230 V**, cambiar el conexionado del motor (de estrella a triángulo) y la regulación del relé térmico.

Legenda schema (A)

LEYENDA ESQUEMAS (A)

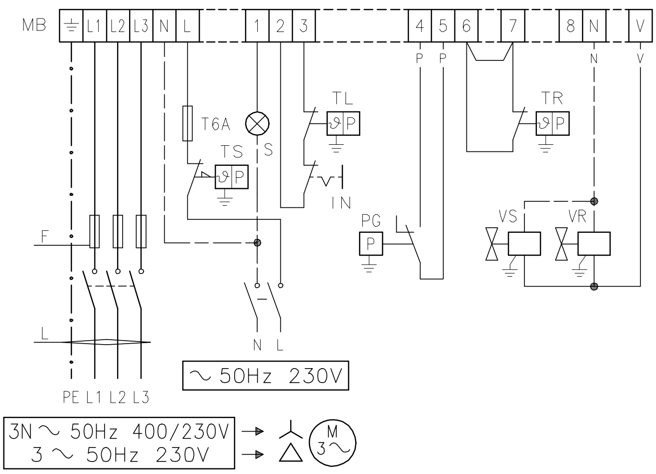
CMV	- Contactor motor
DA	- Caja de control (Landis RMG)
F1	- Filtro contra radiointerferencias
K1	- Relé
I1	- Interruptor: marcha - paro
I2	- Interruptor: 1.ª - 2.ª llama
MB	- Regleta quemador
MV	- Motor ventilador
PA	- Presostato aire
RT	- Relé térmico
SM	- Servomotor
SO	- Sonda de ionización
SP	- Conector
TA	- Transformador de encendido
TB	- Conexión a tierra quemador
XP1	- Connettore

ATENCIÓN
En caso de alimentación fase-fase es necesario efectuar un puente en la regleta de conexiones de la caja de control entre el borne 6 y el borne de tierra.



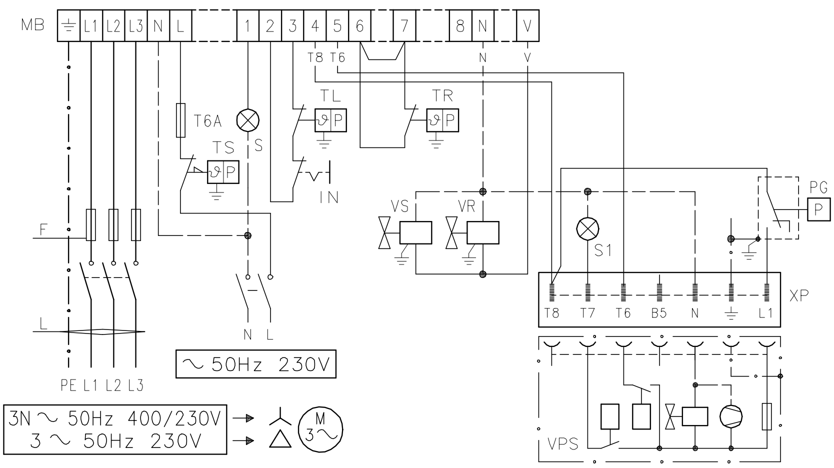
(A) D955

RS 70 - RS 100 - RS 130 sin control de estanqueidad en las válvulas de gas



(B) D956

RS 70 - RS 100 - RS 130 con control de estanqueidad en válvulas de gas VPS



(C) D957

		RS 70		RS 100		RS 130	
		230 V	400 V	230 V	400 V	230 V	400 V
F	A	T10	T6	T16	T10	T16	T10
L	mm^2	1,5	1,5	1,5	1,5	1,5	1,5

(D)

CONEXIONADO ELÉCTRICO

Utilizar cables flexibles según norma EN 60 335-1:

- si revestidos de PVC, usar al menos H05 VV-F
- si revestidos de goma, usar al menos H05 RR-F.

Todos los cables que vayan conectados a la regleta 9)(A) del quemador deben canalizarse a través de los pasacables.

Los pasacables y los orificios insinuados pueden utilizarse de varias formas; a modo de ejemplo, indicamos la forma siguiente:

1- Pg 13,5 Alimentación trifásica
2- Pg 11 Alimentación monofásica
3- Pg 11 Termostato TL
4- Pg 9 Termostato TR
5- Pg 13,5 Válvulas de gas
6- Pg 13,5 Presostato gas o dispositivo control de estanqueidad válvulas de gas
7- Pg 11 Agujerear, si se desea utilizar
8- Pg 9 Agujerear, si se desea utilizar

SCHEMA (B)

Conexionado eléctrico quemadores RS 70 - RS 100 - RS 130 sin control de estanqueidad en las válvulas de gas

SCHEMA (C)

Conexionado eléctrico quemadores RS 70 - RS 100 - RS 130 con control de estanqueidad en válvulas de gas VPS

El control de estanqueidad de las válvulas de gas se efectúa justo antes de cada arranque del quemador.

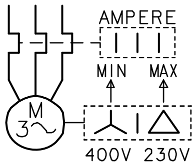
Fusibles y sección cables esquemas (B - C), ver tabla (D).

Sección de bable no indicada: 1,5 mm^2

LEYENDA ESQUEMAS (B) - (C)

IN - Interruptor paro manual quemador
XP - Conector de control de estanqueidad
MB - Regleta quemador
PG - Presostato gas de mínima
S - Señalización de bloqueo a distancia
S1 - Señaliz. bloqueo control estanqueidad a distancia
TR - Termostato de regulación: manda la 1ª y 2ª llama de funcionamiento. Si se desea que el quemador tenga un funcionamiento de una sola llama, sustituir TR con un puente.
TL - Termostato de regulación máxima: provoca el paro del quemador cuando la temperatura o la presión en caldera alcanza el valor preestablecido.
TS - Termostato de seguridad: actúa en caso de avería del termostato TL.
VR - Electroválvula de regulación
VS - Electroválvula de seguridad

REGULACIÓN DEL RELÉ TÉRMICO



(A) D867

ESQUEMA (A)
Regulación del relé térmico 7)(A)p. 3
Sirve para evitar que se queme el motor por un fuerte aumento del consumo debido a la ausencia de una fase.
- Si el motor es alimentado en estrella, **400 V**, el cursor debe situarse en "MIN".
- Si el motor es alimentado a triángulo, **230 V**, el cursor debe situarse en "MAX".

Si la escala del relé térmico no comprende el consumo nominal del motor a 400 V, la protección está igualmente asegurada.

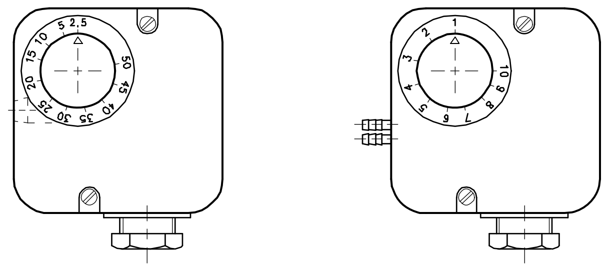
NOTE
• Los quemadores RS 70 - RS 100 - RS 130 salen de fábrica preparados para una alimentación eléctrica a **400 V**. Si la alimentación es a **230 V**, cambiar el conexionado del motor (de estrella a triángulo) y la regulación del relé térmico.

• Los quemadores RS 70 - RS 100 - RS 130 han sido homologados para funcionar de modo intermitente. Ello significa que deben pararse "por Norma" al menos una vez cada 24 horas para permitir que la caja de control efectúe una verificación de la eficacia al arranque. Normalmente, el paro del quemador está asegurado por el termostato de la caldera.
Si no fuese así, debería colocarse en serie con el interruptor IN, un interruptor horario que parase el quemador al menos una vez cada 24 horas.

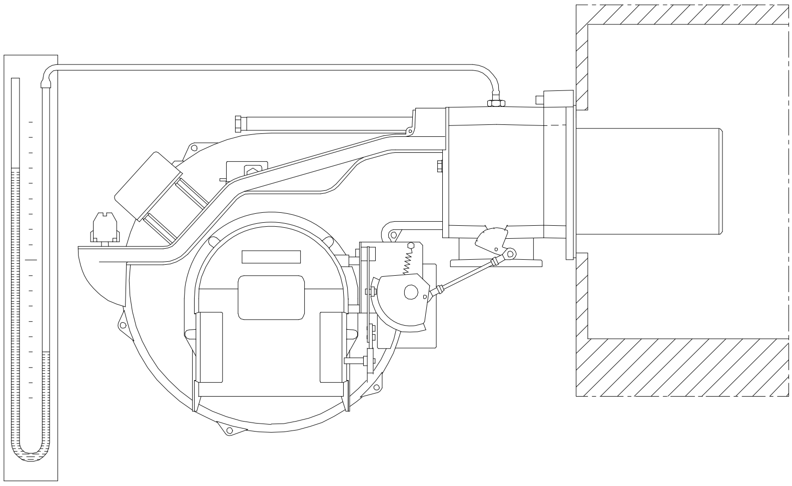
• Los quemadores RS 70 - RS 100 - RS 130 salen de fábrica ajustados para el funcionamiento de dos llamas y, por consiguiente, se debe conectar el termostato TR.
Se si desea que estos quemadores tengan un funcionamiento monostadio (todo-nada), colocar un puente entre los bornes 6 y 7, en sustitución del termostato TR.

ATENCIÓN:
No invertir Neutro con Fase en la línea de alimentación eléctrica.
La inversión provocaría una parada en bloqueo por falta de encendido.

PRESOSTATO GAS DE MÍN. PRESOSTATO AIRE

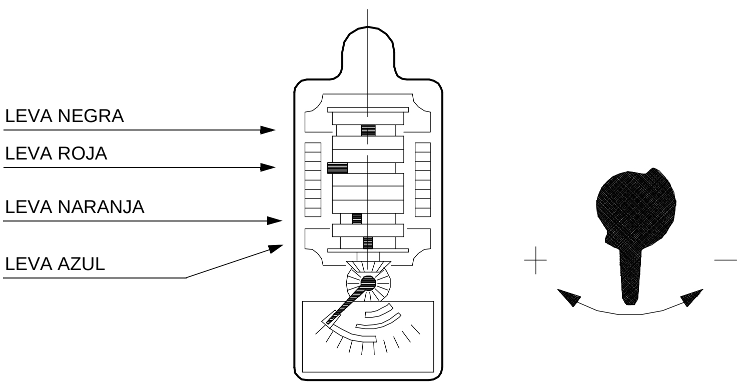


(A) (B) D897

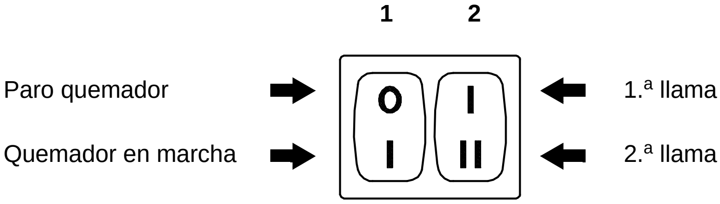


(C) D3033

SERVOMOTOR



(D) D728



(E) D469

REGULACIÓN ANTES DEL PRIMER ENCENDIDO

La regulación del cabezal de combustión, aire y gas, ya se ha descrito en la pág. 7.
Efectuar, además, las siguientes regulaciones:

- Abrir las válvulas manuales situadas antes de la rampa de gas.
- Regular el presostato gas de mínima al inicio de la escala (A).
- Regular el presostato aire al inicio de la escala (B).
- Purgar el aire de la línea de gas.
  Es aconsejable evacuar el aire purgado al exterior del edificio (mediante un tubo de plástico) hasta notar el olor característico del gas.
- Instalar un manómetro de tubo en “U” (C) en la toma de presión del soporte quemador.
  Sirve para calcular, aproximadamente, la potencia del quemador en 2.ª llama mediante las tablas de la pág. 5.
- Conectar en paralelo a las dos electroválvulas de gas VR y VS, dos lámparas o un tester para controlar el momento de la llegada de tensión.
  Esta operación no es necesaria si cada una de las electroválvulas va equipada de una luz piloto que señale la presencia de tensión eléctrica.

Antes de poner en marcha el quemador, es conveniente regular la rampa de gas de forma que el encendido se produzca en condiciones de máxima seguridad, es decir, con un pequeño caudal de gas.

SERVOMOTOR (D)

El servomotor regula simultáneamente el registro del aire por la leva de perfil variable y la válvula de mariposa del gas.
El ángulo de rotación del servomotor es igual al ángulo del sector graduado de la válvula de mariposa del gas. El servomotor gira 90° en 15 segundos.
No modificar la regulación efectuada en fábrica de las 4 levas con que va dotado; verificar simplemente que las levas estén reguladas del siguiente modo:

Leva roja : 90°
Limita la rotación máxima. Con el quemador funcionando en 2.ª llama, la válvula de mariposa del gas debe estar completamente abierta: 90°.

Leva azul : 0°
Limita la rotación mínima.
Con el quemador parado, el registro de aire y la válvula de mariposa del gas deben estar cerrados: 0°.

Leva naranja : 15°
Regula la posición de encendido y potencia en 1.ª llama.

Leva negra : 85°
Enciende el Led de 2.ª llama.

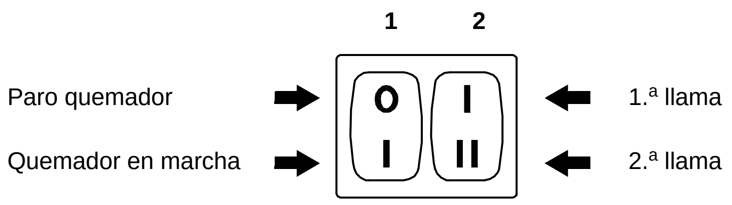
Una tarjeta graduada con 4 sectores coloreados indica la leva que interviene.

PUESTA EN MARCHA DEL QUEMADOR

Cerrar los termostatos y poner:
• el interruptor 1)(E) en la posición “Quemador en marcha”;
• el interruptor 2)(E) en la posición “1ª llama”.
Tan pronto se pone en marcha el quemador, controlar el sentido de giro de la turbina del ventilador a través del visor de llama 13)(A)p.3.
Verificar que las lámparas o el tester conectados a las electroválvulas, o las luces piloto de las propias electroválvulas, indiquen ausencia de tensión. Si señalan que hay tensión, parar **inmediatamente** el quemador y comprobar el conexionado eléctrico.

ENCENDIDO DEL QUEMADOR

Después de haber efectuado las operaciones descritas en el apartado anterior, el quemador debe de encenderse. Si el motor arranca pero no aparece llama y la caja de control se bloquea, rearmarla y efectuar un nuevo intento de puesta en marcha. Si el encendido sigue sin producirse, puede ser debido a que el gas no llega al cabezal de combustión en el tiempo de seguridad de 3 segundos. En tal caso, aumentar el caudal de gas en el encendido.
La llegada de gas al quemador puede observarse en el manómetro de tubo en “U” (C).
Una vez efectuado el encendido, se procederá a la regulación completa del quemador.



(A)

D469

REGULACIÓN DEL QUEMADOR
Para lograr una regulación óptima del quemador, es necesario efectuar un análisis de los gases de combustión en la base de la chimenea.

Hay que regular en secuencia:
1 - Potencia de encendido
2 - Potencia del quemador en 2.ª llama
3 - Potencia del quemador en 1.ª llama
4 - Potencia intermedia
5 - Presostato aire
6 - Presostato gas de mínima

1 - POTENCIA DE ENCENDIDO
Según norma EN 676.

Quemadores con potencia MÁX hasta 120 kW
El encendido puede efectuarse a la potencia máxima de funcionamiento. Ejemplo:
- potencia máxima de funcionamiento : 120 kw
- potencia máxima de encendido : 120 kW

Quemadores con potencia MÁX superior a 120 kW
El encendido debe efectuarse a una potencia reducida respecto a la potencia máxima de funcionamiento.
Si la potencia de encendido no supera los 120 kW, no es necesario hacer ningún cálculo. En cambio, si la potencia supera los 120 kW, la norma establece que su valor sea definido en función del tiempo de seguridad “ts” de la caja de control:
- para “ts” = 2s. La potencia de encendido debe ser igual o inferior a 1/2 de la potencia máxima de funcionamiento;
- para “ts” = 3s. La potencia de encendido debe ser igual o inferior a 1/3 de la potencia máxima de funcionamiento.

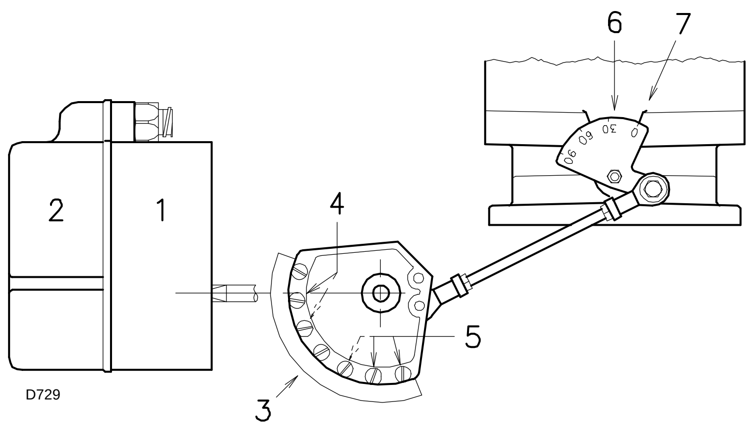
Ejemplo
Potencia MÁX de funcionamiento 600 kW.
La potencia de encendido debe ser igual o inferior a:
- 300 kW con ts = 2 s
- 200 kW con ts = 3 s

Para medir la potencia de encendido:
- Desconectar la conector 8)(A)p.3 del cable de la sonda de ionización (el quemador se enciende y se bloquea pasado el tiempo de seguridad).
- Efectuar 10 encendidos con bloqueos consecutivos.
- Leer en el contador la cantidad de gas consumido.
  Esta cantidad debe ser igual o inferior a la que nos da la fórmula, para ts = 3 s:

$$\frac{\mathbf{Nm^3/h}\ \text{(caudal máx. quemador)}}{\mathbf{360}}$$

Ejemplo con gas natural G 20 (10 kWh/Nm^3):
Potencia máxima de funcionamiento: 600 kW
corresponde un consumo de 60 Nm^3/h.
Después de 10 encendidos con bloqueo, el caudal de gas medido en el contador debe ser igual o inferior a:
60 : 360 = 0,166 Nm^3.

2 - POTENCIA EN 2.ª LLAMA
La potencia en 2.ª llama se elige dentro del campo de trabajo que se indica en la pág. 4.
En la descripción anterior, el quemador estaba encendido en 1ª llama. Situar ahora el interruptor 2)(A) en posición “2.ª llama” y: el servomotor abrirá el registro del aire y, al mismo tiempo, la válvula de mariposa del gas a 90°.
Regulación del gas
Medir el caudal de gas en el contador.
A título orientativo, puede determinarse mediante las tablas de la pág.5, mirando la presión del gas en el manómetro de tubo en “U” (ver Fig. (C)p.12, y siguiendo las indicaciones de la pág.5.
- Si es necesario reducirlo, disminuir la presión del gas a la salida y, si ya está al mínimo, cerrar un poco la electroválvula de regulación VR.
- Si es necesario aumentarla, incrementar la presión de gas a la salida del regulador.



1 Servomotor

2 Tapa levas

3 Leva de perfil variable

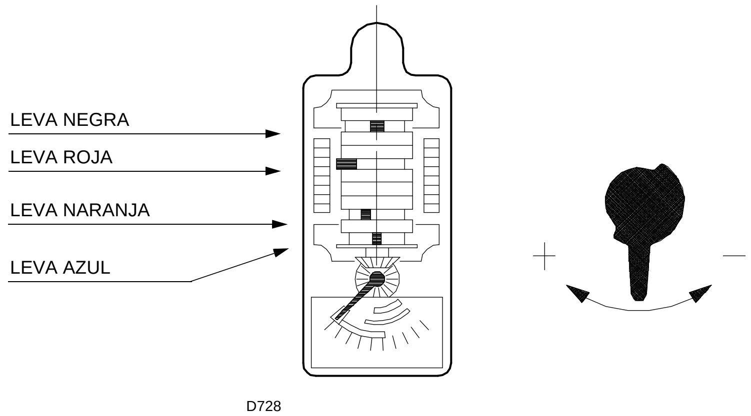
4 Tornillos regulación perfil inicial

5 Tornillos regulación perfil final

6 Sector graduado válvula de mariposa gas

7 Índice del sector graduado 6

(A)



(B)

Regulación del aire

Variar progresivamente el perfil final de la leva 3)(A), actuando sobre los tornillos 5).

- Para aumentar el caudal de aire, enroscar los tornillos.
- Para disminuir el caudal de aire, desenroscar los tornillos.

3 - POTENCIA EN 1.ª LLAMA

La potencia en 1.ª llama se elige dentro del campo de trabajo que se indica en la pág. 4.

Pulsar el interruptor 2)(A)p.13 en posición "1.ª llama": el servomotor cerrará el registro del aire, y al mismo tiempo, el de mariposa situándolo a 15º, que es la regulación efectuada en fábrica.

Regulación del gas

Medir el caudal de gas en el contador.

- Si se desea disminuirlo, reducir un poco el ángulo de la leva naranja (B) mediante cortos desplazamientos sucesivos, es decir, pasando del ángulo de 15° a 13° - 11°....
- Si se desea aumentarlo, pasar a 2.ª llama pulsando el interruptor 2)(A)p. 13 en posición "2.ª llama" y aumentar un poco el ángulo de la leva naranja (B) mediante cortos desplazamientos sucesivos, es decir, pasando del ángulo de 15° a 17° - 19°....
  Seguidamente retornar a 1.ª llama y medir el caudal de gas.

NOTA

El servomotor sigue la regulación de la leva naranja sólo cuando se reduce el ángulo de la misma. Si se tiene que aumentar el ángulo de la leva, es necesario pasar a 2.ª llama, aumentar el ángulo y retornar a 1.ª llama para verificar el efecto de la regulación.

Regulación del aire

Variar progresivamente el perfil inicial de la leva 3)(A), actuando sobre los tornillos 4). Si es posible, no girar el primer tornillo, dado que es el que se utiliza para cerrar el registro del aire completamente.

4 - POTENCIAS INTERMEDIAS

Regulación del gas

No es necesaria ninguna regulación.

Regulación del aire

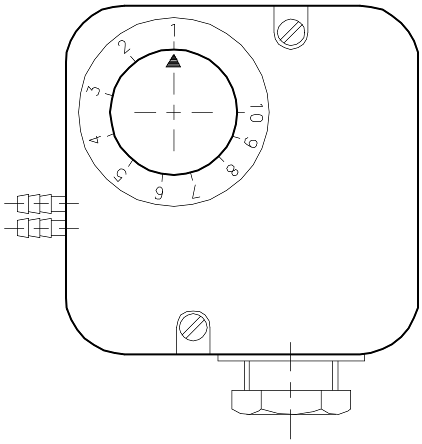
Parar el quemador actuando sobre el interruptor 1)(A)p. 13 y actuar sobre los tornillos intermedios de la guia de manera que la pendiente sea progresiva.

No tocar los tornillos extremos que ya se han utilizado para regular el registro del aire en 1.ª y 2.ª llama.

NOTA

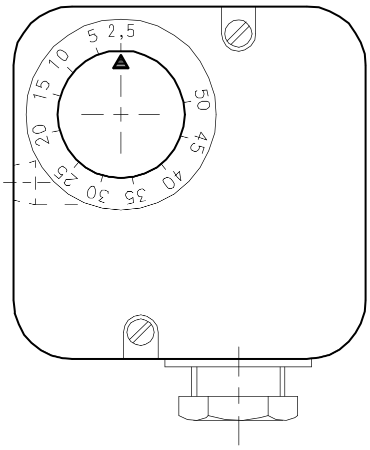
Una vez terminada la regulación de las potencias 2.ª llama - 1.ª llama - intermedias, volver a verificar el encendido: debe producirse un ruido parecido al de funcionamiento sucesivo. Si se observan pulsaciones, reducir el caudal de encendido.

PRESOSTATO DE AIRE 14)(A)p. 3

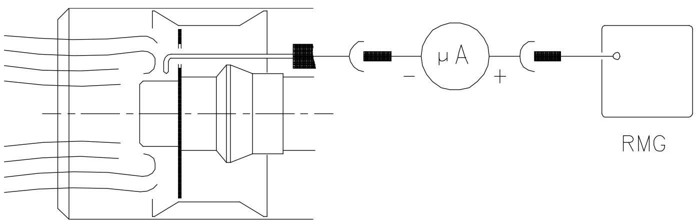


(A) D521

PRESOSTATO GAS DE MÍNIMA 7)(B)p. 8



(B) D896



(C) D3023

5 - PRESOSTATO DE AIRE (A)

Efectuar la regulación del presostato de aire, después de haber efectuado todas las demás regulaciones del quemador, con el presostato de aire ajustado al inicio de la escala (A).

Con el quemador funcionando en 1.ª llama, aumentar la presión de regulación girando lentamente (en sentido horario) el botón que se facilita a tal efecto, hasta que se bloquee el quemador.
A continuación girar dicho botón en sentido contrario a las agujas del reloj, alrededor de un 20% del valor regulado y verificar seguidamente el correcto funcionamiento del quemador.
Si el quemador se bloquea de nuevo, girar el botón un poco más, en sentido contrario a las agujas del reloj.

Atención: por norma, el presostato de aire debe impedir que el CO en los humos sea superior al 1% (10.000 p.p.m.). Para comprobarlo, introducir un analizador de CO en la chimenea, cerrar lentamente la boca de aspiración del ventilador (p.ej. con un cartón) y verificar que el quemador se bloquee antes de que el CO en los humos supere el 1%.

El presostato del aire es del tipo diferencial. Si existe una gran depresión en la cámara de combustión en la fase de prebarrido, puede ocurrir que el presostato no cierre su contacto; en este caso, colocar un tubito entre el presostato y la boca de aspiración del ventilador.

Atención: el uso del presostato de aire con funcionamiento diferencial sólo se permite en aplicaciones industriales y donde las normas permitan que el presostato de aire controle sólo el funcionamiento del ventilador, sin límite de referencia por lo que respecta al CO.

6 - PRESOSTATO GAS DE MÍNIMA (B)

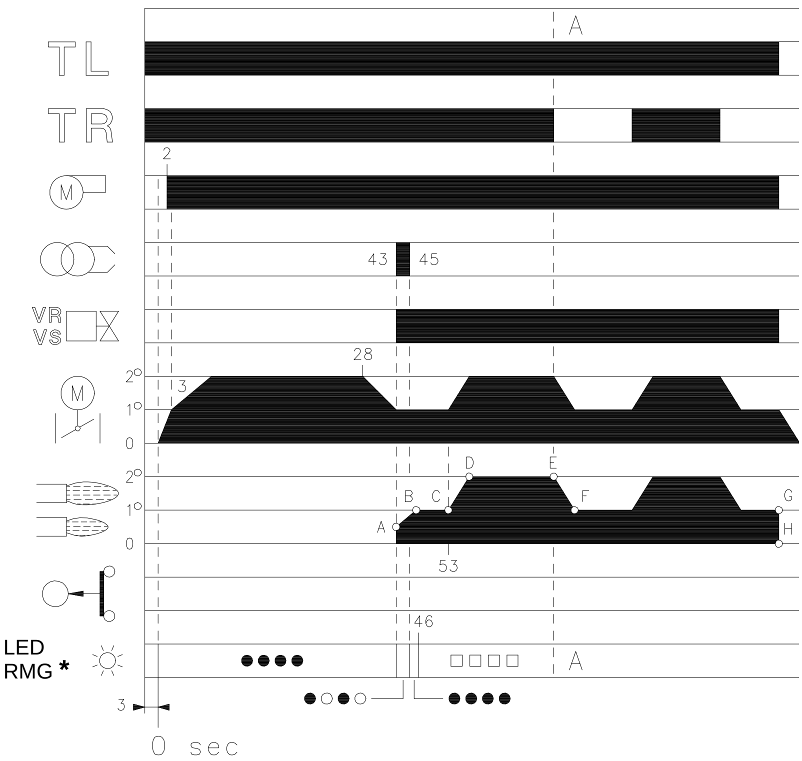
Efectuar la regulación del presostato de gas de mínima después de haber efectuado todas las regulaciones del quemador, con el presostato ajustado al inicio de la escala (B).

Con el quemador funcionando en 2.ª llama, aumentar la presión de regulación girando lentamente (en sentido horario) el botón que se facilita a tal efecto, hasta que se pare el quemador.
A continuación, girar dicho botón (en sentido contrario a las agujas del reloj) 2 mbar y repetir el arranque del quemador para verificar la regularidad de funcionamiento.
Si el quemador se para de nuevo, girar el botón (en sentido contrario a las agujas del reloj) 1 mbar.

CONTROL PRESENCIA LLAMA (C)

El quemador está dotado de un sistema de ionización para controlar la presencia de la llama. La corriente mínima para el funcionamiento de la caja de control es de 5 μA. El quemador genera una corriente netamente superior, no precisando normalmente ningún control. Sin embargo, si se desea medir la corriente de ionización, es preciso desenchufar el conector 8)(A)p.3 del cable de la sonda de ionización y conectar un microamperímetro de corriente continua de una baja escala de 100 μA. Atención a la polaridad.

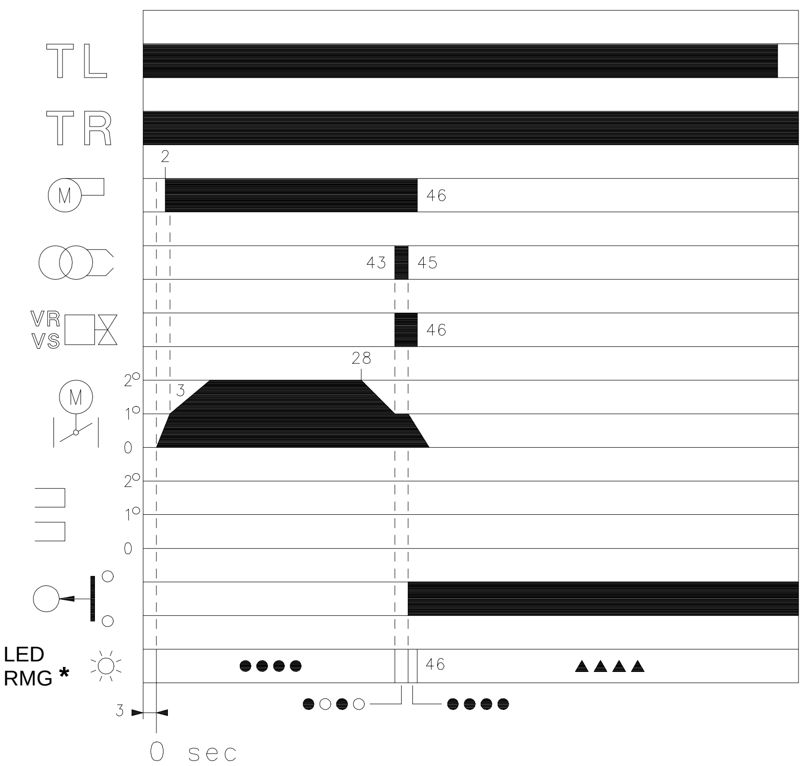
ENCENDIDO NORMAL
(n° = segundos a partir del instante 0)



* ○ Apagado ● Amarillo □ Verde ▲ Rojo
Para mayores informaciones, véase la pág. 18.

(A) D3051

FALTA DE ENCENDIDO



* ○ Apagado ● Amarillo ▲ Rojo
Para mayores informaciones, véase la pág. 18.

(B) D3052

FUNCIONAMIENTO DEL QUEMADOR

PUESTA EN MARCHA DEL QUEMADOR (A)

Se cierra el termostato TL.
Se pone en marcha el servomotor: gira hacia la derecha hasta llegar al ángulo escogido con la leva naranja.
Después de alrededor de 3 s:

- 0 s : Inicia el programa la caja de control.
- 2 s : Se pone en marcha el motor ventilador.
- 3 s : Se pone en marcha el servomotor: gira hacia la derecha hasta llegar a la actuación de la leva roja.
  El registro del aire se sitúa en la posición de potencia de 2.ª llama.
  Fase de prebarrido, con el caudal de aire de la potencia de 2.ª llama.
  Duración: 25 segundos.
- 28 s : Se pone en marcha el servomotor: gira hacia la izquierda hasta llegar al ángulo escogido con la leva naranja.
- 43 s : El registro del aire y la válvula de mariposa del gas se sitúan en la posición de potencia de 1.ª llama.
  Se genera chispa en el electrodo de encendido.
  Se abren las electroválvulas de seguridad VS y de regulación VR (abertura rápida). Se enciende la llama, con poca potencia, punto A. Sigue un progresivo aumento de la potencia, abertura lenta de la electroválvula VR, hasta llegar a la potencia de 1.ª llama, punto B.
- 45 s : Cesa la chispa.
- 53 s : Si el termostato TR está cerrado o sustituido por un puente, el servomotor gira hasta llegar a la actuación de la leva roja; colocando el registro del aire y el de mariposa del gas en posición de 2.ª llama, trazo C-D.
  Finaliza el ciclo de puesta en marcha de la caja de control.

FUNCIONAMIENTO A RÉGIMEN (A)

Caldera con termostato TR

Finalizado el ciclo de puesta en marcha, el mando del servomotor pasa al termostato TR, que controla la presión o la temperatura de la caldera, punto D. (La caja de control sigue controlando la presencia de llama y la correcta posición del presostato del aire).

- Cuando la temperatura aumenta hasta la abertura del termostato TR, el servomotor cierra el registro mariposa del gas y el del aire pasando el quemador de 2.ª a 1.ª llama (trazo E-F).
- Cuando la temperatura disminuye hasta el cierre del termostato TR, el servomotor cierra el registro mariposa del gas y el del aire pasando el quemador de 1.ª a 2.ª llama. Y asi sucesivamente.
- El paro del quemador se produce cuando la demanda de calor es inferior a la generada por el quemador en 1.ª llama (trazo G-H). El termostato TL se abre, el servomotor regresa al ángulo 0º, limitado por el contacto de la leva azul. El registro se cierra completamente para reducir las pérdidas de calor al mínimo.

Caldera sin termostato TR, sustituido por un puente

La puesta en marcha del quemador es del modo indicado con anterioridad. Sucesivamente, si la temperatura aumenta hasta la abertura del termostato TL, el quemador se apaga (trazo A-A del gráfico).

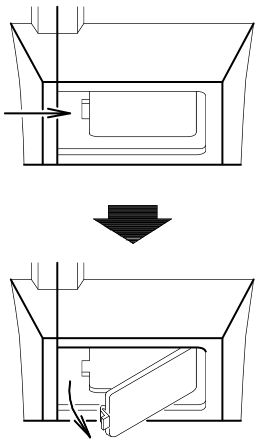
FALTA DE ENCENDIDO(B)

Si el quemador no se enciende, se produce el bloqueo del mismo a los 3 segundos de la abertura de la válvula de gas y a los 49 segundos del cierre del termostato TL. El LED rojo del aparato se enciende.

EXTINCIÓN DE LA LLAMA DURANTE EL FUNCIONAMIENTO

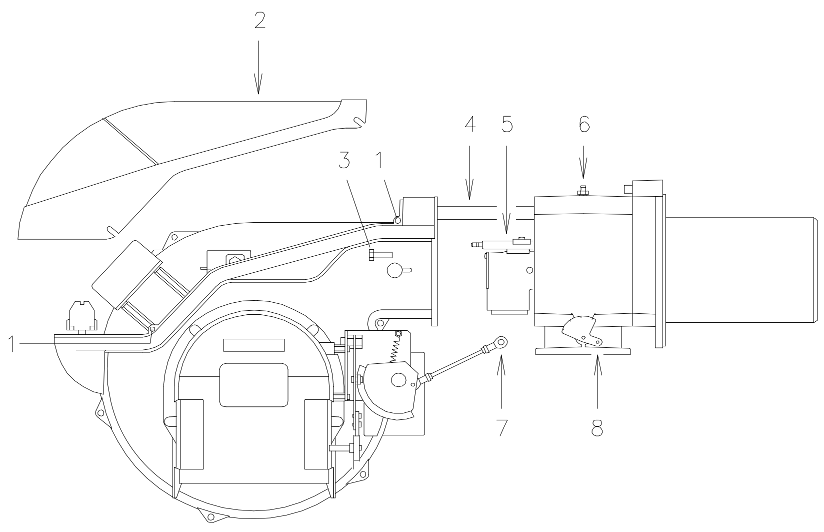
Si la llama se apaga durante el funcionamiento, el quemador se bloquea en 1 segundo.

VISOR LLAMA



(A) D709

APERTURA DEL QUEMADOR



(B) D3034

CONTROL FINAL (con el quemador funcionando)
- Desconectar un hilo del presostato gas de mínima:
- Abrir el termostato TL:
- Abrir el termostato TS:

El quemador debe pararse

- Desconectar el hilo común P del presostato de aire:
- Desconectar el hilo de la sonda de ionización:

El quemador debe bloquearse

- Comprobar que los bloqueos mecánicos de los dispositivos de regulación estén bien apretados.

MANTENIMIENTO

Combustión
Efectuar el análisis de los gases de combustión que salen de la caldera. Las diferencias significativas respecto al último análisis indicarán los puntos donde deberán centrarse las operaciones de mantenimiento.
Fugas de gas
Comprobar que no haya fugas de gas en el conducto contador-quemador.
Filtro de gas
Sustituir el cartucho filtrante cuando esté sucio.
Visor llama
Limpiar el cristal del visor llama (A).
Cabezal de combustión
Abrir el quemador y verificar que todas las partes del cabezal de combustión estén intactas, no estén deformadas por las altas temperaturas, no tengan suciedad proveniente del ambiente y estén correctamente posicionadas. En caso de duda, desmontar el codo 5)(B).
Quemador
Verificar que no haya un desgaste anormal o tornillos flojos en los mecanismos que controlan el registro del aire y la válvula de mariposa del gas. Igualmente, los tornillos que fijan los cables eléctricos en la regleta del quemador deben estar bien apretados.
Limpiar exteriormente el quemador, en particular las rótulas y la leva 3)(A)p.14.
Combustión
Regular el quemador si los valores de la combustión obtenidos al inicio de la intervención no cumplen las normas en vigor o no corresponden a una buena combustión.
Anotar en una ficha de control los nuevos valores de la combustión; serán útiles para controles sucesivos.

PARA ABRIR EL QUEMADOR (B):
- Cortar la alimentación eléctrica.
- Aflojar el tornillo 1) y extraer la cubierta 2).
- Soltar la rótula 7) del sector graduado 8).
- En los modelos con tubo de llama alargado (385-415 mm), montar los prolongadores en las guías 4)
- Quitar el tornillo 3) y desplazar el quemador por las guías 4) unos 100 mm. Desconectar los cables de la sonda y del electrodo y desplazar todo el quemador.

En este punto es posible extraer el distribuidor de gas 5), después de haber desenroscado el tornillo 6).

PARA CERRAR EL QUEMADOR (B):
- Quitar el pasador 9) y empujar el quemador hasta que esté a unos 100 mm del soporte quemador.
- Volver a conectar los cables y desplazar el quemador hasta que haga tope.
- Volver a colocar el tornillo 3) y, con cuidado, tirar de los cables de la sonda y del electrodo hacia afuera, hasta someterlos a una ligera tensión.
- Volver a enganchar la rótula 7) en el sector graduado 8).
- Desmontar los dos prolongadores de guías 4).

DIAGNÓSTICO DEL PROGRAMA DE PUESTA EN MARCHA
Durante el programa de puesta en marcha, en la siguiente tabla se indican las explicaciones:

TABLA CÓDIGO COLOR	
Secuencias	**Código color**
Preventilación	● ● ● ● ● ● ● ● ●
Etapa de encendido	● ○ ● ○ ● ○ ● ○ ●
Funcionamiento con llama ok	□ □ □ □ □ □ □ □ □
Funcionamiento con señal de llama débil	□ ○ □ ○ □ ○ □ ○ □
Alimentación eléctrica inferior que ~ 170V	● ▲ ● ▲ ● ▲ ● ▲ ●
Bloqueo	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲
Luz extraña	▲ □ ▲ □ ▲ □ ▲ □ ▲
Leyenda: ○ Apagado ● Amarillo □ Verde ▲ Rojo	

DESBLOQUEO DE LA CAJA DE CONTROL Y USO DE LA FUNCIÓN DE DIAGNÓSTICO
La caja de control suministrada tiene una función de diagnóstico con la que es posible individuar fáci te las posibles causas de un problema de funcionamiento (señalización: **LED ROJO**).
Para utilizar dicha función hay que esperar 10 segundos como mínimo desde el momento de la puesta en condición de seguridad (**bloqueo**), y luego oprimir el botón de desbloqueo.
La caja de control genera una secuencia de impulsos (cada 1 segundo) que se repite a intervalos constantes de 3 segundos.
Una vez visualizado el número de parpadeos e identificada la posible causa, hay que restablecer el sistema, manteniendo apretado el botón durante un tiempo comprendido entre 1 y 3 segundos.

LED ROJO encendido esperar por lo menos 10s	Bloqueo	Pulsar desbloqueo por > 3s	Impulsos	Intervalo 3s	Impulsos
			● ● ● ● ●		● ● ● ● ●

A continuación se mencionan los métodos posibles para desbloquear la caja de control y para usar l ción de diagnóstico.

DESBLOQUEO DE LA CAJA DE CONTROL
Para desbloquear la caja de control, proceda de la siguiente manera:
- Oprima el botón durante un tiempo comprendido entre 1 y 3 segundos.
  El quemador arranca después de 2 segundos de haber soltado el botón.
  Si el quemador no arranca, hay que controlar el cierre del termostato límite.

DIAGNÓSTICO VISUAL
Indica el tipo de desperfecto del quemador que produce el bloqueo.
Para ver el diagnóstico, proceda de la siguiente manera:
- Mantenga apretado el botón durante más de 3 segundos desde el momento en que el led rojo se encendió (bloqueo del quemador).
  El final de la operación será indicado por un parpadeo amarillo.
  Suelte el botón cuando se produzca dicho parpadeo. El número de parpadeos indica la causa del problema de funcionamiento, según el código que se indica en la tabla de la página 19.

DIAGNÓSTICO SOFTWARE
Suministra el análisis de la vida del quemador mediante una conexión óptica al PC, indicando las horas de funcionamiento, número y tipos de bloqueos, número de serie de la caja de control, etc.
Para ver el diagnóstico, proceda de la siguiente manera:
- Mantenga apretado el botón durante más de 3 segundos desde el momento en que el led rojo se encendió (bloqueo del quemador).
  El final de la operación será indicado por un parpadeo amarillo.
  Suelte el botón durante 1 segundo y luego oprímalo de nuevo durante más de 3 segundos hasta que se produzca otro parpadeo amarillo.
  Al soltar el botón, el led rojo parpadeará intermitentemente con una frecuencia elevada: sólo en este momento se podrá conectar la conexión óptica.

Al concluir la operación hay que restablecer las condiciones iniciales de la caja de control, siguiendo los pasos de desbloqueo antedichos.

PRESIÓN DEL BOTÓN	ESTADO DE LA CAJA DE CONTROL
De 1 a 3 segundos	Desbloqueo de la caja de control sin visualización del diagnóstico visual.
Más de 3 segundos	Diagnóstico visual de la condición de bloqueo: (el led parpadea cada 1 segundo).
Más de 3 segundos desde la condición de diagnóstico visual	Diagnóstico software mediante la ayuda de la interfaz óptica y PC (posibilidad de visualizar las horas de funcionamiento, desperfectos, etc.)

La secuencia de los impulsos emitidos por la caja de control identifica los posibles tipos de avería que se mencionan en la página 19.

SEÑAL	ANOMALÍA	CAUSA PROBABLE	SOLUCIÓN
2 impulsos ● ●	Superado el prebarrido y el tiempo de seguridad, el quemador se bloquea sin aparecer la llama	1 - La electroválvula VR deja pasar poco gas	Aumentarlo
		2 - La electroválvula VR o VS no se abre	Sustituir bobina o panel rectificador
		3 - Presión de gas demasiado baja	Aumentarla en el regulador
		4 - Electrodo de encendido mal regulado	Regularlo; ver Fig. (C)p.6
		5 - Electrodo a masa por rotura aislamiento	Sustituirlo
		6 - Cable de alta tensión defectuoso	Sustituirlo
		7 - Cable de alta tensión deformado por la alta temperatura	Sustituirlo y protegerlo
		8 - Transformador de encendido defectuoso	Sustituirlo
		9 - Conexionado eléctrico válvulas o transformador de encendido incorrecto	Rehacer las conexiones
		10 - Caja de control defectuosa	Sustituirla
		11 - Una válvula antes de la rampa de gas, cerrada	Abrirla
		12 - Aire en las tuberías	Purgarlo
		13 - Electrovál. VS y VR no conexionadas o bobina cortad.	Verificar el conexionado o sostituir bobina
3 impulsos ● ● ●	El quemador no se pone en marcha y aparece el bloqueo	14 - Presostato de aire en posición de funcionamiento	Regularlo o sustituirlo
	El quemador se pone en marcha y luego se bloquea	El presostato de aire no conmuta por presión de aire insuficiente:	
		15 - Presostato de aire mal regulado	Regularlo o sustituirlo
		16 - Tubo toma presión aire del presostato obstruido	Limpiarlo
		17 - Cabezal mal regulado	Regularlo
		18 - Mucha depresión en cámera combustión	Conectar presostato aire a la aspir. ventil.
	Bloqueo durante la ventilación previa	19 - Interruptor remoto mando motor defectuoso	Sustituirlo
		20 - Motor eléctrico defectuoso	Sustituirlo
		21 - Bloqueo motor	Desbloquear el relé térmico al retorno de las 3 fases
4 impulsos ● ● ● ●	El quemador se pone en marcha y luego se bloquea	22 - Simulación de llama	Sustituir la caja de control
	Bloqueo al pararse el quemador	23 - Hay llama en el cabezal de combustión o simulación de llama	Eliminar la llama o sustituir la caja de control
7 impulsos ● ● ● ● ● ● ●	El quemador se bloquea al aparecer la llama	24 - La electroválvula VR deja pasar poco gas	Aumentarlo
		25 - Sonda de ionización mal regulada	Regularla; ver Fig. (C)p.6
		26 - Ionización insuficiente (inferior a 5 µA)	Comprobar la posición de la sonda
		27 - Sonda a masa	Separarla o sustituir cable
		28 - Insuficiente puesta a tierra	Revisar la puesta a tierra
		29 - Inversión del conexionado de fase y neutro	Corregir
		30 - Caja de control defectuosa	Sustituirla
	Bloqueo del quemador al pasar de 1.ª e 2.ª llama o de 2.ª a 1.ª llama	31 - Demasiado aire o poco gas	Regular el aire y el gas
	En funcionamiento, el quemador se bloquea	32 - Sonda o cable ionización a masa	Sustituir la(s) pieza(s) deteriorada(s)
		33 - Presostato de aire averiado	Sustituirlo
10 impulsos ● ● ● ● ● ● ● ● ● ●	El quemador no se pone en marcha y aparece el bloqueo	34 - Conexionado eléctrico incorrecto	Comprobarlo
	El quemador se bloquea	35 - Caja de control defectuosa	Sustituirla
		36 - Presencia de perturbaciones electromagnéticas	Utilizar el kit protección contra las interferencias radio
Ningún parpadeo	El quemador no se pone en marcha	37 - Falta tensión eléctrica	Cerrar interruptores; comprobar conexionado
		38 - Un termostato de regulación o de seguridad abierto	Regularlo o sustituirlo
		39 - Fusible de linea fundido	Sustituirlo (2)
		40 - Caja de control defectuosa	Sustituirla
		41 - Falta de gas	Abrir válvulas manuales entre contador y la rampa
		42 - Presión de gas en red insuficiente	Contacte con la COMPAÑÍA DE GAS
		43 - El presostato gas de mínima no cierra	Regularlo o sustituirlo
	El quemador repite el ciclo de puesta en marcha sin bloquearse	44 - La presión de gas en la red está cercana al valor que se ha regulado el presostato gas de mínima. La pérdida repentina de presión que se produce al abrirse la electroválvula provoca la abertura temporal del propio presostato, que hace que cierre la válvula rápidamente y se pare el quemador. La presión vuelve a aumentar, el presostato se cierra y hace que se repita el ciclo de puesta en marcha. Y así sucesivamente.	Reducir la presión de actuación del presostato de mínima Sustituir el cartucho del filtro de gas.
	Encendido con pulsaciones	45 - Cabezal mal regulado	Regularlo; ver pág.7
		46 - Electrodo de encendido mal regulado	Regularlo; ver Fig. (C)p. 6
		47 - Registro ventilador mal regulado; demasiado aire	Regularlo
		48 - Potencia de encendido demasiado elevada	Reducirla
	El quemador no pasa a 2.ª llama	49 - Termostato TR no cierra	Regularlo o sustituirlo
		50 - Caja de control defectuosa	Sustituirla
		51 - Servomotor defectuoso	Sostituirlo
	El quemador se detiene con el registro vent. abierto	52 - Servomotor defectuoso	Sostituirlo

ACCESORIOS (suministro bajo demanda):

- **KIT PROTECCIÓN CONTRA LAS INTERFERENCIAS RADIO**

En caso de instalar el quemador en ambientes especiales expuestos a interferencias radio (emisión de señales de más de 10 V/m) debido a la presencia de INVERTER o en aplicaciones donde las conexiones del termostato superan los 20 metros de longitud, se encuentra disponible un kit de protección como interfaz entre la caja de control y el quemador.

QUEMADOR	RS 70 - RS 100 - RS 130
Código	3010386

- **KIT CABEZAL LARGO**

QUEMADOR	RS 70	RS 100	RS 130
Código	3010117	3010118	3010119

- **KIT PARA FUNCIONAMIENTO CON GLP:** El kit permite que los quemadores RS 70 - 100 - 130 funcionen con GLP.

QUEMADOR	RS 70		RS 100		RS 130	
Potencia kW	242 ÷ 814		349 ÷ 1163		466 ÷ 1512	
Longitud tubo llama mm	250	385	250	385	280	415
Código	3010097	3010098	3010099	3010100	3010101	3010102

- **KIT REDUCCIÓN VIBRACIONES**

QUEMADOR	RS 70		RS 100		RS 130	
Potencia kW	192 ÷ 814		232 ÷ 1163		185 ÷ 1461	
Longitud tubo llama mm	250	385	250	385	280	415
Código	3010201		3010202		3010373	3010374

- **INTERRUPTOR DIFERENCIAL:** código **3010329**
- **RAMPA DE GAS SEGÚN NORMA EN 676 (completa, con válvulas, regulador de presión y filtro):** ver página 8.

Importante: El instalador es responsable de la eventual incorporación de dispositivos de seguridad no previstos en este manual.

P **ÍNDICE**

CARACTERÍSTICAS TÉCNICAS . . . . página **2**
Dados elétricos. 2
Versões Construtivas 2
Acessórios 2
Descrição do queimador 3
Embalagem - Peso. 3
Dimensões 3
Forma de fornecimento 3
Campos de trabalho 4
Caldeira de ensaio 4
Caldeiras comerciais 4
Pressão do gás 5

INSTALAÇÃO 6
Placa da caldeira 6
Comprimento do tubo de fogo 6
Fixação do queimador à caldeira 6
Regulação do cabeçal de combustão 7
Linha de alimentação gás 8
Instalação eléctrica. 9
Regulação prévia ao acendimento. 12
Servomotor. 12
Arranque do queimador 12
Acendimento do queimador 12
Regulação do queimador: 13
1 - Potência de acendimento 13
2 - Potência na 2ª chama 13
3 - Potência na 1ª chama 14
4 - Potências intermédias. 14
5 - Pressostato de ar 15
6 - Pressostato gás de mínima. 15
Controlo de presença de chama 15
Funcionamento do queimador 16
Controlo final 17
Manutenção 17
Diagnóstico programa de arranque 18
Desbloqueio do equipamento e utilização do diagnóstico 18
Anomalia - Causa Provável - Solução 19
Acessórios 20

Nota
As figuras mencionadas no texto identificam-se da seguinte forma:
1)(A) = Pormenor 1 da figura A, na mesma página que o texto;
1)(A)p.3 = Pormenor 1 da figura A, página N° 3.

CARACTERÍSTICAS TÉCNICAS

MODELO			RS 70		RS 100		RS 130	
TIPO			821 T1		822 T1		823 T1	
POTÊNCIA (1)	2ª chama	kW Mcal/h	465 - 814 400 - 700		698 - 1163 600 - 1000		930 - 1512 800 - 1300	
	min. 1ª chama	kW Mcal/h	192 165		232 200		372 320	
COMBUSTÍVEL			GAS NATURAL: G20 - G21 - G22 - G23 - G25					
			G20	G25	G20	G25	G20	G25
- Poder Calorífico Inferior		kWh/Nm^3 $Mcal/Nm^3$	10 8,6	8,6 7,4	10 8,6	8,6 7,4	10 8,6	8,6 7,4
- Densidade absoluta		kg/Nm^3	0,71	0,78	0,71	0,78	0,71	0,78
- Caudal máximo		Nm^3/h	81	94	116	135	151	175
- Pressão a máximo caudal (2)		mbar	10,3	15,2	9,3	13,7	8,6	12,7
FUNCIONAMENTO			• Intermitente (mín. 1 paragem em 24 horas). • 2 chamas (2ª y 1ª) ou 1 chama (tudo - nada)					
UTILIZAÇÃO			Caldeiras: de água, a vapor e óleo térmico					
TEMPERATURA AMBIENTE		°C	0 - 40					
TEMPERATURA AR COMBURENTE		°C max	60					
CONFORMIDADE COM DIRECTIVAS CEE			90/396 - 2004/108 - 2006/95 - 2006/42					
NÍVEL SONORO (3)		dBA	75		77		78,5	
HOMOLOGAÇÃO		CE	0085AP0944		0085AP0945		0085AP0946	

(1) Condições de referência: Temperatura ambiente 20ºC - Pressão barométrica 1000 mbar - Altitude acima do nivel do mar 100 metros.
(2) Pressão na tomada 16)(A)p.3 com pressão zero na câmara de combustão, com o disco do gás 2)(B)p.7 aberto e à potência máxima do queimador.
(3) Pressão acústica medida em laboratório de combustão do construtor, com o queimador em funcionamento, em caldeira de ensaio, à máxima potência.

DADOS ELÉTRICOS

Motor IE1

MODELLO		RS 70	RS 100	RS 130
ALIMENTAÇÃO ELÉCTRICA	V Hz	230 - 400 com neutro ~ +/-10% 50 - trifásica		
MOTOR ELÉCTRICO	rpm W V A	2800 1100 230 / 400 4,7 - 2,7	2830 1500 230 / 400 6,4 - 3,7	2860 2200 230 / 400 8,5 - 4,9
TRANSFORMADOR DE ACENDIMENTO	V1 - V2 I1 - I2	230 V - 1 x 8 kV 1 A - 20 mA		
POTÊNCIA ELÉCTRICA ABSORVIDA	W max	1400	1800	2600
GRAU DE PROTECÇÃO		IP 44		

Motor IE2

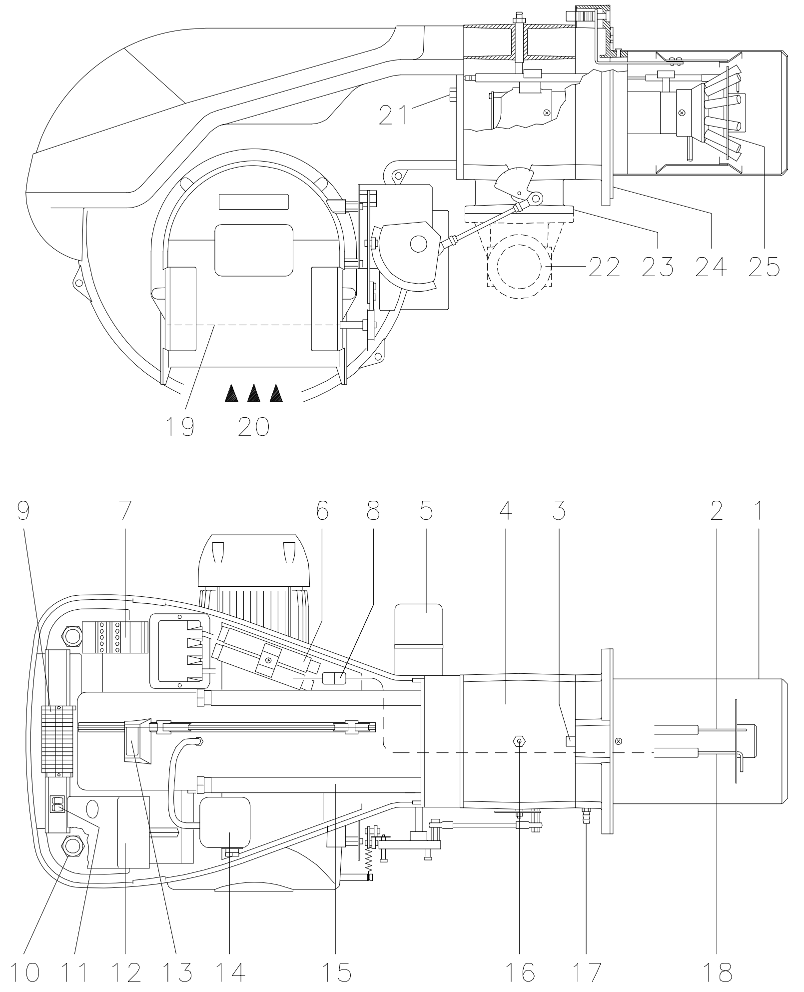
MODELLO		RS 70	RS 100	RS 130
ALIMENTAÇÃO ELÉCTRICA	V Hz	230 - 400 com neutro ~ +/-10% 50 - trifásica		
MOTOR ELÉCTRICO	rpm W V A	2860 1100 230 / 400 4,1 - 2,4	2860 1500 230 / 400 5,5 - 3,4	2860 2200 230 / 400 7,9 - 4,6
TRANSFORMADOR DE ACENDIMENTO	V1 - V2 I1 - I2	230 V - 1 x 8 kV 1 A - 20 mA		
POTÊNCIA ELÉCTRICA ABSORVIDA	W max	1400	1800	2600
GRAU DE PROTECÇÃO		IP 44		

VERSÕES CONSTRUTIVAS

Modelo	Alimentação eléctrica	Comprimento do tubo de fogo mm
RS 70	trifásico trifásico	250 385
RS 100	trifásico trifásico	250 385
RS 130	trifásico trifásico	280 415

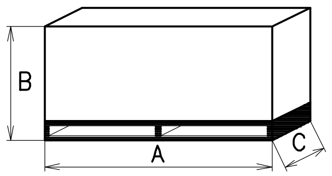
CATEGORÍA GAS

PAÍS	CATEGORÍA
IT - AT - GR - DK - FI - SE	$II_{2H3B / P}$
ES - GB - IE - PT	II_{2H3P}
NL	$II_{2L3B / P}$
FR	II_{2Er3P}
DE	$II_{2ELL3B /P}$
BE	$I_{2E(R)B}$, I_{3P}
LU - PL	$II_{2E 3B/P}$

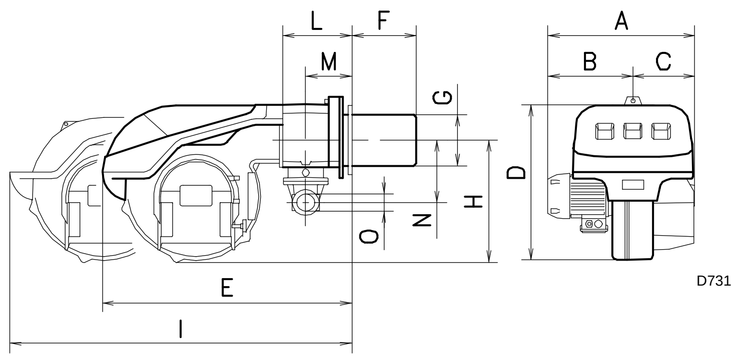


D3030 **(A)**

mm	A	B	C	kg
RS 70	1300	740	682	70
RS 100	1300	740	682	73
RS 130	1300	740	682	76



D36 **(B)**



mm	A	B	C	D	E	$F_{(1)}$	G	H	$I_{(1)}$	L	M	N	O
RS 70	511	296	215	555	840	250 - 385	179	430	1161-1296	214	134	221	2”
RS 100	527	312	215	555	840	250 - 385	179	430	1161-1296	214	134	221	2”
RS 130	553	338	215	555	840	280 - 415	189	430	1161-1296	214	134	221	2”

(1) Tubo de fogo: curto-longo

(C)

DESCRIÇÃO DO QUEIMADOR (A)

1 Cabeçal de combustão
2 Eléctrodo de acendimento
3 Parafuso de regulação do cabeçal de combustão
4 Manguito de união do grupo ventilador ao cabeçal de combustão
5 Servomotor, para o controlo da válvula borboleta do gás e, através de uma came de perfil variável, o registo do ar.
Quando o queimador está parado, o registo do ar está completamente fechado de forma a reduzir ao mínimo a dispersão térmica da caldeira devido ao tipo de conduta de fumos que toma o ar da boca de aspiração do ventilador.
6 Prolongadores guias
7 Contactor motor e relé térmico com botão de rearme
8 Ficha do cabo da sonda de ionização
9 Régua de ligações
10 Passacabos para as ligações eléctricas a cargo do instalador
11 Dois interruptores:
- um “paragem-arranque”
- um para “1ª chama - 2ª chama”
12 Caixa de controlo com piloto luminoso de bloqueio e botão de desbloqueio
13 Visor chama
14 Pressostato de ar (tipo diferencial)
15 Guias para abertura do queimador e inspecção do cabeçal de combustão
16 Tomada de pressão do gás e parafuso de fixação do cabeçal
17 Tomada de pressão do ar
18 Sonda de ionização
19 Registo de ar
20 Entrada de ar do ventilador
21 Parafuso de fixação do ventilador ao suporte do queimador
22 Conduta de entrada de gás
23 Válvula borboleta gás
24 Flange para fixação à caldeira
25 Disco estabilizador da chama

Existem duas possibilidades de bloqueio do queimador:

- **BLOQUEIO DA CAIXA DE CONTROLO:**
Ao ficar aceso (**Led vermelho**) o botão da caixa 12)(A) indica que o queimador está bloqueado.
Para desbloquear, premir o botão por um período de tempo compreendido entre 1 e 3 segundos.
- **BLOQUEIO MOTOR**:
Para desbloquear, premir o botão do relé térmico 7)(A).

EMBALAGEM - PESO (B) -medidas aproximadas

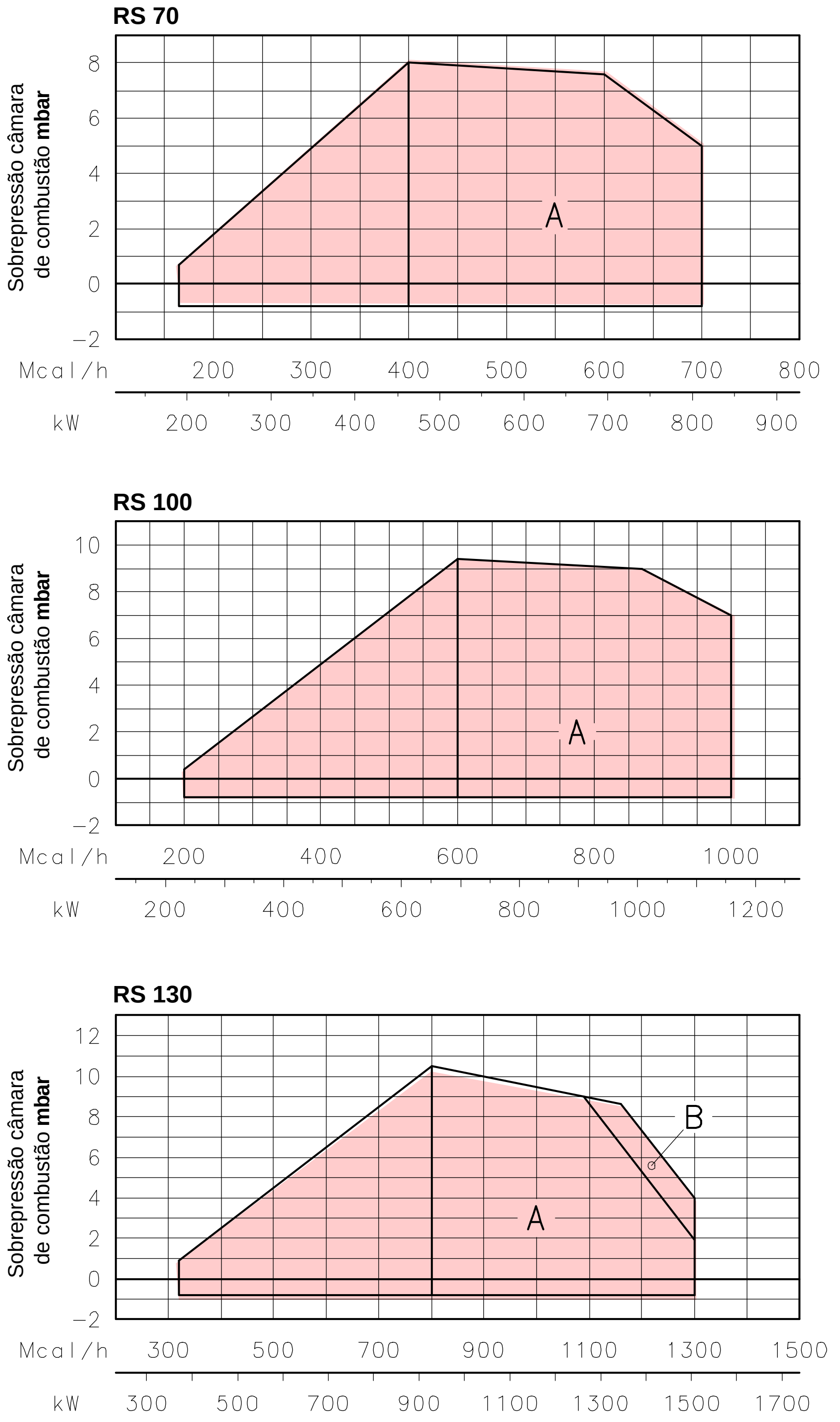
- A embalagem do queimador apoia-se num suporte de madeira adaptado para um empilhador. As dimensões exteriores da embalagem indicam-se na tabela (B).
- O peso do queimador completo com a embalagem é indicado na tabela (B).

DIMENSÕES MÁXIMAS (C) - medidas aproximadas

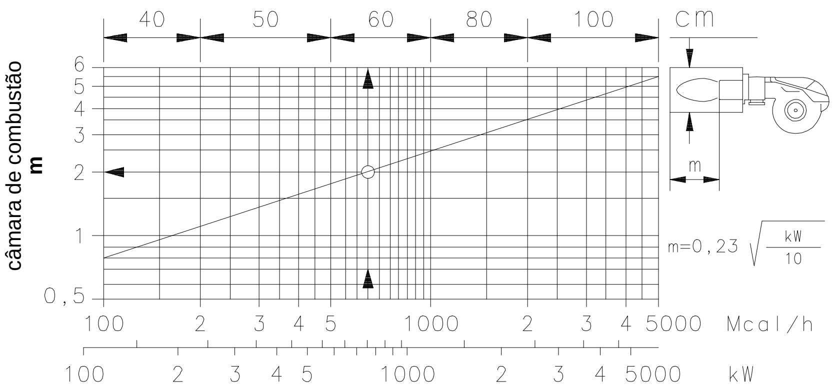
As dimensões máximas do queimador são indicadas em (C).
Ter em conta que para inspeccionar o cabeçal de combustão, o queimador deve ser aberto deslocando a parte posterior pelas guias.
O comprimento máximo do queimador aberto, sem envolvente, está indicado pela cota I.

FORMA DE FORNECIMENTO

1 - Flange de ligação à linha de gás
1 - Junta da flange
4 - Parafusos M10 x 35 de fixação da flange
1 - Junta isolante
2 - Prolongadores 6)(A) para guias 15)(A) (só em modelos com cabeçal de 385 - 415 mm)
4 - Parafusos M12 x 35 para fixar a flange do queimador à caldeira
1 - Instruções
1 - Lista de peças de substituição



(A) D950



(B) D715

CAMPOS DE TRABALHO (A)

Os queimadores RS 70 - 100 - 130 podem funcionar de duas formas: uma chama ou duas chama.

A **POTÊNCIA MÁXIMA** situa-se na zona A,
Para poder utilizar também a zona B (RS 130) é preciso efectuar a pré-taragem do cabeçal de combustão conforme explicado na página 6.

A **POTÊNCIA MÍNIMA** não deve ser inferior ao limite mínimo do gráfico:

RS 70 = 192 kW
RS 100 = 232 kW
RS 130 = 372 kW

Atenção
O CAMPO DE TRABALHO foi calculado considerando uma temperatura ambiente de 20ºC, uma pressão barométrica de 1000 mbar (aprox. 100 metros acima do nível do mar) e com o cabeçal de combustão regulado conforme se indica na página 7.

CALDEIRA DE ENSAIO (B)

Os gráficos foram obtidos com caldeiras de ensaio especiais, conforme a norma EN 676.
Na figura (B) é indicado o diâmetro e o comprimento da câmara de combustão da caldeira de ensaio.
Exemplo
Potência 756 kW:
diâmetro 60 cm - comprimento 2 m.

CALDEIRAS COMERCIAIS

Não existe problema algum no acoplamento queimador-caldeira se esta tiver homologação CE e se as dimensões da câmara de combustão se aproximam das indicadas no gráfico (B).
Se, pelo contrário, o queimador for instalado numa caldeira comercial não homologada CE ou com as dimensões da câmara de combustão muito mais pequenas que as indicadas no gráfico (B), deve-se consultar o fabricante.

RS 70 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
465	4,2	0,2	11,6	8,5	4,8	5,2	-	-
515	4,8	0,2	13,9	10,0	5,8	6,2	-	-
565	5,6	0,3	16,3	12,0	6,8	7,2	-	-
615	6,4	0,3	18,9	13,5	8,0	8,2	-	-
665	7,3	0,3	21,7	15,0	9,2	9,5	-	-
715	8,3	0,4	24,6	17,2	10,5	10,8	-	-
765	9,3	0,4	27,7	18,5	11,3	11,5	4,4	-
814	10,3	0,4	30,9	20,0	13,2	13,0	5,0	-

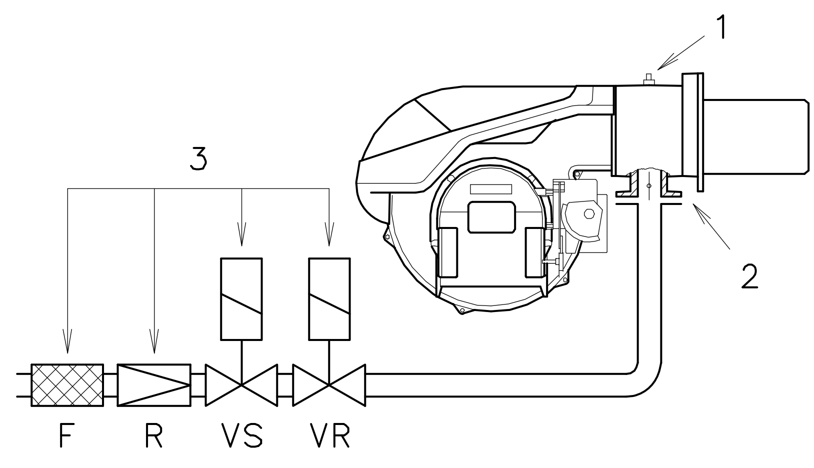
RS 100 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
695	3,7	0,4	23,5	17,0	9,9	10,1	-	-
760	4,2	0,4	27,4	18,5	11,7	11,5	4,4	-
825	5,0	0,5	31,6	20,5	13,6	13,2	5,1	-
890	5,8	0,5	36,1	23,0	15,6	14,0	5,8	-
955	6,5	0,6	40,9	26,0	17,7	16,0	6,6	-
1020	7,3	0,7	45,9	29,0	19,9	18,0	7,5	-
1085	8,3	0,8	51,1	33,0	22,3	20,0	8,4	4,5
1163	9,3	0,8	57,7	38,0	25,3	22,0	9,5	5,0

RS 130 Δp (mbar)

kW	1	2	3					
			Ø 1" 1/2 3970145	Ø 1" 1/2 3970180	Ø 2" 3970146 3970160	Ø 2" 3970181 3970182	DN 65 3970147 3970161	DN80 3970148 3970162
930	3,8	1,0	39,0	22,0	16,9	15,0	6,3	-
1010	4,5	1,1	44,9	28,0	19,6	17,0	7,4	-
1090	5,1	1,3	51,5	33,0	22,5	20,0	8,5	4,5
1170	5,8	1,5	58,3	37,0	25,6	22,0	9,6	5,1
1250	6,5	1,7	65,4	40,0	28,8	25,0	10,8	5,7
1330	7,2	1,8	72,9	43,0	32,2	28,0	12,2	6,4
1410	7,9	1,9	80,7	48,0	35,8	31,0	13,6	7,1
1512	8,6	2,0	91,2	53,0	40,6	34,0	15,3	8,0

(A)



D963 **(B)**

PRESSÃO DO GÁS

As tabelas existentes na margem indicam as perdas de carga mínimas da linha de alimentação de gás em função da potência do queimador na 2ª chama.

Coluna 1
Perda de carga cabeçal de combustão.
Pressão do gás na tomada 1)(B), com:
- Câmara de combustão a 0 mbar
- Queimador funcionando na 2ª chama
- Disco do gás 2)(B)p.7 regulado como é indicado no gráfico (C)p.7.

Coluna 2
Perda de carga registo borboleta gás 2)(B) com abertura máxima: 90°.

Coluna 3
Perda de carga rampa de gás 3)(B) compreende: válvula de regulação VR, válvula de segurança VS (ambas com a máxima abertura), regulador de pressão R, filtro F.

Os valores indicados nas tabelas referem-se a:
gás natural G 20 PCI 10 kWh/Nm^3 (8,6 Mcal/Nm^3)
Com:
gás natural G 25 PCI 8,6 kWh/Nm^3 (7,4 Mcal/Nm^3)
multiplicar os valores das tabelas por 1,3.

Para conhecer a potência aproximada à que está a funcionar o queimador na 2ª chama:
- Subtrair à pressão do gás na tomada 1)(B) a sobrepressão da câmara de combustão.
- Procurar na tabela relativa ao queimador considerado, coluna 1, o valor da pressão mais próxima ao resultado obtido na subtracção.
- Ler à esquerda a potência correspondente.

Exemplo - RS 100:
- Funcionamento em 2ª chama
- Gás natural G 20 PCI 10 kWh/Nm^3
- Disco do gás 2)(B)p.8 regulado como é indicado no gráfico (C)p.8
- Pressão do gás na tomada 1)(B) = 8 mbar
- Pressão na câmara de combustão = 3 mbar
  8 - 3 = 5 mbar

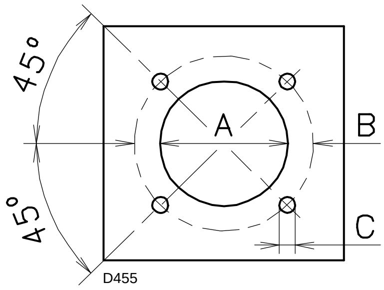
À pressão de 5 mbar, coluna 1, corresponde na tabela do RS 100 uma potência na 2ª chama de 825 kW.
Este valor serve como primeira aproximação; o real determinar-se-á através do contador.

Pelo contrário, para conhecer a pressão do gás necessária na tomada 1)(B), uma vez fixada a potência à qual se deseja que o queimador funcione em 2ª chama:
- Procurar a potência mais próxima ao valor desejado, na tabela relativa ao queimador que se considere.
- Ler à direita, coluna 1, a pressão na tomada 1)(B).

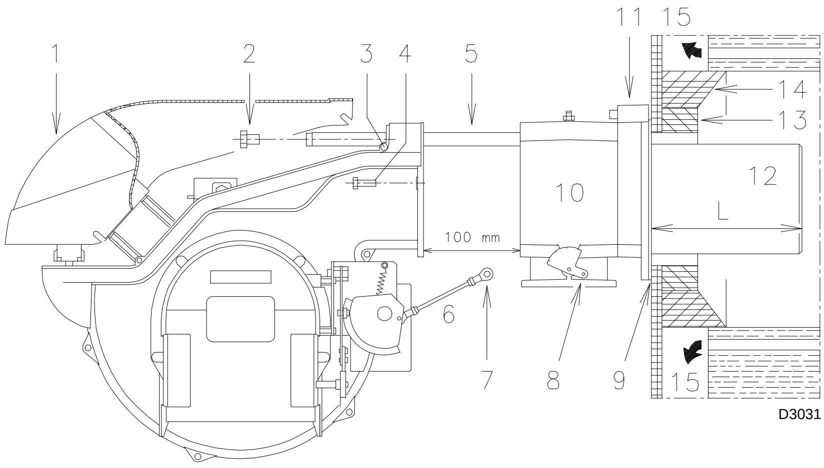
Somar a este valor a sobrepressão estimada na câmara de combustão.

Exemplo - RS 100:
- Potência desejada em 2ª chama: 825 kW
- Gás natural G 20 PCI 10 kWh/Nm^3
- Disco do gás 2)(B)p.7 regulado como é indicado no gráfico (C)p. 7
- Pressão do gás à potência de 825 kW, na tabela do RS 100, coluna 1 = 5 mbar
- Pressão na câmara de combustão = 3 mbar
  5 + 3 = 8 mbar
  pressão necessária na tomada 1)(B).

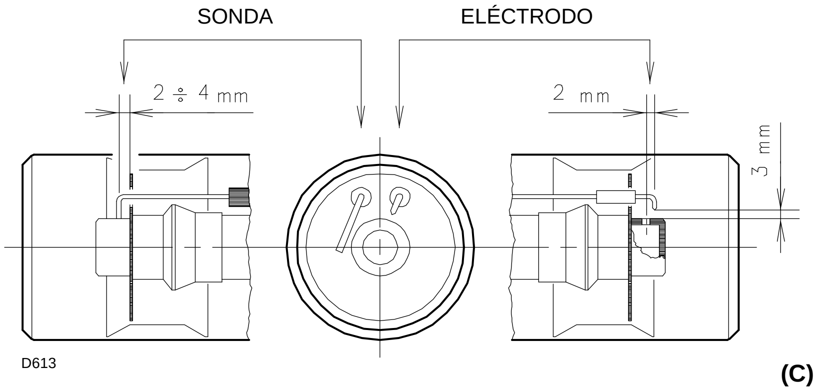
mm	A	B	C
RS 70	185	275 - 325	M 12
RS 100	185	275 - 325	M 12
RS 130	195	275 - 325	M 12



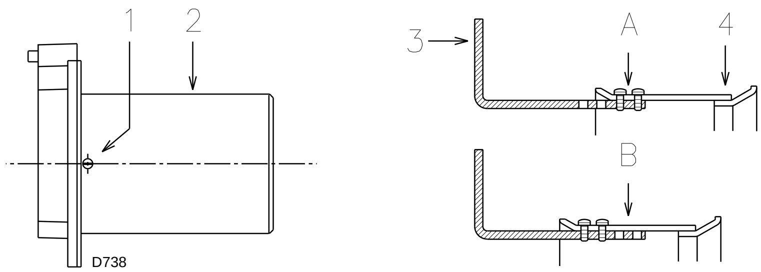
(A)



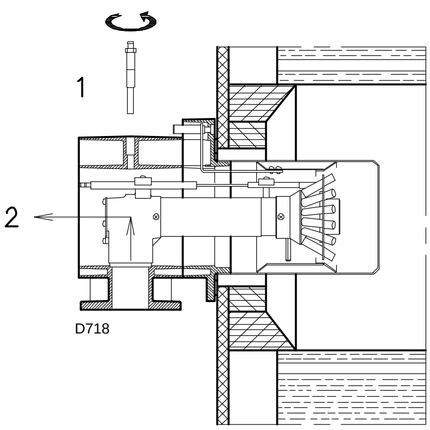
(B)



(C)



(D)



(E)

INSTALAÇÃO

PLACA DA CALDEIRA (A)
Furar a placa de fecho da câmara de combustão tal como é indicado em (A). Pode marcar-se a posição dos orifícios roscados utilizando a junta isolante que é fornecida com o queimador.

COMPRIMENTO DO TUBO DE FOGO (B)
O comprimento do tubo de fogo deve ser seleccionado de acordo com as indicações do fabricante da caldeira e, em qualquer caso, deve ser maior que a espessura da porta da caldeira completa, com o material refractário incluído. Os comprimentos, L (mm), disponíveis são

Tubo chama 12):	**RS 70**	**RS 100**	**RS 130**
• curto	250	250	280
• longo	385	385	415

Para caldeiras com passagens de fumos dianteiras 15) ou com câmara de inversão de chama, colocar uma protecção em material refractário 13) entre o refractário da caldeira 14) e o tubo de fogo 12).
Esta protecção deve permitir o deslocamento do tubo de fogo.
Nas caldeiras com frontal refrigerado por água, não é necessário o revestimento refractário 13)-14)(B), salvo se este for indicado pelo fabricante da caldeira.

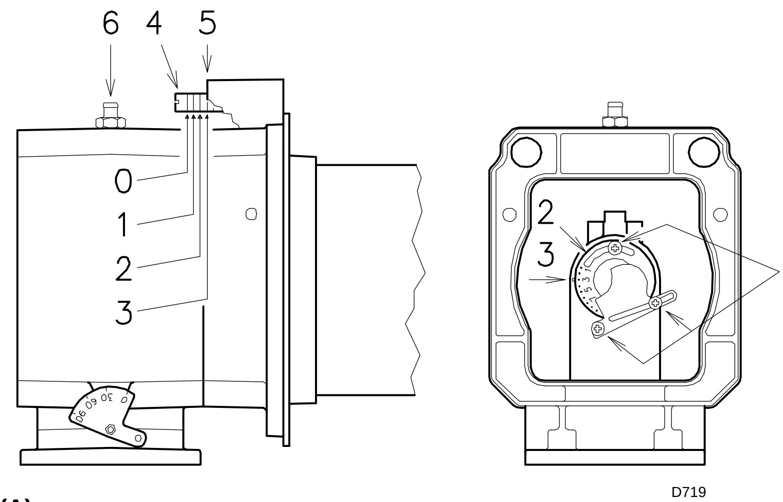
FIXAÇÃO DO QUEIMADOR À CALDEIRA (B)
Antes de fixar o queimador à caldeira, verificar (através da abertura do tubo de fogo) se a sonda e o eléctrodo de acendimento estão correctamente posicionados como indica a figura (C).

Seguidamente separar o cabeçal de combustão do resto do queimador, fig. (B):
- Desenroscar os 4 parafusos 3) e retirar a envolvente 1);
- Desprender a articulação 7) do sector graduado 8);
- Desenroscar os parafusos 2) das duas guias 5);
- Desenroscar os 2 parafusos 4) e deslocar o queimador pelas guias 5) cerca de 100 mm;
- Desligar os cabos da sonda e do eléctrodo e seguidamente retirar por completo o queimador das guias.

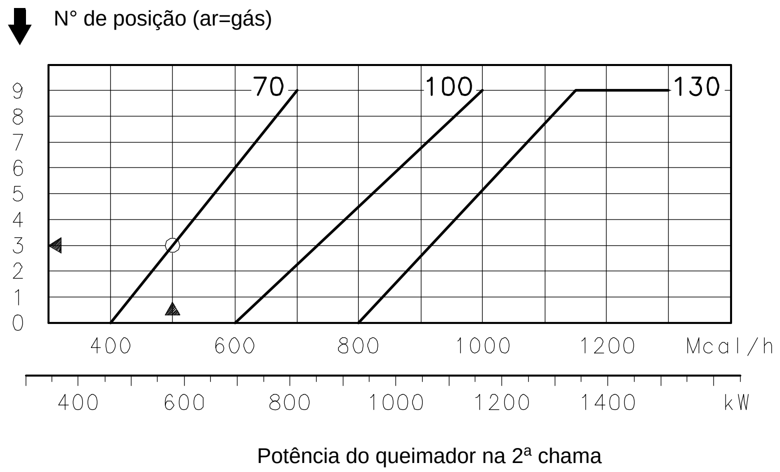
PRÉ-TARAGEM DO CABEÇAL DE COMBUSTÃO
Para o modelo RS 130 verificar, a este ponto, se o caudal máximo do queimador em 2a chama está compreendido na zona A ou B do campo de trabalho. Ver página 4.
Se estiver na zona A não é necessário alguma intervenção.
Se pelo contrário, não estiver na zona B:
- Desenroscar os parafusos 1 (D) e desmontar o tubo de fogo 2).
- Deslocar a fixação da haste 3(D) da posição A para a posição B, fazendo desta maneira retrocer o obturador 4).
- Remontar o tubo de fogo 2)(D) e os parafusos 1).

Uma vez efectuada esta eventual operação, fixar a flange 11)(B) à placa da caldeira, intercalando a junta 9)(B) fornecida. Utilizar os 4 parafusos fornecidos, depois de ter protegido a rosca com um produto antibloqueio.
O acoplamento do queimador à caldeira deve ser hermético.

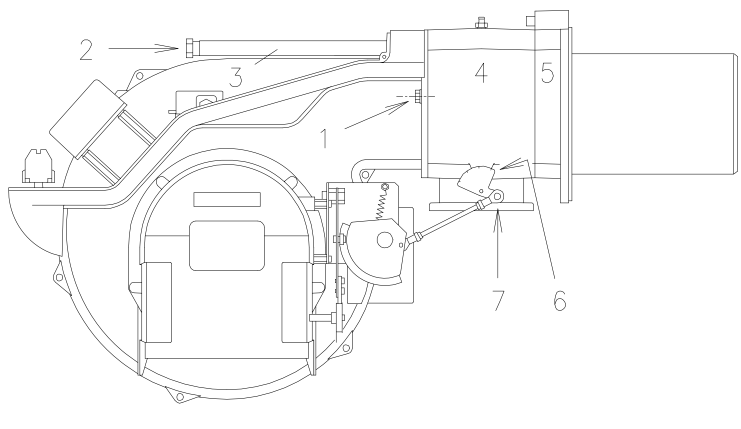
Se na verificação anterior, a posição da sonda ou do eléctrodo não era correcta, desenroscar o parafuso 1)(E), retirar a parte interior 2)(E) do cabeçal e proceder à sua calibragem.
Não rodar a sonda, mas sim, deixá-la conforme o indicado em (C), aproximar demasiado do eléctrodo de acendimento poderá danificar o amplificador da caixa de controlo.



(A) (B)



(C)



(D)

REGULAÇÃO DO CABEÇAL DE COMBUSTÃO

Neste ponto da instalação, o tubo de fogo e o suporte queimador fixam-se à caldeira como é indicado na Fig. (A). Assim, resulta particularmente fácil fazer a regulação do cabeçal de combustão; esta regulação depende unicamente da potência desenvolvida pelo queimador na 2ª chama.
Portanto, antes de regular o cabeçal de combustão, é preciso fixar este valor.
São previstas duas regulações do cabeçal, a do ar e a do gás.

Procurar no gráfico (C) a posição à qual regular o ar e o gás, da seguinte forma:

Regulação do ar (A)

Rodar o parafuso 4)(A) até que coincida o número de posição calculada com o plano anterior 5)(A) da flange.

Regulação do gás (B)

Aliviar os 3 parafusos 1)(B) e rodar o disco 2) até que coincida o número de posição calculada com o índice 3). Apertar bem os 3 parafusos 1).

Exemplo:

Queimador RS 70
Potência queimador = 581 kW (500 Mcal/h)
No gráfico (C), para esta potência o número de posição de regulação de ar e gás é a 3, tal como está nos desenhos Fig. (A) e Fig. (B).

NOTA

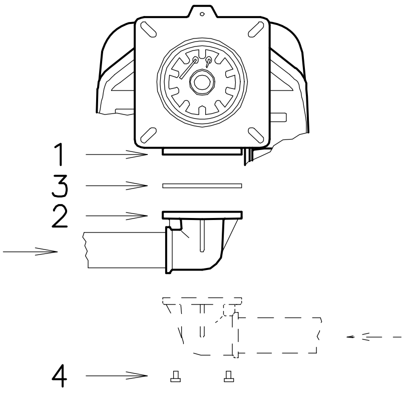
O gráfico (C) indica a regulação óptima do cabeçal. Se a pressão da rede de alimentação de gás é muito baixa e não permite que seja alcançada a pressão indicada na pág. 5 na 2ª chama, e se o disco 2)(B) só está parcialmente aberto, ainda é possível abrir o disco 1 ou 2 posições

Seguindo o exemplo anterior, na pág. 6 pode-se observar que para um queimador RS 70 com uma potência de 581 kW (500 Mcal/h), é necessária uma pressão aproximada de 6 mbar na tomada 6)(A). Se não se dispõe da referida pressão, abrir o disco 2)(B) até à posição 4-5.
Verificar que a combustão é satisfatória e sem pulsações.

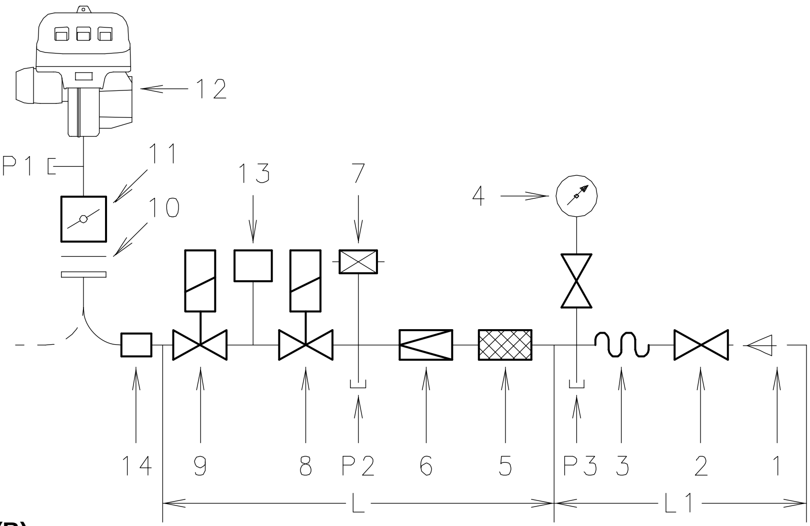
Finalizada a regulação do cabeçal, voltar a montar o queimador nas guias 3)(D) a cerca de 100 mm do suporte queimador 4)(D) (queimador na posição indicada na Fig. (B)p.6 - ligar os cabos da sonda e do eléctrodo e seguidamente deslocar o queimador até ao suporte (queimador na posição indicada na Fig. (D).
Voltar a colocar os parafusos 2) nas guias 3).
Fixar o queimador ao suporte através dos parafusos 1).
Montar a articulação 7) no sector graduado 6).

Atenção

No momento de fechar o queimador nas guias, é conveniente puxar suavemente para fora o cabo de alta tensão e da sonda de ionização até que estejam ligeiramente esticados.



(A) D722



(B) D953

QUEIMADORES E LINHAS DE GÁS HOMOLOGADAS CONFORME NORMA EN 676

Linha de gás L			Queimador			13	14
Ø	C.T.	Código	RS 70	RS 100	RS 130	Código	Código
1"1/2	-	3970145	•	•	•	3010123	3000843
1"1/2	-	3970180	•	•	•	3010123	3000843
2"	-	3970146	•	•	•	3010123	-
2"	♦	3970160	•	•	•	-	-
2"	-	3970181	•	•	•	3010123	-
2"	♦	3970182	•	•	•	-	-
DN 65	-	3970147	•	•	•	3010123	3000825
DN 65	♦	3970161	•	•	•	-	3000825
DN 80	–	3970148	-	-	•	3010123	3000826
DN 80	♦	3970162	-	-	•	-	3000826

(C)

COMPONENTES LINHA DE GÁS L

Código	Componentes		
	Filtro 5	Regulador de pressão 6	Válvulas 8 - 9
3970145	GF 515/1	FRS 515	DMV-DLE 512/11
3970180	Multiblock MB DLE 415		
3970146 3970160	GF 520/1	FRS 520	DMV-DLE 520/11
3970181 3970182	Multiblock MB DLE 420		
3970147 3970161	GF 40065/3	FRS 5065	DMV-DLE 5065/11
3970148 3970162	GF 40080/3	FRS 5080	DMV-DLE 5080/11

LINHA ALIMENTAÇÃO DE GÁS

- A linha de gás está unida à ligação 1)(A), através da flange 2), a junta 3) e os parafusos 4, fornecidos com o queimador.
- A linha pode chegar pela direita ou pela esquerda, conforme convenha. Ver Fig. (A).
- As electroválvulas 8)-9)(B) de gás devem estar o mais perto possível do queimador, para assegurar a chegada do gás ao cabeçal de combustão no tempo de segurança de 3 segundos.
- Certificar-se de que o campo de taragem do regulador de pressão (cor da mola) abarca a pressão de gás de que necessita o queimador.

LINHA DE GÁS (B)

Está homologada conforme a norma EN 676 e é fornecida em separado, com o número de referência que é indicado na tabela (C).

LEGENDA (B)

1 - Conduta de chegada do gás
2 - Válvula manual
3 - Junta anti-vibratória
4 - Manómetro com válvula de botão
5 - Filtro
6 - Regulador de pressão (vertical)
7 - Pressostato gás de mínima
8 - Electroválvula de segurança VS (vertical)
9 - Electroválvula de regulação VR (vertical)
Tem duas regulações:
• caudal de acendimento (abertura rápida)
• caudal máximo (abertura lenta)
10 - Junta e flange, fornecidas com o queimador
11 - Registo borboleta de gás
12 - Queimador
13 - Dispositivo para o controlo da estanquecidade das electroválvulas 8)-9).
Conforme a norma EN 676, o controlo de estanquecidade é obrigatório para queimadores com potência máxima superior a 1200 kW.
14 - Adaptador linha de gás-queimador

P1 - Pressão no cabeçal de combustão
P2 - Pressão à saída do regulador
P3 - Pressão antes do filtro

L - Linha de gás fornecida em separado, com o N° de Ref. que é indicado na tabela (C).
L1 - A cargo do instalador

LEGENDA TABELA (C)

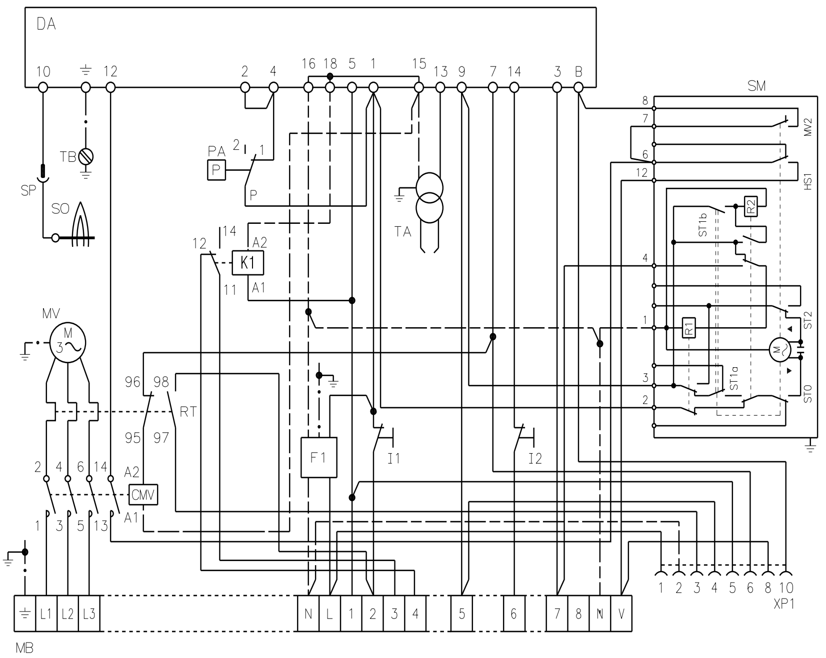
C.T.= Dispositivo de controlo de estanquecidade válvulas gás 8) - 9):
- = Linha de gás sem dispositivo para o controlo de estanquicidade; dispositivo que pode ser encomendado à parte, ver coluna 13, e montado sucessivamente.
♦ = Linha de gás com o dispositivo para o controlo de estaquicidade VPS montado.

13 = Dispositivo de controlo de estanquecidade válvula VPS.
É fornecido à parte da linha de gás, por encomenda.
14 = Adaptador linha de gás-queimador.
É fornecido à parte da linha de gás, por encomenda.

Nota

Para a regulação da linha de gás, ver as instruções que acompanham a mesma.

LIGAÇÃO ELÉCTRICA DE FÁBRICA
RS 70 - RS 100 - RS 130



(A) D3055

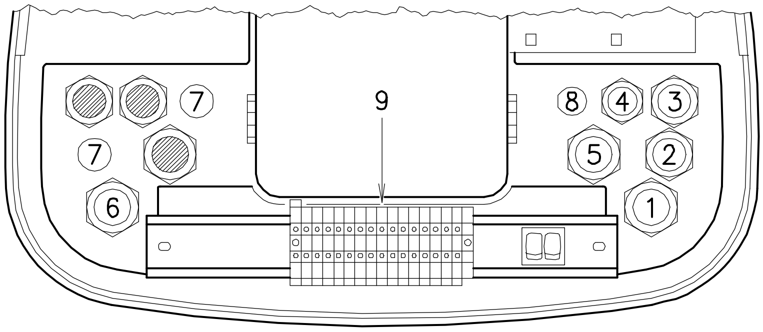
INSTALAÇÃO ELÉCTRICA de fábrica

ESQUEMA (C)
Queimador RS 70 - RS 100 - RS 130
- Os modelos RS 70 - RS 100 - RS 130, saem de fábrica previstos para uma corrente eléctrica a **400 V**.
- Se a alimentação for de **230 V**, alterar a ligação do motor (de estrela a triângulo) e a regulação do relé térmico**.**

Legenda schema (A)

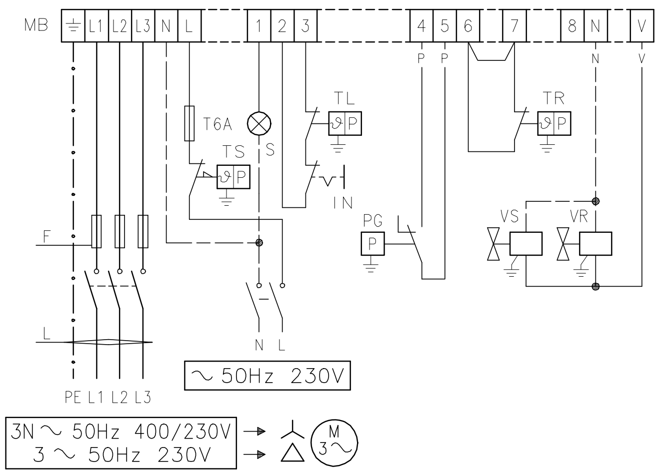
CMV	- Contactor motor
DA	- Caixa de controlo (Landis RMG)
F1	- Filtro contra radio-interferências
K1	- Relé
I1	- Interruptor arranque - paragem
I2	- Interruptor 1ª - 2ª chama
MMI 813	- Caixa de controlo
MB	- Régua queimador
MV	- Motor ventilador
PA	- Pressostato ar
RT	- Relé térmico
SM	- Servomotor
SO	- Sonda de ionização
SP	- Ficha-Tomada
TA	- Transformador de acendimento
TB	- Ligação à terra do queimador
XP1	- Conector

ATENÇÃO
Em caso de alimentação fase/fase, é necessário efectuar uma ponte na régua do equipamento entre o terminal 6 e o terminal de terra.



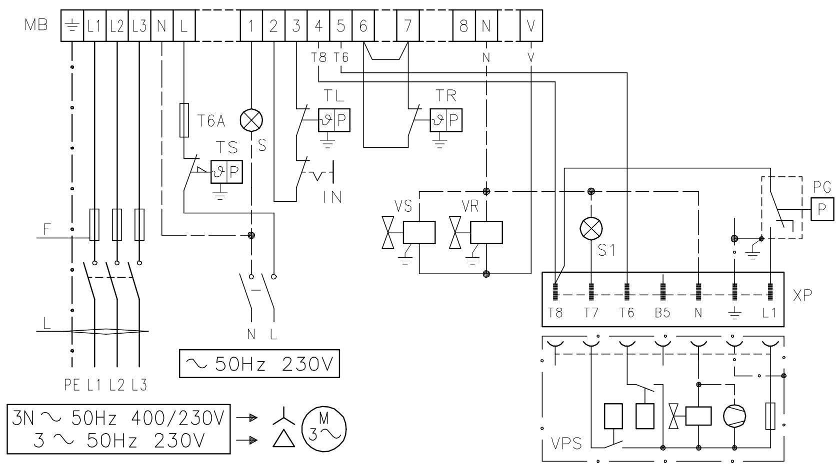
(A) D955

RS 70 - RS 100 - RS 130 sem controlo de estanquecidade das válvulas de gás



(B) D956

RS 70 - RS 100 - RS 130 sem controlo de estanquecidade das válvulas de gás VPS



(C) D957

		RS 70		RS 100		RS 130	
		230 V	400 V	230 V	400 V	230 V	400 V
F	A	T10	T6	T16	T10	T16	T10
L	mm^2	1,5	1,5	1,5	1,5	1,5	1,5

(D)

LIGAÇÃO ELÉCTRICA

Utilizar cabos flexíveis conforme a norma EN 60 335-1:

- se revestidos de PVC, utilizar pelo menos H05 VV-F
- se revestidos de borracha, utilizar pelo menos H05 RR-F.

Todos os cabos que estão ligados à régua de ligações 7)(A) do queimador, devem ser instalados através dos passacabos.
Os passacabos e os orifícios marcados podem ser utilizados de várias formas; como exemplo, indicamos a seguinte forma:

1- Pg 13,5 Alimentação trifásica
2- Pg 11 Alimentação monofásica
3- Pg 11 Termostato TL
4- Pg 9 Termostato TR
5- Pg 13,5 Válvulas de gás
6- Pg 13,5 Pressostato de gás ou dispositivo de controlo de estanquecidade das válvulas de gás
7- Pg 11 Perfurar, caso se pretenda utilizar
8- Pg 9 Perfurar, caso se pretenda utilizar

ESQUEMA (B)
Ligação eléctrica do queimador RS 70 - RS 100 - RS 130 sem controlo de estanquecidade dnas válvulas de gás

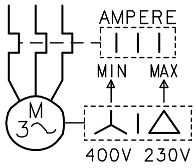
ESQUEMA (C)
Ligação eléctrica do queimador RS 70 - RS 100 - RS 130 com controlo de estanquecidade das válvulas de gás VPS
O controlo de estanquecidade das válvulas de gás faz- -se justamente antes de cada arranque do queimador.

Fusíveis e secção dos cabos dos esquemas (B - C), ver tabela (D).
Secção cabos não indicada é de 1,5 mm^2

LEGENDA ESQUEMAS (B) - (C)

IN - Interruptor de paragem manual do queimador
XP - Ficha de controlo de estanquecidade
MB - Régua queimador
PG - Pressostato gás de mínima
S - Sinalização de bloqueio à distância
S1 - Sinalização bloqueio controlo estanquecidade à distância
TR - Termostato de regulação: comanda a 1ª e 2ª chamas de funcionamento.
Se desejar que o queimador tenha só a 1a chama de funcionamento, substituir TR com uma ponte.
TL - Termostato de regulação máxima: provoca a paragem do queimador quando a temperatura ou a pressão na caldeira atinge o valor pré-estabelecido.
TS - Termostato de segurança: actua em caso de avaria do termostato TL.
VR - Electroválvula de regulação
VS - Electroválvula de segurança

REGULAÇÃO DO RELÉ TÉRMICO



(A)

D867

ESQUEMA (A)
Regulação do relé térmico 7)(A)p. 3
Serve para evitar que o motor se queime por um forte aumento do consumo devido à ausência de uma fase.

- Se motor é alimentado em estrela, **400 V**, o cursor deve situar-se em “MÍN”.
- Se motor é alimentado a triângulo, **230 V**, o cursor deve situar-se em “MÁX”.

Se a escala do relé térmico não compreende o consumo nominal do motor a 400 V, a protecção está igualmente assegurada.

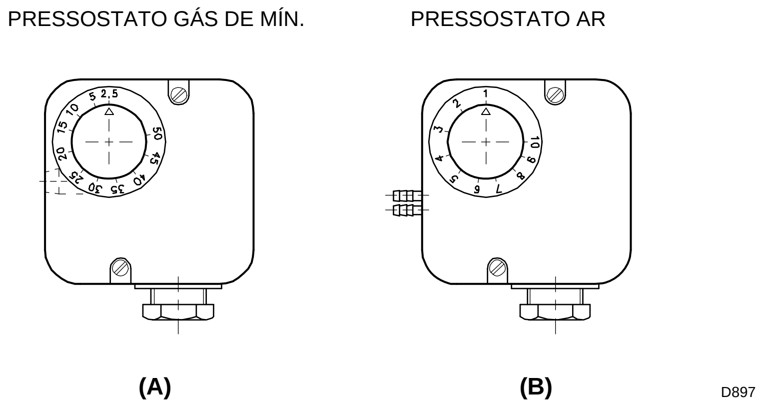
NOTE

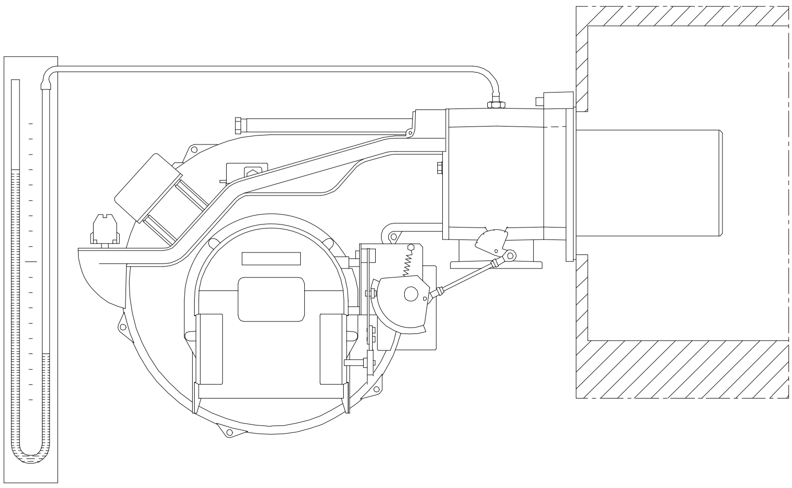
• Os queimadores RS 70 - RS 100 - RS 130 saem de fábrica preparados para uma corrente eléctrica a **400 V**. Se a corrente for a **230 V**, mudar a ligação do motor (de estrela a triângulo) e a regulação do relé térmico.

• Os queimadores RS 70 - RS 100 - RS 130 foram homologados para funcionar de modo intermitente. Isto significa que devem parar “por Norma” pelo menos uma vez cada 24 horas para permitir que a caixa de controlo faça uma verificação da eficácia ao arranque. Normalmente, a paragem do queimador está assegurada pelo termostato da caldeira.
Se assim não for, deverá colocar em série com o interruptor IN, um interruptor horário que pare o queimador pelo menos uma vez cada 24 horas.

• Os queimadores RS 70 - RS 100 - RS 130 saem da fábrica preparados para funcionar com 1a e 2a chamas e portanto deve ser ligado ao termostato TR.
Se si deseja que estes queimadores tenham um funcionamento de um escalão (tudo-nada), colocar um shunt entre os bornes 6 e 7, em substituição do termostato TR.

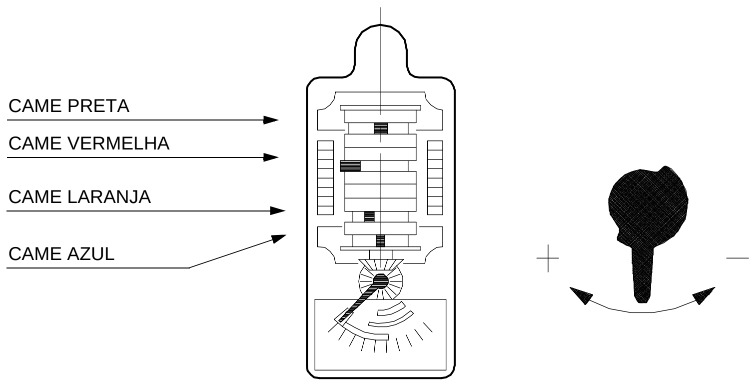
Atenção:
Não inverter o Neutro com a Fase na linha de alimentação eléctrica.
A eventual inversão poderia determinar uma paragem em bloqueio por falta de acendimento.



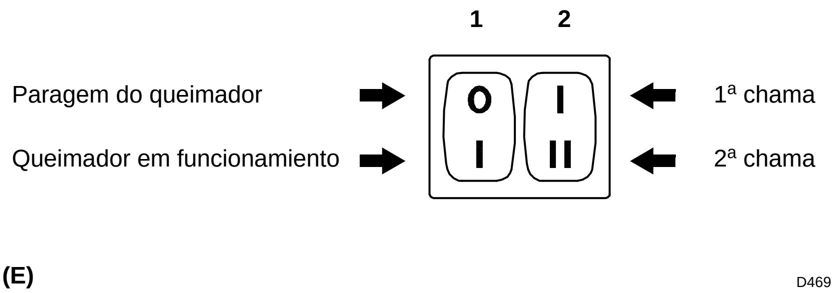


(C)

SERVOMOTOR



(D)



(E)

REGULAÇÃO ANTES DO PRIMEIRO ACENDIMENTO

A regulação do cabeçal de combustão, ar e gás, já foi descrita na pág. 7.

Efectuar, ainda, as seguintes regulações:
- Abrir as válvulas manuais localizadas antes da linha de gás.
- Regular o pressostato gás de mínima ao início da escala (A).
- Regular o pressostato ar ao início da escala (B).
- Purgar o ar da linha de gás.
  É aconselhável evacuar o ar purgado ao exterior do edifício (através de um tubo de plástico) até notar o odor característico do gás.
- Instalar um manómetro de tubo em "U" (C) na tomada de pressão do suporte queimador.
  Serve para calcular, aproximadamente, a potência do queimador em 2ª chama através das tabelas da pág. 5.
- Ligar em paralelo às duas electroválvulas de gás VR e VS, duas lâmpadas ou um tester para controlar o momento da chegada de corrente.
  Esta operação não é necessária se cada uma das electroválvulas estiver equipada com uma luz piloto que assinale a presença de corrente eléctrica.

Antes de colocar em funcionamento o queimador, é conveniente regular a linha de gás de forma que o acendimento se faça em condições de máxima segurança, isto é, com um pequeno caudal de gás.

SERVOMOTOR (D)

O servomotor regula em simultâneo o registo do ar pela came de perfil variável e a válvula borboleta do gás.

O ângulo de rotação do servomotor é igual ao ângulo do sector graduado da válvula borboleta do gás. O servomotor roda 90º em 15 segundos.

Não modificar a regulação feita de fábrica das 4 cames com que está dotado; verificar simplesmente que as cames estão reguladas da seguinte forma:

Came vermelha : 90°
Limita a rotação máxima. Com o queimador funcionando em 2ª chama, a válvula de borboleta do gás deve estar completamente aberta: 90°.

Came azul : 0°
Limita a rotação mínima.
Com o queimador parado, o registo de ar e a válvula borboleta do gás devem estar fechados: 0°.

Came laranja : 15°
Regula a posição de acendimento e da potência em 1ª chama.

Came preta : 85°
Acende o Led da 2ª chama.

Uma etiqueta graduata com os 4 sectores coloridos indica a came que intervém.

ARRANQUE DO QUEIMADOR

Fechar os termostatos e premir:
- o interruptor 1)(E) para a posição "Queimador em funcionamento";
- o interruptor 2)(E) para a posição "1ª chama".

Assim que o queimador entre em funcionamento, controlar o sentido de giro da turbina do ventilador através do visor de chama 13)(A)p.3.

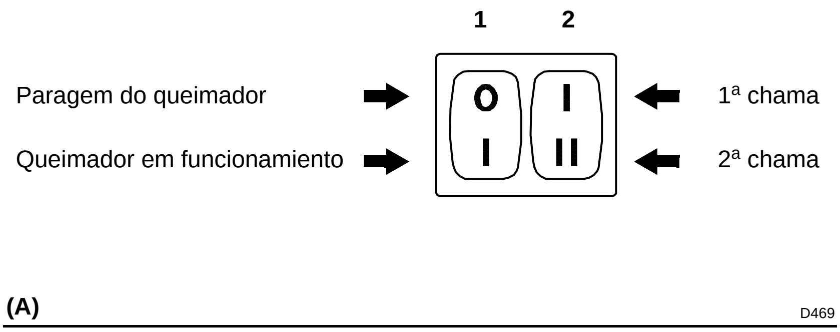
Verificar que as lâmpadas ou o tester ligados às electroválvulas, ou às luzes piloto das próprias electroválvulas, indicam ausência de corrente. Se assinalam que existe corrente, parar **imediatamente** o queimador e verificar a ligação eléctrica.

ACENDIMENTO DO QUEIMADOR

Depois de ter efectuado as operações descritas no parágrafo anterior, o queimador deve acender-se. Se o motor arranca mas não aparece chama e a caixa de controlo se bloqueia, rearmar esta e fazer uma nova tentativa de arranque. Se o acendimento continua sem efeito, pode ser devido a que o gás não chega ao cabeçal de combustão no tempo de segurança de 3 segundos. Em tal caso, aumentar o caudal de gás no acendimento.

A chegada de gás ao queimador pode observar-se no manómetro do tubo em "U" (C).

Uma vez efectuado o acendimento, proceder-se-á à regulação completa do queimador.



REGULAÇÃO DO QUEIMADOR
Para conseguir uma óptima regulação do queimador, é necessário fazer uma análise dos gases de combustão na base da chaminé.

Terá que se regular consecutivamente:
1 - Potência de acendimento
2 - Potência do queimador na 2ª chama
3 - Potência do queimador na 1ª chama
4 - Potência intermédia
5 - Pressostato ar
6 - Pressostato gás de mínima

1 - POTÊNCIA DE ACENDIMENTO
Conforme a norma EN 676.

Queimadores com potência MÁX até 120 kW
O acendimento pode ser feito à máxima potência de funcionamento. Exemplo:
- potência máxima de funcionamento : 120 kw
- potência máxima de acendimento : 120 kW

Queimadores com potência MÁX superior a 120 kW
O acendimento deve ser feito a uma potência reduzida em relação à potência máxima de funcionamento.
Se a potência de acendimento não ultrapassa os 120 kW, não é necessário fazer cálculo algum. Pelo contrário, se a potência supera os 120 kW, a norma estabelece que o seu valor seja definido em função do tempo de segurança "ts" da caixa de controlo:
- para "ts" = 2s. A potência de acendimento deve ser igual ou inferior a 1/2 da potência máxima de funcionamento;
- para "ts" = 3s. A potência de acendimento deve ser igual ou inferior a 1/3 da potência máxima de funcionamento.

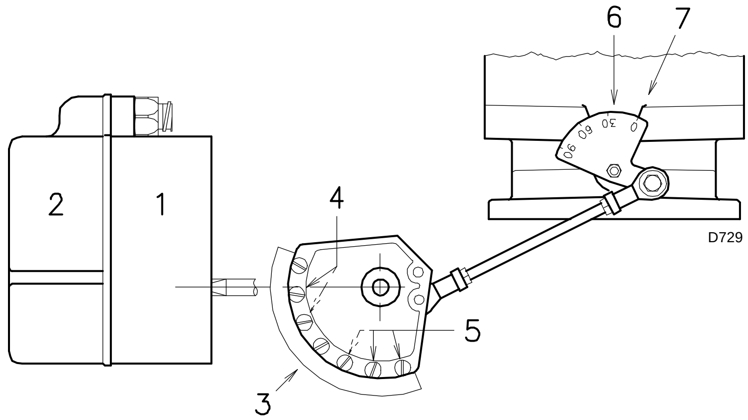
Exemplo
Potência MÁX de funcionamento 600 kW.
A potência de acendimento deve ser igual ou inferior a:
- 300 kW com ts = 2 s
- 200 kW com ts = 3 s

Para medir a potência de acendimento:
- Desligar a ficha-tomada 8)(A)p.3 do cabo da sonda de ionização (o queimador acende-se e bloqueia-se passado o tempo de segurança).
- Efectuar 10 acendimentos com bloqueios consecutivos.
- Ler no contador o gás consumido.
  Esta quantidade deve ser igual ou inferior à que nos dá a fórmula:

$$\frac{\mathbf{Nm^3/h}\ \text{(caudal máx. queimador)}}{\mathbf{360}}$$

Exemplo: com gás natural G 20 (10 kWh/Nm^3):
Potência máxima de funcionamento: 600 kW corresponde a um consumo de 60 Nm^3/h.
Depois de 10 acendimentos com bloqueio, o caudal de gás medido no contador deve ser igual ou inferior a:
60 : 360 = 0,166 Nm^3.

2 - POTÊNCIA NA 2ª CHAMA
A potência na 2ª chama é escolhida dentro do campo de trabalho indicado na pág. 4.
Na descrição anterior, o queimador estava em funcionamento na 1ª chama. Situar agora o interruptor 2)(A) na posição "2ª chama": o servomotor abrirá o registo de ar e ao mesmo tempo a válvula borboleta do gás a 90°.
Regulação do gás
Medir o caudal de gás no contador.
A título de orientação, pode determinar-se através das tabelas da pág. 6, observando a pressão do gás no manómetro do tubo em "U" (ver Fig. (C)p.12 e seguindo as indicações da pág.5.
- Se for necessário reduzi-lo, diminuir a pressão do gás à saída e, se já está no mínimo, fechar um pouco a electroválvula de regulação VR.
- Se for necessário aumentá-la, aumentar a pressão de gás à saída do regulador.



1 Servomotor

2 Tampa cames

3 Came de perfil variável

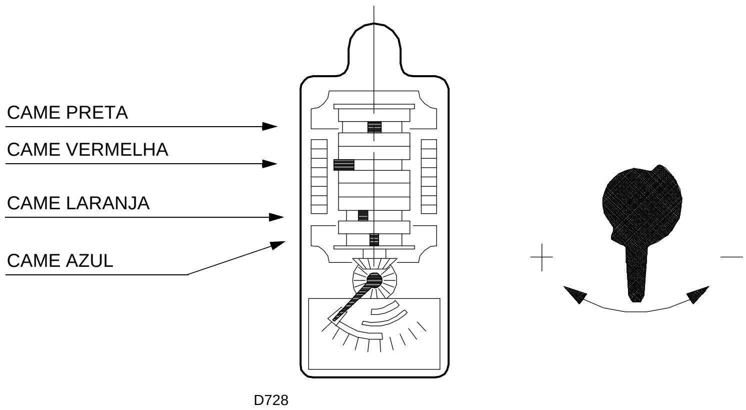
4 Parafusos regulação perfil inicial

5 Parafusos regulação perfil final

6 Sector graduado válvula borboleta de gás

7 Índice do sector graduado 6

(A)



(B)

Regulação do ar
Variar progressivamente o perfil final da came 3)(A) actuando sobre os parafusos 5).
- Para aumentar o caudal de ar, roscar os parafusos.
- Para diminuir o caudal de ar, desenroscar os parafusos.

3 - POTÊNCIA NA 1ª CHAMA

A potência na 1ª chama é escolhida dentro do campo de trabalho indicado na pág. 4.
Pressionar o interruptor 2)(A)p.13 para posição “1ª chama”: o servomotor fechará o registo de ar, e ao mesmo tempo, o da válvula borboleta do gás situando-lo a 15º, que é a regulação efectuada em fábrica.

Regulação do gás
Medir o caudal de gás no contador.
- Se deseja diminui-lo, reduzir um pouco o ângulo da came laranja (B) através de curtos e sucessivos deslocamentos, isto é, passando do ângulo de 15° a 13° - 11°....
- Se deseja aumentá-lo, passar à 2ª chama pressionando o interruptor 2)(A)p. 13 para a posição “2ª chama” e aumentar um pouco o ângulo da came laranja através de curtos e sucessivos deslocamentos, isto é, passando do ângulo de 15° a 17° - 19°....
  Seguidamente retornar à 1ª chama e medir o caudal de gás.

NOTA
O servomotor segue a regulação da came laranja só quando se reduz o ângulo da mesma. Se se tem que aumentar o ângulo, é necessário passar à 2ª chama, aumentar o ângulo e retornar à 1ª chama para verificar o efeito da regulação.

Regulação do ar
Variar progressivamente o perfil inicial da came 3)(A), actuando sobre os parafusos 4). Se possível, não rodar o primeiro parafuso, dado que é o utilizado para fechar o registo do ar completamente.

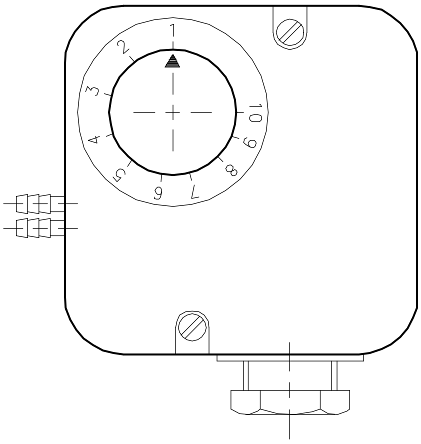
4 - POTÊNCIAS INTERMÉDIAS

Regulação do gás
Não é necessário regulação alguma.

Regulação do ar
Para e o queimador actuando sobre o interruptor 1)(A)p. 13 e actuar sobre os parafusos intermédios da guia de maneira que a pendente seja progressiva.
Não actuar os parafusos das extremidades que já foram utilizados para regular o registo do ar na 1ª e 2ª chamas.

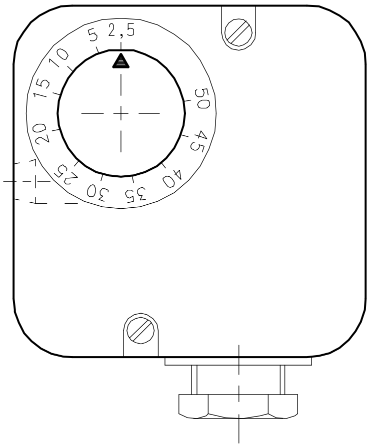
NOTA
Uma vez terminada a regulação das potências 2ª chama - 1ª chama - INTERMÉDIAS, voltar a verificar o acendimento: deve produzir-se um ruído parecido ao do funcionamento sucessivo. Se forem observadas pulsações, reduzir o caudal do acendimento.

PRESSOSTATO DE AR 14)(A)p. 3

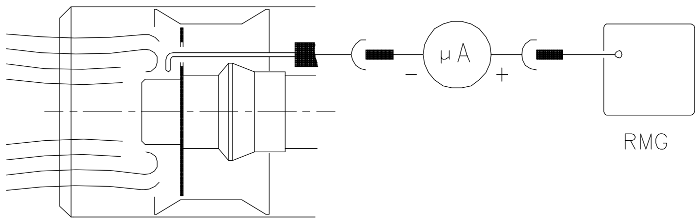


(A) D521

PRESSOSTATO GAS DE MÍNIMA 7)(B)p. 8



(B) D896



(C) D3023

5 - PRESSOSTATO DE AR (A)

Efectuar a regulação do pressostato de ar, depois de ter feito todas as restantes regulações do queimador, com o pressostato de ar ajustado ao início da escala (A).

Com o queimador a funcionar na 1ª chama, aumentar a pressão de regulação rodando lentamente (no sentido horário) o botão fornecido para tal efeito, até que o queimador se bloqueie.
Seguidamente rodar o referido botão no sentido contrário ao dos ponteiros do relógio, cerca de 20% do valor regulado e verificar de seguida o correcto funcionamento do queimador.
Se o queimador se bloqueia de novo, rodar o botão um pouco mais, no sentido contrário ao dos ponteiros do relógio.

Atenção: normalmente, o pressostato de ar deve impedir que o CO nos fumos seja superior a 1% (10.000 p.p.m.). Para o comprovar, introduzir um analisador de CO na chaminé, fechar lentamente a boca de aspiração do ventilador (p.ex. com um cartão) e verificar que o queimador se bloqueia antes que o CO nos fumos ultrapasse 1%.

O pressostato de ar instalado pode funcionar de maneira "diferencial", se for ligado a dois tubos. Se existe uma grande depressão na câmara de combustão na fase varrimento pode ocorrer que o pressostato não feche o seu contacto, neste caso, colocar um tubinho entre o pressostato e a boca de aspiração do ventilador.
Deste modo o pressostato funcionará como pressostato diferencial.

Atenção: o uso do pressostato de ar com funcionamento diferencial só é permitido em aplicações industriais e onde as normas permitam que o pressostato de ar controle só o funcionamento do ventilador, sem limite de referência no que respeita ao CO.

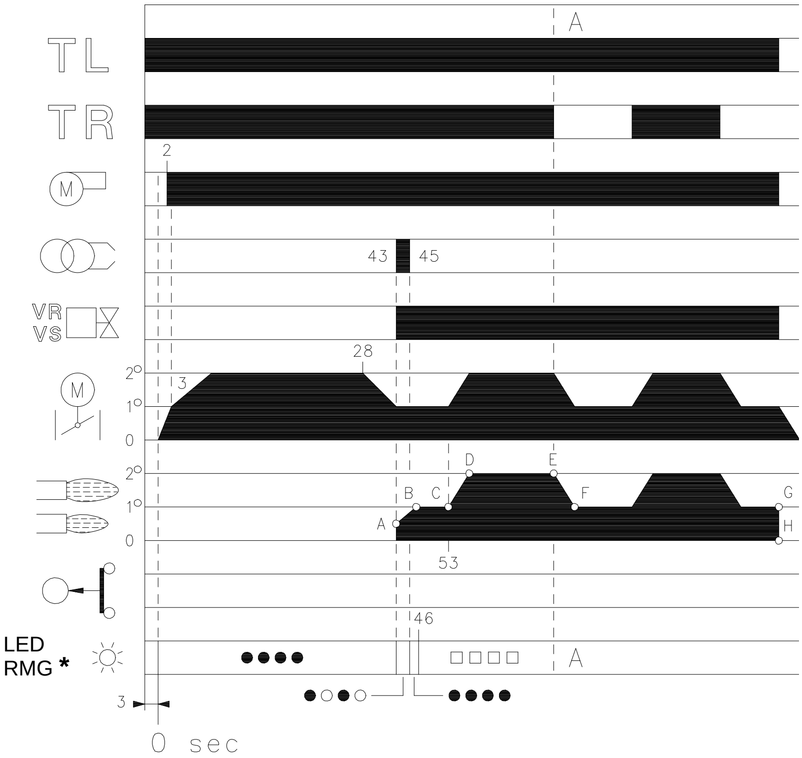
6 - PRESSOSTATO GÁS DE MÍNIMA (B)

Efectuar a regulação do pressostato de gás de mínima depois de ter feito todas as regulações do queimador, com o pressostato ajustado ao início da escala (B).
Com o queimador funcionando à potência MÁX, aumentar a pressão de regulação rodando lentamente (no sentido horário) o botão fornecido para tal efeito, até que o queimador pare.
Seguidamente, rodar o referido botão (no sentido contrário ao dos ponteiros do relógio) 2 mbar e repetir o arranque do queimador para verificar a regularidade de funcionamento.
Se o queimador parar de novo, rodar o botão (no sentido contrário ao dos ponteiros do relógio) 1 mbar.

CONTROLO DE PRESENÇA DE CHAMA (C)

O queimador está dotado de um sistema de ionização para controlar a presença da chama. A corrente mínima para o funcionamento da caixa de controlo é de 5 µA. O queimador gera uma corrente nitidamente superior, não precisando normalmente de nenhum controlo. No entanto, se desejar medir a corrente de ionização, é necessário desligar a ficha-tomada 8)(A)p.3 do cabo da sonda de ionização e ligar um microamperímetro de corrente contínua de escala baixa de 100 µA.
Atenção à polaridade

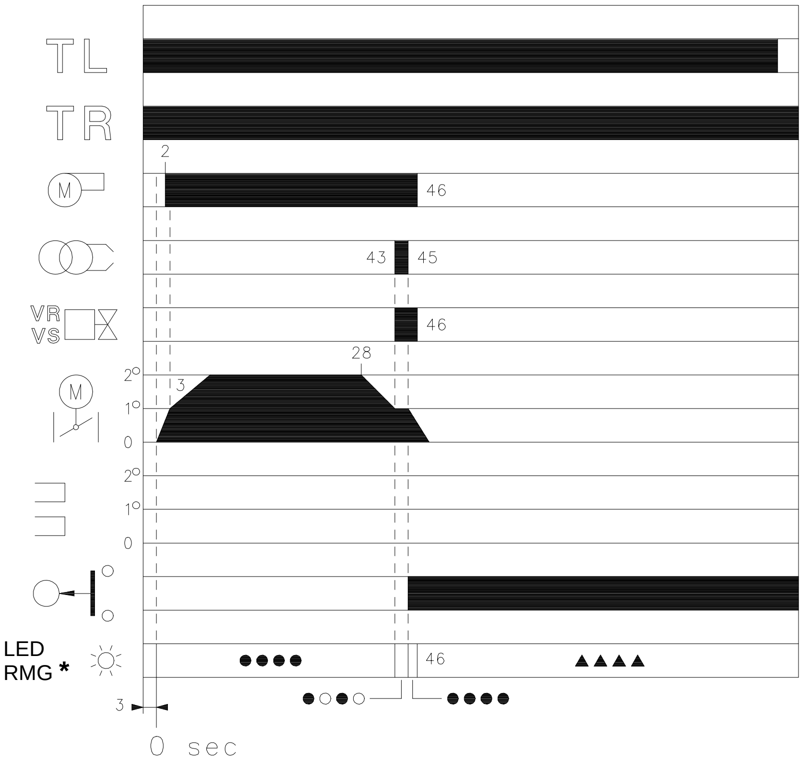
ACENDIMENTO NORMAL
(n° = segundos a partir do instante 0)



* ○ Apagado ● Amarelo □ Verde ▲ Vermelho
Para ulteriores informações ver pág. 18.

(A) D3051

FALTA DE ACENDIMENTO



* ○ Apagado ● Amarelo ▲ Vermelho
Para ulteriores informações ver pág. 18.

(B) D3052

FUNCIONAMENTO DO QUEIMADOR

ARRANQUE DO QUEIMADOR (A)

Fecha-se o termostato TL.
Entra em funcionamento o servomotor: roda em abertura até atingir o ângulo escolhido com a came laranja.
Passados cerca de 3s:

- 0 s : Inicia o programa da caixa de controle.
- 2 s : Entra em funcionamento o motor ventilador.
- 3 s : Entra em funcionamento o servomotor: roda em abertura até atingir a actuação de came vermelha.
  O registo do ar coloca-se na posição de potência 2ª chama.
  Fase de pré-varrimento, com o caudal de ar da potência da 2ª chama.
  Duração: 25 segundos.
- 28 s : Entra em funcionamento o servomotor: roda em fechamento até atingir o ângulo escolhido pela came laranja.
- 43 s : O registo do ar e a válvula de borboleta do gás estão na posição de potência de 1ª chama.
  Gera-se faísca no eléctrodo de acendimento.
  Abrem-se as electroválvulas de segurança VS e de regulação VR (abertura rápida). Acende-se a chama, com pouca potência, ponto A. Continua um progressivo aumento da potência, abertura lenta da electroválvula VR, até chegar à potência da 1ª chama, ponto B.
- 45 s : A faísca apaga-se.
- 53 s : Se o termostato TR está fechado ou substituido por um shunt, o servomotor roda até atingir a actuação da came vermelha colocando o registo de ar e o de borboleta de gás na posição de 2ª chama, intervalo C-D.
  Finaliza o ciclo de arranque da caixa de controlo.

FUNCIONAMENTO A REGIME (A)

Caldeira com termostato TR

Finalizado o ciclo de arranque, o comando do servomotor passa ao termostato TR, que controla a pressão ou a temperatura da caldeira, ponto D. (A caixa de controlo continua a controlar a presença de chama e a correcta posição do pressostato de ar).

- Quando a temperatura ou a pressão aumenta até à abertura do termostato TR, o servomotor fecha o registo de ar e de borboleta do gás passando o queimador da 2ª à 1ª chama, intervalo E-F).
- Quando a temperatura ou a pressão diminui até ao fecho do termostato TR, o servomotor abre o registo de ar e o de borboleta do gás passando o queimador da 1ª à 2ª chama. E assim sucessivamente.
- A paragem do queimador faz-se quando a procura de calor é inferior à gerada pelo queimador na 1ª chama (intervalo G-H). O termostato TL abre-se, o servomotor regressa ao ângulo 0º, limitado pelo contacto da came azul. O registo fecha-se completamente para reduzir as perdas de calor ao mínimo.

Caldeira sem termostato TR, substituído por um shunt

A entrada em funcionamento do queimador é da forma indicada anteriormente. Sucessivamente se a temperatura ou a pressão aumenta até à abertura do termostato TL, o queimador apaga-se (intervalo A-A do gráfico).

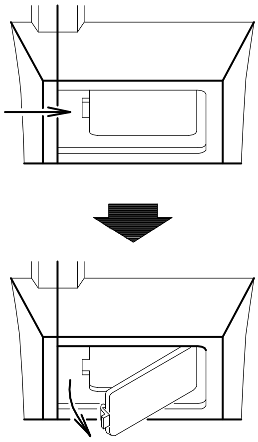
FALTA DE ACENDIMENTO (B)

Se o queimador não se acende, produz-se o bloqueio do mesmo ao fim de 3 segundos da abertura da válvula de gás e aos 49 segundos do fecho do termostato TL. Acende-se o led vermelho do equipamento.

EXTINÇÃO DA CHAMA DURANTE O FUNCIONAMENTO

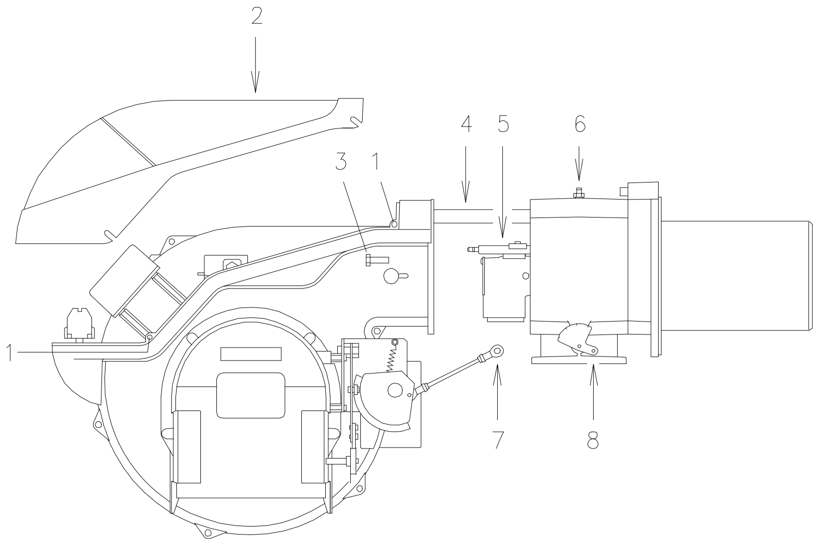
Se a chama se apagar durante o funcionamento, o queimador bloqueia-se em 1 segundo.

VISOR CHAMA



(A) D709

ABERTURA DO QUEIMADOR



(B) D3034

CONTROLO FINAL (com o queimador em funcionamento)
- Desligar um fio do pressostato gás de mínima:
- Abrir o termostato TL:
- Abrir o termostato TS:

O queimador deve parar

- Desligar o fio comum P do pressostato de ar:
- Desligar o fio da sonda de ionização:

O queimador deve bloquear-se

- Comprovar que os bloqueios mecânicos dos dispositivos de regulação estão bem apertados.

MANUTENÇÃO

Combustão
Fazer a análise dos gases de combustão que saem da caldeira. As diferenças significativas em relação à última análise indicarão os pontos onde deverão centrar-se as operações de manutenção.
Fugas de gás
Comprovar que não existem fugas de gás na conduta contador-queimador.
Filtro de gás
Substituir o cartucho filtrante quando estiver sujo.
Visor chama
Limpar o vidro do visor chama (A).
Cabeçal de combustão
Abrir o queimador e verificar que todas as partes do cabeçal de combustão estão intactas e não deformadas pelas altas temperaturas, não têm sujidade proveniente do ambiente e que estão correctamente posicionadas. No caso de duvida, desmontar a curva 5)(B).
Queimador
Verificar que não há um desgaste anormal ou parafusos frouxos nos mecanismos que controlam o registo do ar e a válvula de borboleta do gás. De igual modo, os parafusos que fixam os cabos eléctricos na régua do queimador devem estar bem apertados.
Limpar exteriormente o queimador, em particular as rótulas e a came 3)(A)p.14.
Combustão
Regular o queimador se os valores da combustão obtidos no início da intervenção não cumprem as normas em vigor ou não correspondem a uma boa combustão.
Anotar numa ficha de controlo os novos valores da combustão; serão úteis para controlos sucessivos.

PARA ABRIR O QUEIMADOR (B):
- Cortar a corrente eléctrica.
- Extrair o parafuso 1) e extrair a cobertura 2).
- Soltar a rótula 7) do sector graduado 8).
- Nos modelos com tubo de chama prolongado (385-415 mm), montar os prolongadores nas guias 4).
- Tirar o parafuso 3) e deslocar o queimador pelas guias 4) uns 100 mm.
- Desligar os cabos da sonda e do eléctrodo e deslocar todo o queimador.

Neste ponto é possível extrair o distribuidor de gás 5), depois de se ter desenroscado o parafuso 6).

PARA FECHAR O QUEIMADOR (B):
- Tirar o passador 9) e empurrar o queimador até que esteja a uns 100 mm do suporte do queimador.
- Voltar a ligar os cabos e deslocar o queimador até ao fim.
- Voltar a colocar o parafuso 3) e, com cuidado, puxar os dois cabos da sonda e do eléctrodo para fora, até que fiquem sujeitos a uma ligeira tensão.
- Voltar a enganchar a rótula 7) no sector graduado 8).
- Desmontar os dois prolongadores das guias 4).

DIAGNÓSTICO PROGRAMA DE ARRANQUE

As indicações que aparecem durante o programa de arranque, estão explicadas na seguinte tabela:

TABELA CÓDIGO COR	
Sequências	**Código cor**
Pré-varrimento	● ● ● ● ● ● ● ● ●
Fase de ligação	● ○ ● ○ ● ○ ● ○ ●
Funcionamento com chama ok	□ □ □ □ □ □ □ □ □
Funcionamento com sinal de chama fraca	□ ○ □ ○ □ ○ □ ○ □
Alimentação eléctrica inferior a ~ 170V	● ▲ ● ▲ ● ▲ ● ▲ ●
Bloqueio	▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲ ▲
Luz estranha	▲ □ ▲ □ ▲ □ ▲ □ ▲
Legenda: ○ Apagado ● Amarelo □ Verde ▲ Vermelho	

DESBLOQUEIO DO EQUIPAMENTO E UTILIZAÇÃO DO DIAGNÓSTICO

O equipamento fornecido de série possui uma sua função de diagnóstico, por meio da qual é possível localizar facilmente as eventuais causas de mau funcionamento (sinalização: **LED VERMELHO**).
Para utilizar tal função, é necessário aguardar pelo menos 10 segundos após a colocação da segurança (bloqueio) e, em seguida, pressionar o botão de desbloqueio.
O equipamento cria uma sequência de impulsos (à distância de 1 segundo) que se repete a intervalos constantes de 3 segundos.
Visualizado o número de sinais intermitentes e identificada a provável causa, é necessário reiniciar o sistema, mantendo o botão pressionado por um período de tempo compreendido entre 1 e 3 segundos.

LED VERMELHO aceso aguardar pelo menos 10s	Bloqueio	Premir desbloqueio por > 3s	Impulsos	Intervalo 3s	Impulsos
			● ● ● ● ●		● ● ● ● ●

A seguir, estão ilustrados os métodos possíveis para efectuar o desbloqueio do equipamento e para a utilização do diagnóstico.

DESBLOQUEIO DO EQUIPAMENTO

Para efectuar o desbloqueio do equipamento, agir como segue:

- Premir o botão por um período de tempo compreendido entre 1 e 3 segundos.
  O queimador arranca após uma pausa de 2 segundos depois de se ter largado o botão.
  No caso em que o queimador não arranque é necessário verificar o fechamento do termostato limite.

DIAGNÓSTICO VISUAL

Indica o tipo de defeito do queimador que determina o bloqueio do mesmo.
Para visualizar o diagnóstico, agir como segue:

- Com o led vermelho fixo (bloqueio do queimador), manter premido o botão por mais de 3 segundos.
  O fim da operação será indicado pelo acender de um led amarelo intermitente.
  Soltar o botão após o piscar do led. O número de sinais intermitentes evidencia a causa do mau funcionamento de acordo com a codificação indicada na tabela de pag. 19.

DIAGNÓSTICO SOFTWARE

Fornece a análise da vida vida do queimador por meio da conexão óptica ao PC, indicado as relativas horas de funcionamento, número e tipos de bloqueios, número de série do equipamento etc…
Para visualizar o diagnóstico, agir como segue:

- Com o led vermelho fixo (bloqueio do queimador), manter premido o botão por mais de 3 segundos.
  O fim da operação será indicado pelo acender de um led amarelo intermitente.
  Soltar o botão por 1 segundo e em seguida, voltar a premi-lo por mais de 3 segundos até à visualização de um ulterior piscar amarelo.
  Quando se solta o botão, o led vermelho irá piscar em modo intermitente com frequência elevada: só nessa altura será possível inserir a conexão óptica.

Uma vez executadas as operações, é necessário restabelecer o estado inicial do equipamento por meio do procedimento de desbloqueio acima descrito.

PRESSÃO NO BOTÃO	ESTADO DO EQUIPAMENTO
De 1 a 3 segundos	Desbloqueio do equipamento sem visualização do diagnóstico visual.
Mais de 3 segundos	Diagnóstico visual da condição de bloqueio: (piscar do led com intermitência de 1 segundo).
Mais de 3 segundos a partir da condição de diagnóstico visual	Diagnóstico software com auxílio de interface óptica e PC (possibilidade de visualização das horas de funcionamento, das anomalias, etc..)

A sequência dos impulsos emitidos pelo equipamento identifica os possíveis tipos de avaria que são ilustrados na tabela de pag. 19.

SINAL	ANOMALIA	CAUSA PROVÁVEL	SOLUÇÃO
2 sinais intermitentes ● ●	Superado o pré-varrimento e o tempo de segurança, o queimador bloqueia-se sem aparecer a chama	1 - A electroválvula VR deixa passar pouco gás	Aumentá-lo
		2 - A electroválvula VR ou VS não se abre	Substituir bobina ou painel rectificador
		3 - Pressão de gás demasiado baixa	Aumentá-la no regulador
		4 - Eléctrodo de acendimento mal regulado	Regulá-lo; ver Fig. (C)p.6
		5 - Eléctrodo à massa por rotura do isolamento	Substituí-lo
		6 - Cabo de alta tensão defeituoso	Substituí-lo
		7 - Cabo de alta tensão deformado pela alta temperatura	Substituí-lo e protegê-lo
		8 - Transformador de acendimento defeituoso	Substituí-lo
		9 - Ligação eléctrica das válvulas ou do transformador de acendimento incorrecta	Refazer as ligações
		10 - Caixa de controlo defeituosa	Substituí-la
		11 - Uma válvula antes da linha de gás, fechada	Abri-la
		12 - Ar nas tubagens	Purgá-lo
		13 - Electrov. VS e VR não ligadas ou bobina interrompida	Verificar ligação ou substituir bobina
3 sinais intermitentes ● ● ●	O queimador não arranca e acontece o bloqueio	14 - Pressostato de ar em posição de funcionamento	Regulá-lo ou substituí-lo
	O queimador arranca mas bloqueia-se de imediato	O pressostato de ar não comuta por pressão de ar insuficiente:	
		15 - Pressostato de ar mal regulado	Regulá-lo ou substituí-lo
		16 - Tubo tomada pressão ar do pressostato obstruído	Limpá-lo
		17 - Cabeçal mal regulado	Regulá-lo
		18 - Depressão excessiva na câmara de combustão	Ligar pressostato de ar à aspiração
	Bloqueio durante o pré-varrimento	19 - Interruptor remoto comando motor defeituoso	Substituí-lo
		20 - Motor eléctrico defeituoso	Substituí-lo
		21 - Bloqueio motor	Desbloquear o relé térmico ao retorno das 3 fases
4 sinais intermitentes ● ● ● ●	O queimador arranca mas bloqueia-se de imediato	22 - Simulação de chama	Substituir a caixa de controlo
	Bloqueio ao parar o queimador	23 - Há chama no cabeçal de combustão ou simulação de chama	Eliminar a chama ou substituir a caixa de controlo
7 sinais intermitentes ● ● ● ● ● ● ●	O queimador bloqueia-se ao aparecer a chama	24 - A electroválvula VR deixa passar pouco gás	Aumentá-lo
		25 - Sonda de ionização mal regulada	Regulá-la; ver Fig. (C)p.6
		26 - Ionização insuficiente (inferior a 5 µA)	Verificar a posição da sonda
		27 - Sonda à massa	Separá-la ou substituir o cabo
		28 - Terra defeituosa	Rever tomada de terra
		29 - inversão de ligação fase-neutro	Corrigir
		30 - Caixa de controlo defeituosa	Substituí-la
	Bloqueio do queimador ao passar da 1ª à 2ª chama ou da 2ª à 1ª chama	31 - Demasíado ar ou pouco gás	Regular o ar e o gás
	Em funcionamento, o queimador bloqueia-se	32 - Sonda ou cabo de ionização à massa	Substituir a(s) peça(s) deteriorada(s)
		33 - Pressostato de ar avariado	Substituí-lo
10 sinais intermitentes ● ● ● ● ● ● ● ● ● ●	O queimador não arranca e acontece o bloqueio	34 - Ligações eléctricas incorrectas	Comprová-lo
	O queimador bloqueia-se	35 - Caixa de controlo defeituosa	Substituí-la
		36 - Presença de distúrbios electromagnéticos	Utilizar o kit protecção contra as rádio-interferências
		37 - Presença de distúrbios electromagnéticos sobre as linhas dos termóstatos	Filtrá-los ou eliminá-los
Nenhum sinal intermitente	O queimador não arranca	38 - Falta corrente eléctrica	Fechar interruptores; controlar ligações eléctricas
		39 - Um termostato de regulação ou de segurança aberto	Regulá-lo ou substituí-lo
		40 - Fusível de linha de controlo fundido	Substituí-lo (2)
		41 - Caixa de controlo defeituosa	Substituí-la
		42 - Falta de gás	Abrir válvulas manuais entre o contador e a linha
		43 - Pressão de gás na rede insuficiente	Contacte a COMPANHIA DO GÁS
		44 - O pressostato de gás de mínima não fecha	Regulá-lo ou substituí-lo
	O queimador repete o ciclo de arranque sem se bloquear	45 - A pressão de gás na rede está perto do valor que se regulou no pressostato de gás de mínima. A perda repentina de pressão que se produz ao abrir-se a electroválvula provoca a abertura temporária do próprio pressostato, que faz com que a válvula feche rapidamente e o queimador pare. A pressão volta a aumentar, o pressostato fecha e faz com que o ciclo de arranque se repita. E assim sucessivamente.	Reduzir a pressão de actuação do pressostato de mínima Substituir o cartucho do filtro de gás.
	Acendimento com pulsações	46 - Cabeçal mal regulado	Regulá-lo; ver pág. 7
		47 - Eléctrodo de acendimento mal regulado	Regulá-lo; ver Fig. (C)p.6
		48 - Registo ventilador mal regulado; demasiado ar	Regulá-lo
		49 - Potência de acendimento demasiado elevada	Reduzi-la
	O queimador não passa à 2ª chama	50 - Termostato TR não fecha	Regulá-lo ou substituí-lo
		51 - Caixa de controlo defeituosa	Substituí-la
		52 - Servomotor defeituoso	Substituí-lo
	O queimador fica com o registo do ventilador aberto	53 - Servomotor defeituoso	Substituí-lo

ACESSÓRIOS (por encomenda):

- **KIT PROTECÇÃO CONTRA AS RÁDIO-INTERFERÊNCIAS**

No caso de instalação do queimador em ambientes especiais sujeitos a rádio-interferências (emissão de sinais superiores a 10 V/m) devido a presença de INVERTER ou em aplicações onde os comprimentos das conexões do termóstato superem os 20 metros, está disponível um kit de protecção como interface entre a aparelhagem e o queimado.

QUEIMADOR	RS 70 - RS 100 - RS 130
Código	3010386

- **KIT CABEÇA COMPRIDA**

QUEIMADOR	RS 70	RS 100	RS 130
Código	3010117	3010118	3010119

- **KIT PARA FUNCIONAMENTO COM GPL:** O kit permite que os queimadores RS 70 - 100 -130 funcionem com GPL.

QUEIMADOR	RS 70		RS 100		RS 130	
Potência kW	242 ÷ 814		349 ÷ 1163		466 ÷ 1512	
Comprimento do tubo de fogo mm	250	385	250	385	280	415
Código	3010097	3010098	3010099	3010100	3010101	3010102

- **KIT PARA REDUÇÃO DAS VIBRAÇÕES**

QUEIMADOR	RS 70		RS 100		RS 130	
Potência kW	192 ÷ 814		232 ÷ 1163		185 ÷ 1461	
Comprimento do tubo de fogo mm	250	385	250	385	280	415
Código	3010201		3010202		3010373	3010374

- **INTERRUPTOR DIFERENCIAL:** código **3010329**
- **LINHA DE COMANDO DE GÁS CONFORME A NORMA EN 676** (completa, com válvulas, regulador de pressão e filtro): ver página 8.

Importante: O instalador é responsável pela eventual incorporação de dispositivos de segurança não previstos neste manual.

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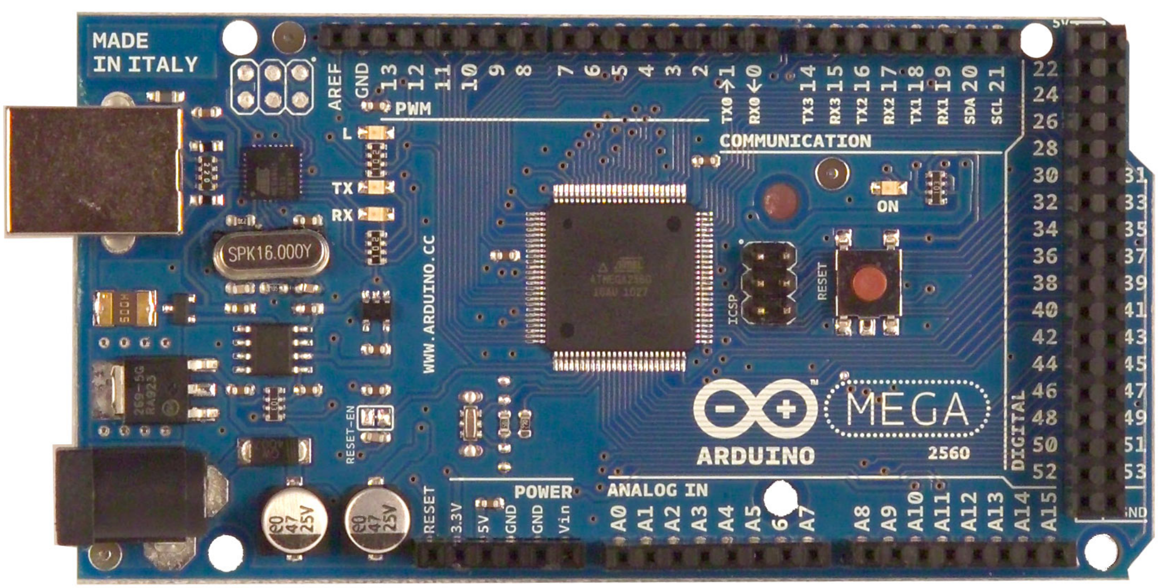
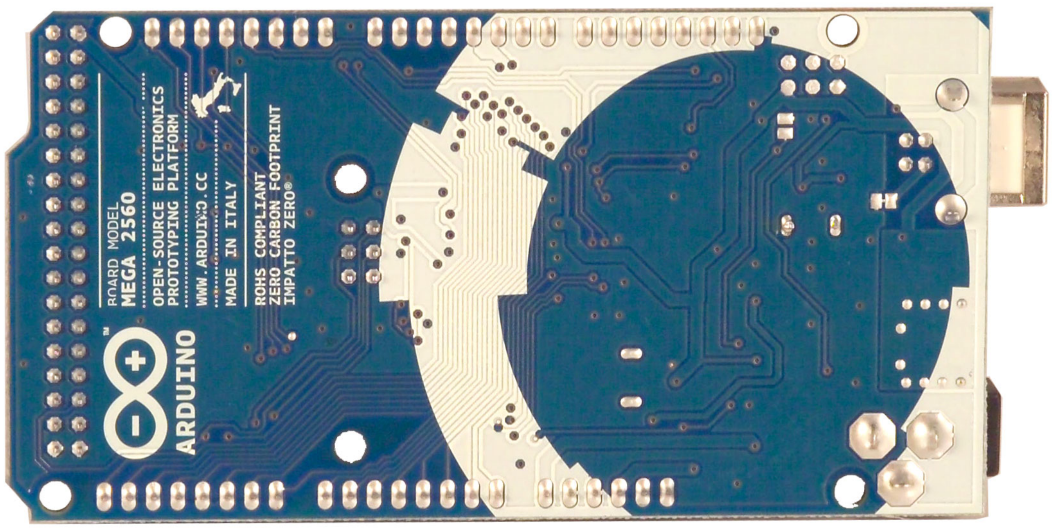
ARDUINO

Arduino Mega 2560 Datasheet





Overview

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

Schematic & Reference Design

EAGLE files: arduino-mega2560-reference-design.zip

Schematic: arduino-mega2560-schematic.pdf

Summary

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

Power

The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The Mega2560 differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

The power pins are as follows:

- **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3.** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND.** Ground pins.

Memory

The ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library).

Input and Output

Each of the 54 digital pins on the Mega can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial: 0 (RX) and 1 (TX); Serial 1: 19 (RX) and 18 (TX); Serial 2: 17 (RX) and 16 (TX); Serial 3: 15 (RX) and 14 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. Pins 0 and 1 are also connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts: 2 (interrupt 0), 3 (interrupt 1), 18 (interrupt 5), 19 (interrupt 4), 20 (interrupt 3), and 21 (interrupt 2).** These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.
- **PWM: 0 to 13.** Provide 8-bit PWM output with the analogWrite() function.
- **SPI: 50 (MISO), 51 (MOSI), 52 (SCK), 53 (SS).** These pins support SPI communication using the SPI library. The SPI pins are also broken out on the ICSP header, which is physically compatible with the Uno, Duemilanove and Diecimila.
- **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH

value, the LED is on, when the pin is LOW, it's off.

- **I2C: 20 (SDA) and 21 (SCL).** Support I2C (TWI) communication using the Wire library (documentation on the Wiring website). Note that these pins are not in the same location as the I2C pins on the Duemilanove or Diecimila.

The Mega2560 has 16 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and analogReference() function.

There are a couple of other pins on the board:

- **AREF.** Reference voltage for the analog inputs. Used with analogReference().
- **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

Communication

The Arduino Mega2560 has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega2560 provides four hardware UARTs for TTL (5V) serial communication. An ATmega8U2 on the board channels one of these over USB and provides a virtual com port to software on the computer (Windows machines will need a .inf file, but OSX and Linux machines will recognize the board as a COM port automatically. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the ATmega8U2 chip and USB connection to the computer (but not for serial communication on pins 0 and 1).
A SoftwareSerial library allows for serial communication on any of the Mega2560's digital pins.
The ATmega2560 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; see the documentation on the Wiring website for details. For SPI communication, use the SPI library.

Programming

The Arduino Mega can be programmed with the Arduino software (download). For details, see the reference and tutorials.
The ATmega2560 on the Arduino Mega comes preburned with a bootloader that allows you to upload new code to it without the use of an external hardware programmer. It

communicates using the original STK500 protocol (reference, C header files).
You can also bypass the bootloader and program the microcontroller through the ICSP (In-Circuit Serial Programming) header; see these instructions for details.

Automatic (Software) Reset

Rather then requiring a physical press of the reset button before an upload, the Arduino Mega2560 is designed in a way that allows it to be reset by software running on a connected computer. One of the hardware flow control lines (DTR) of the ATmega8U2 is connected to the reset line of the ATmega2560 via a 100 nanofarad capacitor. When this line is asserted (taken low), the reset line drops long enough to reset the chip. The Arduino software uses this capability to allow you to upload code by simply pressing the upload button in the Arduino environment. This means that the bootloader can have a shorter timeout, as the lowering of DTR can be well-coordinated with the start of the upload.
This setup has other implications. When the Mega2560 is connected to either a computer running Mac OS X or Linux, it resets each time a connection is made to it from software (via USB). For the following half-second or so, the bootloader is running on the Mega2560. While it is programmed to ignore malformed data (i.e. anything besides an upload of new code), it will intercept the first few bytes of data sent to the board after a connection is opened.
If a sketch running on the board receives one-time configuration or other data when it first starts, make sure that the software with which it communicates waits a second after opening the connection and before sending this data.
The Mega2560 contains a trace that can be cut to disable the auto-reset. The pads on either side of the trace can be soldered together to re-enable it. It's labeled "RESET-EN". You may also be able to disable the auto-reset by connecting a 110 ohm resistor from 5V to the reset line; see this forum thread for details.

USB Overcurrent Protection

The Arduino Mega2560 has a resettable polyfuse that protects your computer's USB ports from shorts and overcurrent. Although most computers provide their own internal protection, the fuse provides an extra layer of protection. If more than 500 mA is applied to the USB port, the fuse will automatically break the connection until the short or overload is removed.

Physical Characteristics and Shield Compatibility

The maximum length and width of the Mega2560 PCB are 4 and 2.1 inches respectively, with the USB connector and power jack extending beyond the former dimension. Three screw holes allow the board to be attached to a surface or case. Note that the distance between digital pins 7 and 8 is 160 mil (0.16"), not an even multiple of the 100 mil spacing of the other pins.

The Mega2560 is designed to be compatible with most shields designed for the Uno, Diecimila or Duemilanove. Digital pins 0 to 13 (and the adjacent AREF and GND pins), analog inputs 0 to 5, the power header, and ICSP header are all in equivalent locations. Further the main UART (serial port) is located on the same pins (0 and 1), as are external interrupts 0 and 1 (pins 2 and 3 respectively). SPI is available through the ICSP header on both the Mega2560 and Duemilanove / Diecimila. *Please note that* I_2C *is not located on the same pins on the Mega (20 and 21) as the Duemilanove / Diecimila (analog inputs 4 and 5).*

```
<include <LiquidCrystal.h#

<include <Stepper.h#

<include <EEPROM.h#

*****************************************//

;unsigned long currentMillis = 0

;unsigned long previousMillis = 0

;unsigned long previousMillis2 = 0

;unsigned long previousMillis3 = 0

;unsigned long previousMillis4 = 0


;int ss = 0


;int Step = 0


;int Sec = 0

;int LCDPage = 0


;boolean LEDD = LOW


Keypad//

;int LCDRstBtn = 8

;int LCDOKBtn = 9

;int LCDMenuBtn = 10

;int LCDIncBtn = 11

;int LCDDecBtn = 12


;int LCDRstBtnValue = 0

;int LCDOKBtnValue = 0
```

```
;int LCDMenuBtnValue = 0
;int LCDIncBtnValue = 0
;int LCDDecBtnValue = 0

;boolean LCDRstBtnFlag = 0
;boolean LCDOKBtnFlag = 0
;boolean LCDMenuBtnFlag = 0
;boolean LCDIncBtnFlag = 0
;boolean LCDDecBtnFlag = 0

********************************************//

********************************************//
LCD//

;int LCDRS = 0
;int LCDEn = 1
;int LCDData4 = 2
;int LCDData5 = 3
;int LCDData6 = 4
;int LCDData7 = 5
*/
LCD R/W pin to ground *
:K resistor10 *
ends to +5V and ground *
/*

********************************************//
```

```
*******************************************//
Switchs Signals//
;int OnOffSwitch = 16//
;int AutoManualSwitch = 13
;int SignalSwitch = 20

;int OnOffSwitchValue = 0//
;int AutoManualSwitchValue = 0
;int AutoManualSwitchFlaq = 0
;boolean AutoManualSwitchBtnFlag = 0

;int SignalSwitchValue = 0
;int SignalSwitchFlag = 0
;int SignalSwitchOk = 0
;boolean SignalSwitchBtnFlag = 0

*******************************************//

*******************************************//
output//
;int Relay = 19
int LED = 21;    //LED notification
;int FlashingTime = 100
*******************************************//

*******************************************//
Analoge Sensor//
```

```
;int O2Sensor = A0

;int PressureSensor = A1

;float O2SensorValue = 0

;float PressureSensorValue = 0


********************************************//


********************************************//

Steppers//

;int AirStepperI0 = 22

;int AirStepperI1 = 24

;int AirStepperI2 = 26

;int AirStepperI3 = 28

; int AirStepperSpeed1 = 30

; int AirStepperSpeed2 = 32

;int AirStepperLimit = 46

;int AirStepperLimitValue = 0

;int AirStepperCurrentLocation = 0


;int GasStepperI0 = 34

;int GasStepperI1 = 36

;int GasStepperI2 = 38

;int GasStepperI3 = 40

;int GasStepperSpeed1 = 42

;int GasStepperSpeed2 = 44

;int GasStepperLimit = 48

;int GasStepperLimitValue = 0

;int GasStepperCurrentLocation = 0
```

```
*******************************************//

*******************************************//
Variable for eeprom//
;int StepperAngle1Address = 10
;int StepperAngle2Address = 11
;int StepperAngle3Address = 12
;int StepperAngle4Address = 13
;int AutoManualAddress = 14

;int PressureAtAngle1Address = 15
;int PressureAtAngle2Address = 20
;int PressureAtAngle3Address = 25
;int PressureAtAngle4Address = 30



;int StepperAngel1 = 0
;int StepperAngel2 = 0
;int StepperAngel3 = 0
;int StepperAngel4 = 0

;float PressureAtAngel1 = 0.0
;float PressureAtAngel2 = 0.0
;float PressureAtAngel3 = 0.0
;float PressureAtAngel4 = 0.0

;float StepperAngle = 0
```

```
*******************************************//

;(LiquidCrystal lcd(LCDRS, LCDEn, LCDData4, LCDData5, LCDData6, LCDData7

;const int stepsPerRevolution = 200
Stepper AirStepper(stepsPerRevolution, AirStepperI0, AirStepperI1, AirStepperI2,
;(AirStepperI3
Stepper GasStepper(stepsPerRevolution, GasStepperI0, GasStepperI1, GasStepperI2,
;(GasStepperI3



} ()void setup
:put your setup code here, to run once //

;()Iniat_LCD
;()Iniat_Steppers
;()Iniat_OutputAndSwitchSignals
;()Read_Storg_Data

{

} ()void loop
:put your main code here, to run repeatedly //
;(GasStepper.step(-1//
;(delay(3000//
;(GasStepper.setSpeed(ss//
;++ss//
(if(ss == 150//
;ss =0 //
```

```
;()Read_PressureSensor

;()Check_Inputs

;()check_Time

(if(SignalSwitchFlag == 1

}


;Sec = 0

;Step = 1

; analogWrite(AirStepperSpeed1,150);    // set the motor_1 speed

; analogWrite(AirStepperSpeed2,150);    // set the motor_2 speed

; analogWrite(GasStepperSpeed1,150);    // set the motor_1 speed

; analogWrite(GasStepperSpeed2,150);    // set the motor_2 speed


(while(SignalSwitchFlag == 1

}

;()Read_PressureSensor

;()Check_Inputs

;()check_Time

;()Starting_

(if(Step >= 5

}

;SignalSwitchFlag = 2

;break

{

{

{
```

```
if(SignalSwitchFlag == 2 && AutoManualSwitchFlaq == 1 &&(GasStepperCurrentLocation == StepperAngel1 || GasStepperCurrentLocation == StepperAngel2 || GasStepperCurrentLocation == StepperAngel3 || GasStepperCurrentLocation == ((StepperAngel4

}

;()Read_O2Sensor

{

{

****************************************************************************************************//
********************

****************************************************************************************************//
********************

****************************************************************************************************//
********************

} ()void Iniat_LCD

;(lcd.begin(16, 2

;(pinMode(LCDRstBtn,INPUT

;(pinMode(LCDOKBtn,INPUT

;(pinMode(LCDMenuBtn,INPUT

;(pinMode(LCDIncBtn,INPUT

;(pinMode(LCDDecBtn,INPUT
```

```
{

*********************************************************************************************//
*********

}()void Iniat_Steppers

;(AirStepper.setSpeed(5

;(GasStepper.setSpeed(5


;(pinMode(AirStepperSpeed1,OUTPUT

;(pinMode(AirStepperSpeed2,OUTPUT


;(pinMode(GasStepperSpeed1,OUTPUT

;(pinMode(GasStepperSpeed2,OUTPUT


;(pinMode(AirStepperLimit,INPUT

;(pinMode(GasStepperLimit,INPUT


; analogWrite(AirStepperSpeed1,150);    // set the motor_1 speed

; analogWrite(AirStepperSpeed2,150);    // set the motor_2 speed

; analogWrite(GasStepperSpeed1,150);    // set the motor_1 speed

; analogWrite(GasStepperSpeed2,150);    // set the motor_2 speed


{

*********************************************************************************************//
*********
```

```
}()void Iniat_OutputAndSwitchSignals
;(pinMode(OnOffSwitch,INPUT //
;(pinMode(AutoManualSwitch,INPUT
;(pinMode(SignalSwitch,INPUT

;(pinMode(Relay,OUTPUT
;(pinMode(LED,OUTPUT
{

*****************************************************************************************//
*********

}()void _Starting
;(lcd.setCursor(0, 0//
;("    ... lcd.print("Starting//
;(delay(1000//


(if(Step == 1 && SignalSwitchFlag == 1
}
;(lcd.setCursor(0, 0
;("   lcd.print("Seting of Air
;(lcd.setCursor(0, 1
;("  lcd.print("and Gas values

;FlashingTime = 200
;(AirStepperLimitValue = digitalRead(AirStepperLimit
;(GasStepperLimitValue = digitalRead(GasStepperLimit
```

```
(if(AirStepperLimitValue == LOW
}
;(AirStepper.step(-1
{
(if(GasStepperLimitValue == HIGH
}
;(GasStepper.step(-1
{
;(delay(5


;()check_Time//
;if(Sec >= 3) break //


(if(AirStepperLimitValue == HIGH && GasStepperLimitValue == LOW
;Step = 2
{
;(delay(3000 //
(if(Step == 2 && SignalSwitchFlag == 1
}
;FlashingTime = 400
;()lcd.clear
;(lcd.setCursor(0, 0
;(" ...lcd.print("Go Max angle
;AirStepperCurrentLocation = -5
;GasStepperCurrentLocation = 0
;(GasStepper.step(StepperAngel4
;(AirStepper.step(StepperAngel4-AirStepperCurrentLocation
;AirStepperCurrentLocation = StepperAngel4-AirStepperCurrentLocation
```

```
;GasStepperCurrentLocation = StepperAngel4
;StepperAngle = StepperAngel4
;Step = 3
{
(if(Step == 3 && Sec >= 28  && SignalSwitchFlag == 1
}
;FlashingTime = 600
;()lcd.clear
;(lcd.setCursor(0, 0
;(" ...lcd.print("Go Min angle
;(GasStepper.step(StepperAngel1-GasStepperCurrentLocation
;(AirStepper.step(StepperAngel1-AirStepperCurrentLocation
;AirStepperCurrentLocation = StepperAngel1
;GasStepperCurrentLocation = StepperAngel1
;StepperAngle = StepperAngel1
;()Check_Inputs//
;LCDPage = 0
;(Show_LCD(LCDPage
;Step = 4
{
(if(Step == 4 && Sec >= 53  && SignalSwitchFlag == 1
}
;Step = 5
;FlashingTime = 1500
{
{

}()void check_Time
```

```
;()currentMillis = millis
} (if (currentMillis - previousMillis >= 1000
;previousMillis = currentMillis
;++Sec
;if(Sec >= 60) Sec = 0
{

} (if (currentMillis - previousMillis4 >= FlashingTime
;previousMillis4 = currentMillis
(if(LEDD == HIGH
}
;(digitalWrite(LED,LOW
;LEDD = LOW
{
else
}
;(digitalWrite(LED,HIGH
;LEDD = HIGH
{
{
{

*******************************************************************************************//
*********

}()void Read_Storg_Data
;(StepperAngel1 = EEPROM.read(StepperAngle1Address
;(StepperAngel2 = EEPROM.read(StepperAngle2Address
```

```
;(StepperAngel3 = EEPROM.read(StepperAngle3Address
;(StepperAngel4 = EEPROM.read(StepperAngle4Address

;(EEPROM.put(PressureAtAngle1Address, 4.5f //
;(EEPROM.put(PressureAtAngle2Address, 4.5f //
;(EEPROM.put(PressureAtAngle3Address, 4.5f //
;(EEPROM.put(PressureAtAngle4Address, 4.5f //


;(EEPROM.get(PressureAtAngle1Address, PressureAtAngel1
;(EEPROM.get(PressureAtAngle2Address, PressureAtAngel2
;(EEPROM.get(PressureAtAngle3Address, PressureAtAngel3
;(EEPROM.get(PressureAtAngle4Address, PressureAtAngel4

;(AutoManualSwitchFlaq = EEPROM.read(AutoManualAddress

{


}()void Stored_Data
(switch(LCDPage
}
:case 1
}
;(EEPROM.write(StepperAngle1Address, StepperAngel1
;break
{
:case 2
```

```
}
;(EEPROM.write(StepperAngle2Address, StepperAngel2
;break
{
:case 3
}
;(EEPROM.write(StepperAngle3Address, StepperAngel3
;break
{
:case 4
}
;(EEPROM.write(StepperAngle4Address, StepperAngel4
;break
{
:case 5
}
;(EEPROM.put(PressureAtAngle1Address, PressureAtAngel1
;break
{
:case 6
}
;(EEPROM.put(PressureAtAngle2Address, PressureAtAngel2
;break
{
:case 7
}
;(EEPROM.put(PressureAtAngle3Address, PressureAtAngel3
;break
```

```
{
:case 8
}
;(EEPROM.put(PressureAtAngle4Address, PressureAtAngel4
;break
{




{


{
************************************************************************************************//
*********


}()void Check_Inputs


;(LCDRstBtnValue = digitalRead(LCDRstBtn
;(LCDOKBtnValue = digitalRead(LCDOKBtn
;(LCDMenuBtnValue = digitalRead(LCDMenuBtn
;(LCDIncBtnValue = digitalRead(LCDIncBtn
;(LCDDecBtnValue = digitalRead(LCDDecBtn


;(OnOffSwitchValue = digitalRead(OnOffSwitch//
;(AutoManualSwitchValue = digitalRead(AutoManualSwitch
;(SignalSwitchValue = digitalRead(SignalSwitch


( if(LCDRstBtnValue == LOW && LCDRstBtnFlag == 0
```

```
}
;LCDRstBtnFlag = 1

(switch(LCDPage
}
:case 1
}
;(StepperAngel1 = EEPROM.read(StepperAngle1Address
;break
{
:case 2
}
;(StepperAngel2 = EEPROM.read(StepperAngle2Address
;break
{
:case 3
}
;(StepperAngel3 = EEPROM.read(StepperAngle3Address
;break
{
:case 4
}
;(StepperAngel4 = EEPROM.read(StepperAngle4Address
;break
{
:case 5
}
;(EEPROM.get(PressureAtAngle1Address, PressureAtAngel1
```

```
;break
{
:case 6
}
;(EEPROM.get(PressureAtAngle1Address, PressureAtAngel2
;break
{
:case 7
}
;(EEPROM.get(PressureAtAngle1Address, PressureAtAngel3
;break
{
:case 8
}
;(EEPROM.get(PressureAtAngle1Address, PressureAtAngel4
;break
{
{
;(Show_LCD(LCDPage
{
(else if(LCDRstBtnValue == HIGH
;LCDRstBtnFlag = 0

(if(LCDOKBtnValue == LOW && LCDOKBtnFlag == 0 && LCDPage>0
}
;LCDOKBtnFlag = 1
;()Stored_Data
;(lcd.setCursor(14, 1
```

```
;("lcd.print("OK
{
(else if(LCDOKBtnValue == HIGH
;LCDOKBtnFlag = 0

(if(LCDMenuBtnValue == LOW && LCDMenuBtnFlag == 0
}
;LCDMenuBtnFlag = 1
;++LCDPage
;if(LCDPage == 9) LCDPage = 0
;(Show_LCD(LCDPage
{
(else if(LCDMenuBtnValue == HIGH
;LCDMenuBtnFlag = 0

(if(LCDIncBtnValue == LOW && LCDPage>0 && LCDIncBtnFlag == 0
}
;LCDIncBtnFlag = 1
;(AirStepper.step(1 //
;StepperAngle = StepperAngle + 1.8 //
(switch(LCDPage
}
:case 1
}
;++StepperAngel1
;if(StepperAngel1 >=51) StepperAngel1 = 51
;break
{
```

```
:case 2
}
;++StepperAngel2
;if(StepperAngel2 >=51) StepperAngel2 = 51
;break
{
:case 3
}
;++StepperAngel3
;if(StepperAngel3 >=51) StepperAngel3 = 51
;break
{
:case 4
}
;++StepperAngel4
;if(StepperAngel4 >=51) StepperAngel4 = 51
;break
{
:case 5
}
;PressureAtAngel1 = PressureAtAngel1 + 0.5
;if(PressureAtAngel1 >= 12) PressureAtAngel1 = 12
;break
{
:case 6
}
;PressureAtAngel2 = PressureAtAngel2 + 0.5
;if(PressureAtAngel2 >= 12) PressureAtAngel2 = 12
```

```
;break
{
:case 7
}
;PressureAtAngel3 = PressureAtAngel3 + 0.5
;if(PressureAtAngel3 >= 12) PressureAtAngel3 = 12
;break
{
:case 8
}
;PressureAtAngel4 = PressureAtAngel4 + 0.5
;if(PressureAtAngel4 >= 12) PressureAtAngel4 = 12
;break
{

{
;(Show_LCD(LCDPage
{
(else if(LCDIncBtnValue == HIGH
;LCDIncBtnFlag = 0

(if(LCDDecBtnValue == LOW && LCDPage>0 && LCDDecBtnFlag == 0
}
;LCDDecBtnFlag = 1
;(AirStepper.step(-1 //
;StepperAngle = StepperAngle - 1.8 //
(switch(LCDPage
}
```

```
:case 1
}
;--StepperAngel1
;if(StepperAngel1 <=0) StepperAngel1 = 0
;break
{
:case 2
}
;--StepperAngel2
;if(StepperAngel2 <=0) StepperAngel2 = 0
;break
{
:case 3
}
;--StepperAngel3
;if(StepperAngel3 <=0) StepperAngel3 = 0
;break
{
:case 4
}
;--StepperAngel4
;if(StepperAngel4 <=0) StepperAngel4 = 0
;break
{
:case 5
}
;PressureAtAngel1 = PressureAtAngel1 - 0.5
;if(PressureAtAngel1 <=0) PressureAtAngel1 = 0
```

```
;break
{
:case 6
}
;PressureAtAngel2 = PressureAtAngel2 - 0.5
;if(PressureAtAngel2 <=0) PressureAtAngel2 = 0
;break
{
:case 7
}
;PressureAtAngel3 = PressureAtAngel3 - 0.5
;if(PressureAtAngel3 <=0) PressureAtAngel3 = 0
;break
{
:case 8
}
;PressureAtAngel4 = PressureAtAngel4 - 0.5
;if(PressureAtAngel4 <=0) PressureAtAngel4 = 0
;break
{


{
;(Show_LCD(LCDPage
{
(else if(LCDDecBtnValue == HIGH
;LCDDecBtnFlag = 0
```

```
( if(AutoManualSwitchValue == LOW && AutoManualSwitchBtnFlag == 0
}
;AutoManualSwitchBtnFlag = 1
(if(AutoManualSwitchFlaq == 0
}
;AutoManualSwitchFlaq = 1
;(EEPROM.write(AutoManualAddress, AutoManualSwitchFlaq
{

else
}
;AutoManualSwitchFlaq = 0
;(EEPROM.write(AutoManualAddress, AutoManualSwitchFlaq
{
{
(else if(AutoManualSwitchValue == HIGH
;AutoManualSwitchBtnFlag = 0

(if(SignalSwitchValue == LOW && SignalSwitchFlag == 0 && SignalSwitchBtnFlag == 0
}
;SignalSwitchFlag = 1
;SignalSwitchBtnFlag = 1
{
( else if(SignalSwitchValue == HIGH
}
;SignalSwitchFlag = 0
;SignalSwitchBtnFlag = 0
;Step = 0
```

```
; analogWrite(AirStepperSpeed1,0);    // set the motor_1 speed
; analogWrite(AirStepperSpeed2,0);    // set the motor_2 speed
; analogWrite(GasStepperSpeed1,0);    // set the motor_1 speed
; analogWrite(GasStepperSpeed2,0);    // set the motor_2 speed

{

{

********************************************************************************************//
*********

}(void Show_LCD(int Page
}(switch(Page
:case 0
}
;()lcd.clear
;(lcd.setCursor(0, 0
;("=lcd.print("O2
;(lcd.print(O2SensorValue
;("=lcd.print("% Pr
;(lcd.print(PressureSensorValue
;("lcd.print("B
;(lcd.setCursor(0, 1
;("<lcd.print("A&G
;(lcd.print(StepperAngle * 1.8
;(" if(AutoManualSwitchFlaq == 0) lcd.print(" Ma
```

```
;(" if(AutoManualSwitchFlaq == 1) lcd.print(" Au
;(lcd.print(Sec

;break
{
:case 1
}
;()lcd.clear
;(lcd.setCursor(0, 0
;(" = lcd.print("Angel1
;(lcd.print(StepperAngel1*1.8
;break
{
:case 2
}
;()lcd.clear
;(lcd.setCursor(0, 0
;(" = lcd.print("Angel2
;(lcd.print(StepperAngel2*1.8
;break
{
:case 3
}
;()lcd.clear
;(lcd.setCursor(0, 0
;(" = lcd.print("Angel3
;(lcd.print(StepperAngel3*1.8
;break
```

```
{
:case 4
}
;()lcd.clear
;(lcd.setCursor(0, 0
;(" = lcd.print("Angel4
;(lcd.print(StepperAngel4*1.8
;break
{
:case 5
}
;()lcd.clear
;(lcd.setCursor(0, 0
;("=lcd.print("Ang1
;(lcd.print(StepperAngel1* 1.8
;(lcd.setCursor(0, 1
;("=lcd.print("--> Pr
;(lcd.print(PressureAtAngel1
;break
{
:case 6
}
;()lcd.clear
;(lcd.setCursor(0, 0
;("=lcd.print("Ang2
;(lcd.print(StepperAngel2* 1.8
;(lcd.setCursor(0, 1
;("=lcd.print("--> Pr
```

```
;(lcd.print(PressureAtAngel2
;break
{
:case 7
}
;()lcd.clear
;(lcd.setCursor(0, 0
;("=lcd.print("Ang3
;(lcd.print(StepperAngel3* 1.8
;(lcd.setCursor(0, 1
;("=lcd.print("--> Pr
;(lcd.print(PressureAtAngel3
;break
{
:case 8
}
;()lcd.clear
;(lcd.setCursor(0, 0
;("=lcd.print("Ang4
;(lcd.print(StepperAngel4* 1.8
;(lcd.setCursor(0, 1
;("=lcd.print("--> Pr
;(lcd.print(PressureAtAngel4
;break
{
{
{
```

```
*******************************************************************************************//
*****************
}()void Read_PressureSensor



;()currentMillis = millis


} (if (currentMillis - previousMillis2 >= 1000
;previousMillis2 = currentMillis


;(int PressuresensorInt = analogRead(PressureSensor
;(float voltage = PressuresensorInt * (5.0 / 1023.0


;PressureSensorValue = (voltage-1) / 0.15


if(PressureSensorValue < PressureAtAngel4 && SignalSwitchValue == LOW &&
(SignalSwitchFlag == 2
}
(if(GasStepperCurrentLocation <StepperAngel4
}
(if(GasStepperCurrentLocation == AirStepperCurrentLocation
}
;(GasStepper.step(1
;(AirStepper.step(1
;++AirStepperCurrentLocation
;++GasStepperCurrentLocation
;StepperAngle = GasStepperCurrentLocation
{
else
```

```
}

;(AirStepper.setSpeed(60

;(AirStepper.step(GasStepperCurrentLocation-AirStepperCurrentLocation

;(AirStepper.setSpeed(5

;AirStepperCurrentLocation = GasStepperCurrentLocation

{

{

{


else if(PressureSensorValue < PressureAtAngel3 && PressureSensorValue >=
(PressureAtAngel4 && SignalSwitchValue == LOW && SignalSwitchFlag == 2

}

(if(GasStepperCurrentLocation == AirStepperCurrentLocation

}

(if(GasStepperCurrentLocation <StepperAngel3

}

;(GasStepper.step(1

;(AirStepper.step(1

;++AirStepperCurrentLocation

;++GasStepperCurrentLocation

;StepperAngle = GasStepperCurrentLocation

{

(else if(GasStepperCurrentLocation > StepperAngel3

}

;(GasStepper.step(-1

;(AirStepper.step(-1

;--AirStepperCurrentLocation

;--GasStepperCurrentLocation
```

```
;StepperAngle = GasStepperCurrentLocation
{
{
else
}
;(AirStepper.setSpeed(60
;(AirStepper.step(GasStepperCurrentLocation-AirStepperCurrentLocation
;(AirStepper.setSpeed(5
;AirStepperCurrentLocation = GasStepperCurrentLocation
{
{
else if(PressureSensorValue < PressureAtAngel2 && PressureSensorValue >=
(PressureAtAngel3 && SignalSwitchValue == LOW && SignalSwitchFlag == 2
}
(if(GasStepperCurrentLocation == AirStepperCurrentLocation
}
(if(GasStepperCurrentLocation <StepperAngel2
}
;(GasStepper.step(1
;(AirStepper.step(1
;++AirStepperCurrentLocation
;++GasStepperCurrentLocation
;StepperAngle = GasStepperCurrentLocation
{
(else if(GasStepperCurrentLocation > StepperAngel2
}
;(GasStepper.step(-1
;(AirStepper.step(-1
```

```
;--AirStepperCurrentLocation

;--GasStepperCurrentLocation

;StepperAngle = GasStepperCurrentLocation

{

{

else

}

;(AirStepper.setSpeed(60

;(AirStepper.step(GasStepperCurrentLocation-AirStepperCurrentLocation

;(AirStepper.setSpeed(5

;AirStepperCurrentLocation = GasStepperCurrentLocation

{




{


else if(PressureSensorValue < PressureAtAngel1 && PressureSensorValue >=
(PressureAtAngel2 && SignalSwitchValue == LOW && SignalSwitchFlag == 2

}

(if(GasStepperCurrentLocation == AirStepperCurrentLocation

}

(if(GasStepperCurrentLocation > StepperAngel1

}

;(GasStepper.step(-1

;(AirStepper.step(-1

;--AirStepperCurrentLocation

;--GasStepperCurrentLocation
```

```
;StepperAngle = GasStepperCurrentLocation
{
{
else
}
;(AirStepper.setSpeed(60
;(AirStepper.step(GasStepperCurrentLocation-AirStepperCurrentLocation
;(AirStepper.setSpeed(5
;AirStepperCurrentLocation = GasStepperCurrentLocation
{
{
(if(PressureSensorValue < PressureAtAngel1
}
;(digitalWrite(Relay,LOW
{
(else if (PressureSensorValue >= PressureAtAngel1
}
;(digitalWrite(Relay,HIGH
{
;(Show_LCD(LCDPage
{
{

*************************************************************************************************//
*****************
}()void Read_O2Sensor
```

```
;PressureSensorValue = (voltage-1) / 0.15//


;()currentMillis = millis


} (if (currentMillis - previousMillis3 >= 2000
;previousMillis3 = currentMillis


;(int O2sensorInt = analogRead(O2Sensor
;(float O2SensorValue = O2sensorInt * (5.0 / 1023.0


(if(O2SensorValue <= 0.4
}
;(AirStepper.step(1
;++AirStepperCurrentLocation
{
(else if(O2SensorValue >= 0.6
}
;(AirStepper.step(-1
;--AirStepperCurrentLocation
{
{
{
```

Stepper Motor NEMA 17

This document describes mechanical and electrical specifications for PBC Linear stepper motors; including standard, hollow, and extended shaft variations.

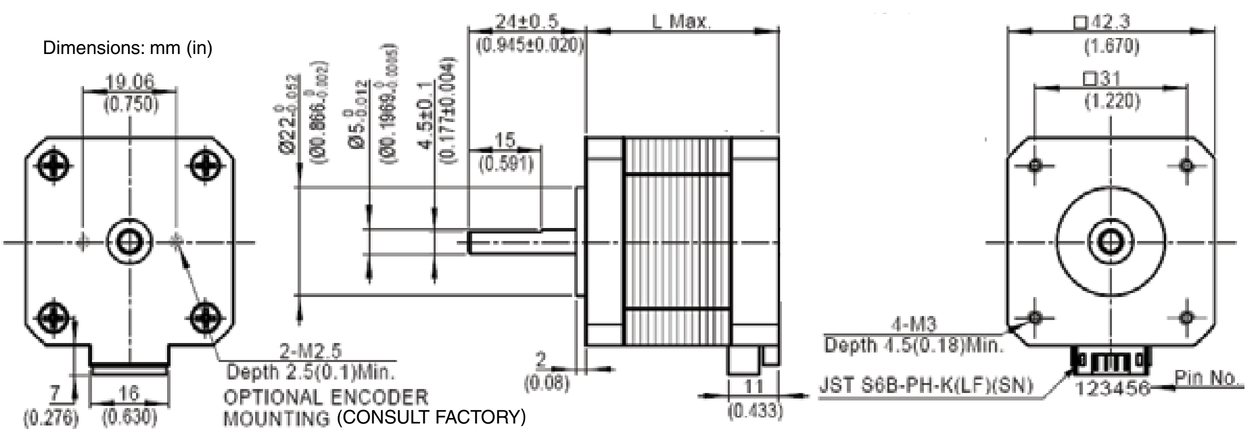
Standard shaft motor shown.

Phases	2
Steps/Revolution	200
Step Accuracy	±5%
Shaft Load	20,000 Hours at 1000 RPM
Axial	25 N (5.6 lbs.) Push
	65 N (15 lbs.) Pull
Radial	29 N (6.5 lbs.) At Flat Center
IP Rating	40
Approvals	RoHS
Operating Temp	-20° C to +40° C
Insulation Class	B, 130° C
Insulation Resistance	100 MegOhms

Description	Length	Mounted Rated Current	Mounted Holding Torque		Winding Ohms	Winding mH	Detent Torque		Rotor Inertia		Motor Weight	
(Stack)	"L" Max	Amps	Nm Typ.	oz-in Typ.	±10% @ 20°C	Typ.	mNm	oz-in	g cm2	oz-in2	kg	lbs
Single	39.8 mm (1.57 in)	2	0.48	68	1.04	2.2	15	2.1	57	0.31	0.28	0.62
Double	48.3 mm (1.90 in)	2	0.63	89	1.3	2.9	25	3.5	82	0.45	0.36	0.79
Triple	62.8 mm (2.47 in)	2	0.83	120	1.49	3.8	30	4.2	123	0.67	0.6	1.3

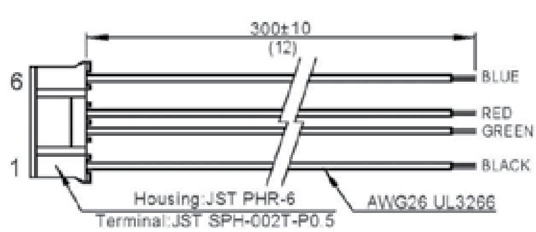
*All standard motors have plug connector. Consult factory for other options.

Dimensions: mm (in)



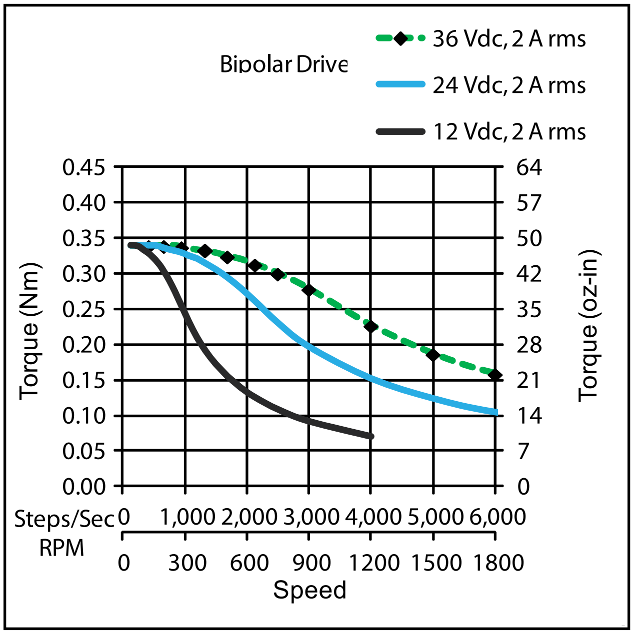
Standard shaft dimensions shown. All other dimensions apply to hollow and extended shaft options.

Dimensions: mm (in)
4 Lead Connector, PBC Part#6200490
(Consult factory for optional motor connectors)

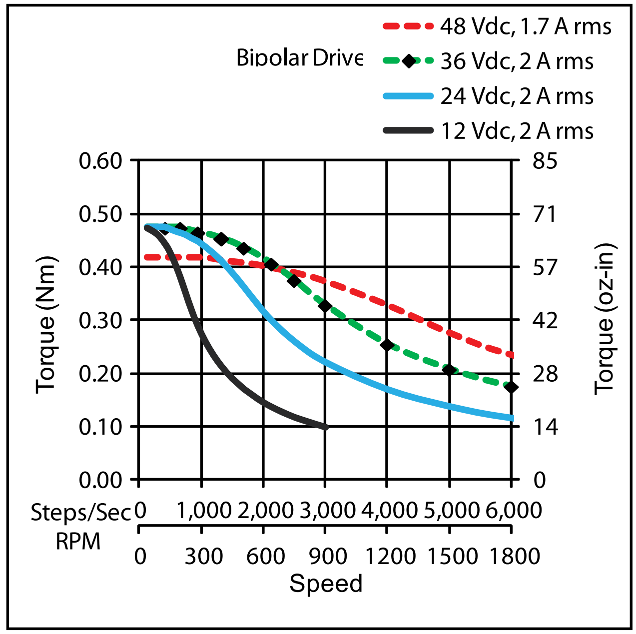


NEMA 17 **Stepper Motor**

*Performance curves apply to continuous duty cycles.
Consult factory for intermittent cycles or other voltages.



Single Stack



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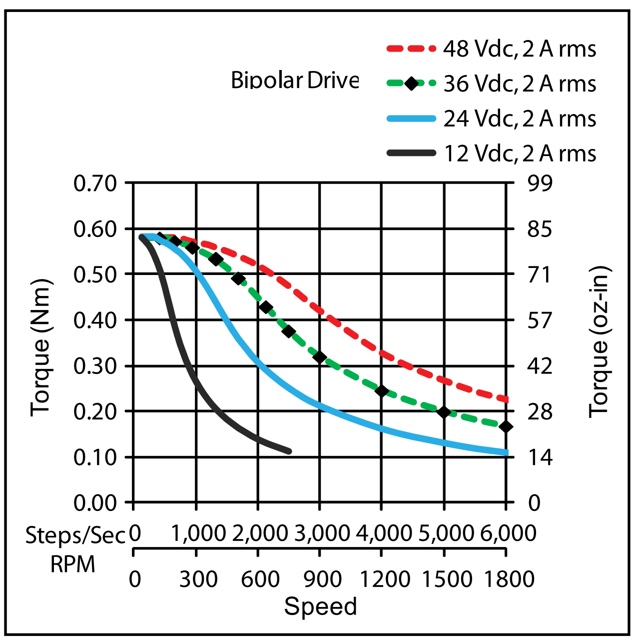


Triple Stack

Stepper Motor NEMA 23

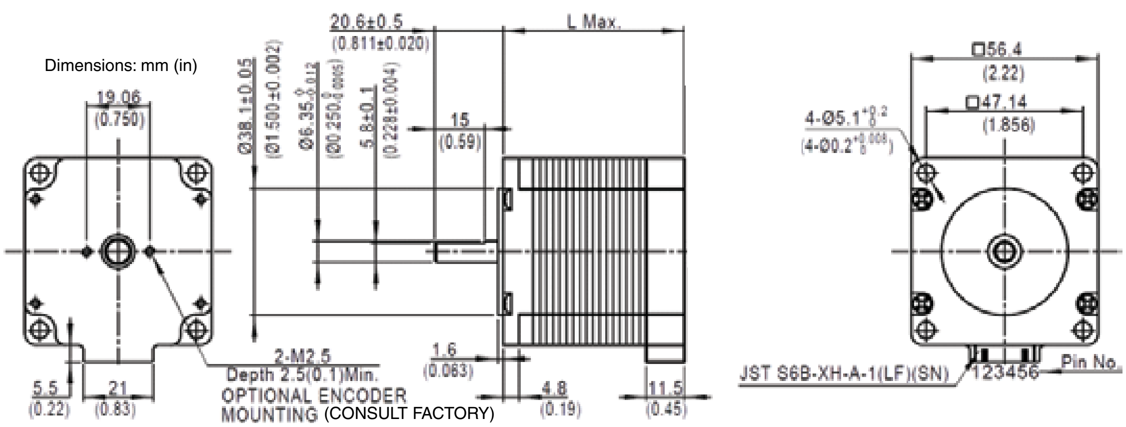
This document describes mechanical and electrical specifications for PBC Linear stepper motors; including standard, hollow, and extended shaft variations.

Standard shaft motor shown.

Phases	2
Steps/Revolution	200
Step Accuracy	±5%
Shaft Load	20,000 Hours at 1000 RPM
Axial	40 N (9 lbs.) Push
	130 N (30 lbs.) Pull
Radial	70 N (15.5 lbs.) At Flat Center
IP Rating	40
Approvals	RoHS
Operating Temp	-20° C to +40° C
Insulation Class	B, 130° C
Insulation Resistance	100 MegOhms

Description	Length	Mounted Rated Current	Mounted Holding Torque		Winding Ohms	Winding mH	Detent Torque		Rotor Inertia		Motor Weight	
(Stack)	"L" Max	Amps	Nm Typ.	oz-in Typ.	±10% @ 20°C	Typ.	mNm	oz-in	g cm2	oz-in2	kg	lbs
Single	55.0 mm (2.17 in)	2.2	1.50	210	1.6	6.9	45	6.4	220	1.2	0.6	1.3
Double	77.0 mm (3.03 in)	3	2.30	330	1.1	4.5	75	11	390	2.1	1	2.2
Power Plus (Triple)	77.0 mm (3.03 in)	3	3.30	470	1.1	3.7	150	21	390	2.1	1.1	2.4

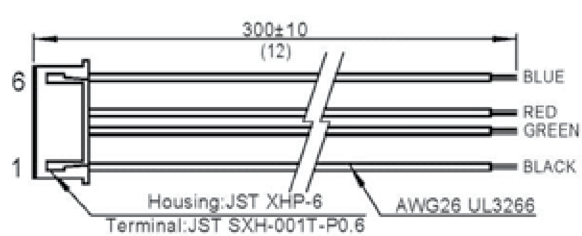
*All standard motors have plug connector. Consult factory for other options.



Motor with leads: Lead wire is 22 AWG UL3266, 300 ±10 (12 ±.5) long

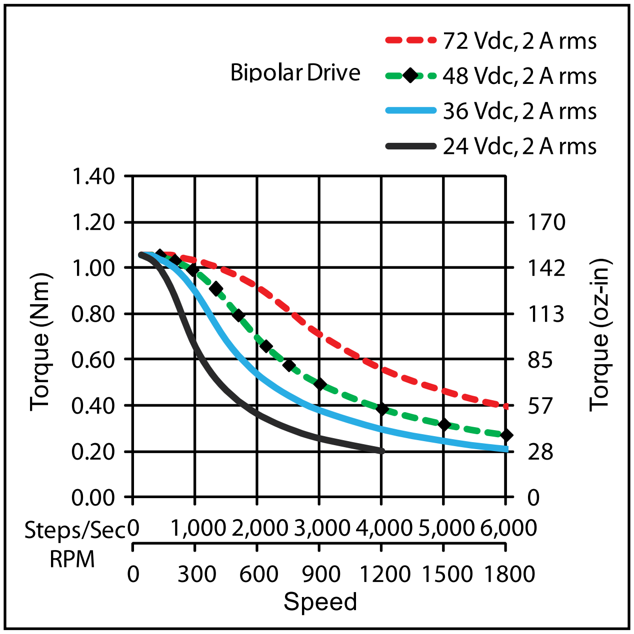
Standard shaft dimensions shown. All other dimensions apply to hollow and extended shaft options.

Dimensions: mm (in)
4 Lead Connector, PBC Part#6200491
(Consult factory for optional motor connectors)



NEMA 23 **Stepper Motor**

*Performance curves apply to continuous duty cycles.
Consult factory for intermittent cycles or other voltages.



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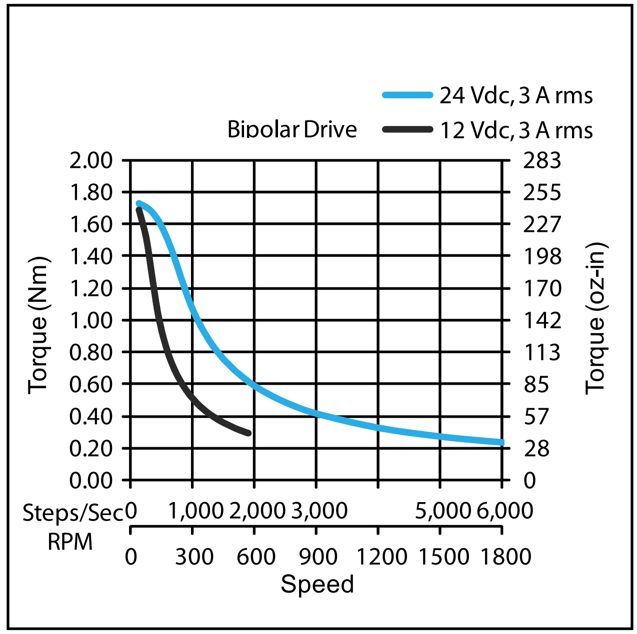

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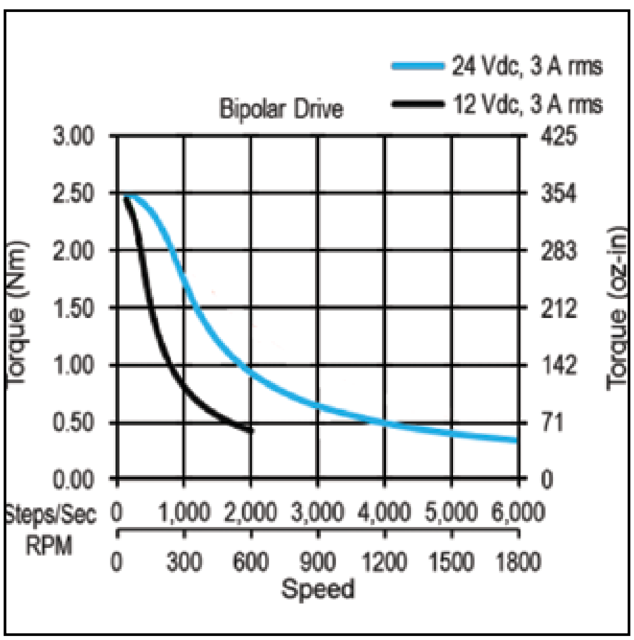


Power Plus (Triple Stack)

STEPPER MOTOR DRIVING

By H. SAX

Dedicated integrated circuits have dramatically simplified stepper motor driving. To apply these ICs designers need little specific knowledge of motor driving techniques, but an under-standing of the basics will help in finding the best solution. This note explains the basics of stepper motor driving and describes the drive techniques used today.

From a circuit designer's point of view stepper motors can be divided into two basic types : unipolar and bipolar.

A stepper motor moves one step when the direction of current flow in the field coil(s) changes, reversing the magnetic field of the stator poles. The difference between unipolar and bipolar motors lies in the may that this reversal is achieved (figure 1) :

Figure 1a : BIPOLAR - with One Field Coil and Two Chargeover Switches That are Switched in the Opposite Direction.

Figure 1b : UNIPOLAR - with Two Separate Field Coils and are Chargeover Switch.

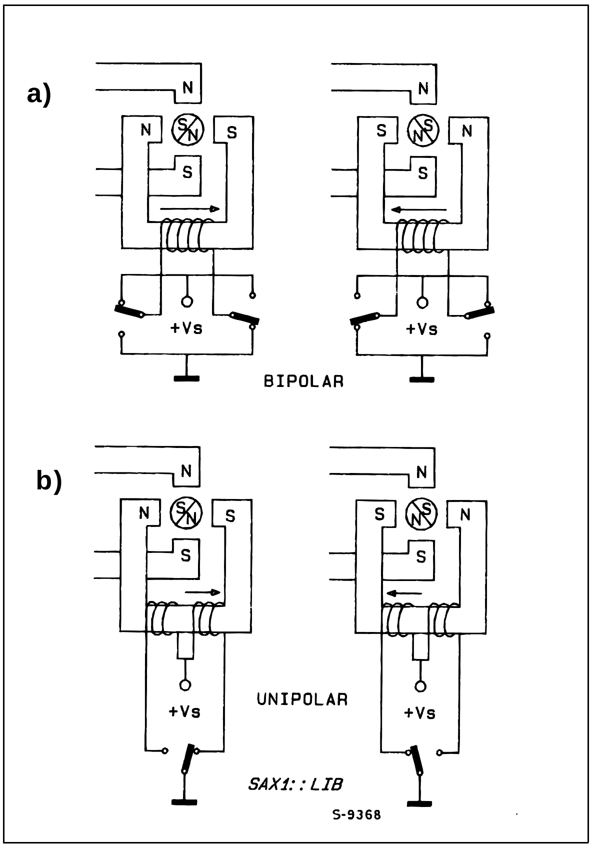
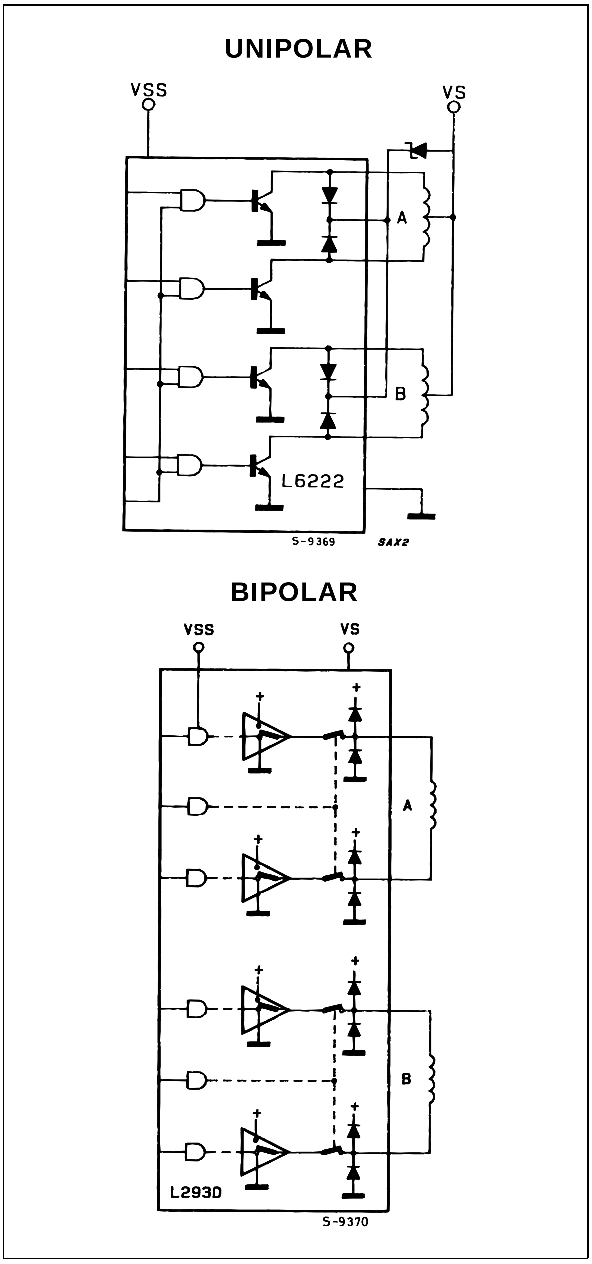


Figure 2 : ICs for Unipolar and Bipolar Driving.



The advantage of the bipolar circuit is that there is only one winding, with a good bulk factor (low winding resistance). The main disapuantages are the two changeover switches because in this case more semiconductors are needed.

The unipolar circuit needs only one changeover switch. Its enormous disadvantage is, however, that a double bifilar winding is required. This means that at a specific bulk factor the wire is thinner and the resistance is much higher. We will discuss later the problems involved.

Unipolar motors are still popular today because the drive circuit appears to be simpler when implemented with discrete devices. However with the integrated circuits available today bipolar motors can be driver with no more components than the unipolar motors. Figure 2 compares integrated unipolar and bipolar devices.

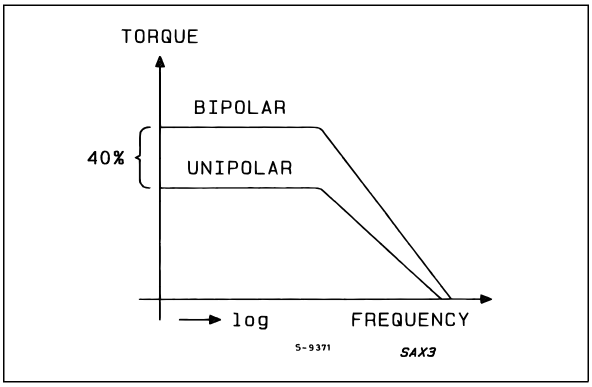
BIPOLAR PRODUCES MORE TORQUE

The torque of the stepper motor is proportional to the magnetic field intensity of the stator windings. It may be increased only by adding more windings or by increasing the current.

A natural limit against any current increase is the danger of saturating the iron core. Though this is of minimal importance. Much more important is the maximum temperature rise of the motor, due to the power loss in the stator windings. This shows one advantage of the bipolar circuit, which, compared to unipolar systems, has only half of the copper resistance because of the double cross section of the wire. The winding current may be increased by the factor $\sqrt{2}$ and this produces a direct proportional affect on the torque. At their power loss limit bipolar motors thus deliver about 40 % more torque (fig. 3) than unipolar motors built on the same frame.

If a higher torque is not required, one may either reduce the motor size or the power loss.

Figure 3 : Bipolar Motors Driver Deliver More Torque than Unipolars.



CONSTANT CURRENT DRIVING

In order to keep the motor's power loss within a reasonable limit, the current in the windings must be controlled.

A simple and popular solution is to give only as much voltage as needed, utilizing the resistance (R_L) of the winding to limit the current (fig. 4a). A more complicated but also more efficient and precise solution is the inclusion of a current generator (fig. 4b), to achieve independence from the winding resistance. The supply voltage in Fig. 4b has to be higher than the one in Fig. 4a. A comparison between both circuits in the dynamic load/working order shows visible differences.

Figure 4 : Resistance Current Limiter (a) and Current Generator Limiting.

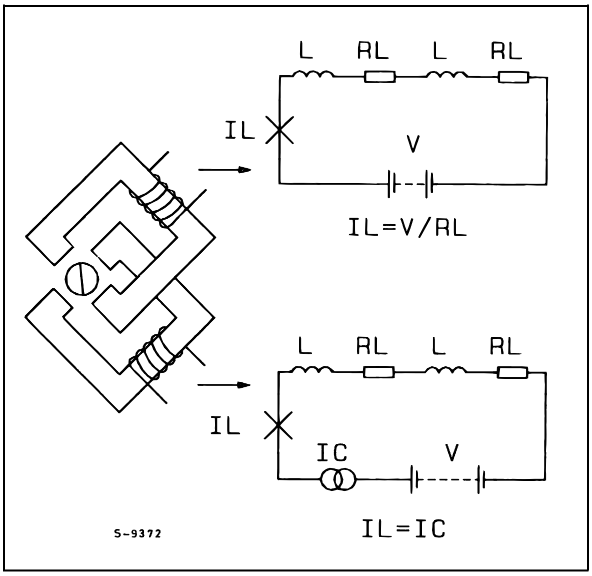
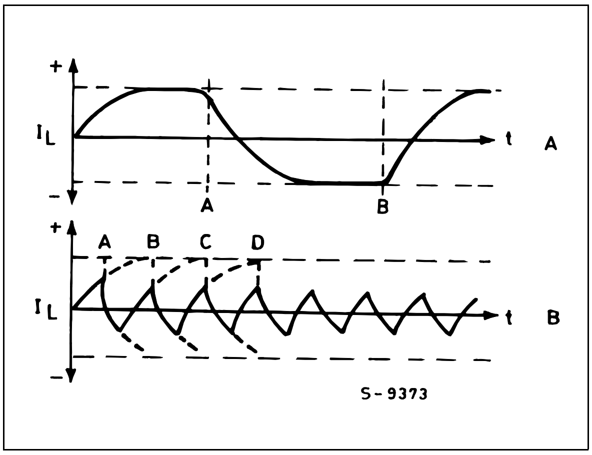


Figure 5 : At High Step Frequencies the Winding Current cannot Reach its Setting Value because of the Continuous Direction Change.



SGS-THOMSON MICROELECTRONICS

It has already been mentioned that this power of the motor is, among others, proportional to the winding current.

In the dynamic working order a stepper motor changes poles of the winding current in the same stator winding after two steps. The speed with which the current changes its direction in the form of an exponential function depends on the specified inductance, the coil resistance and on the voltage. Fig. 5a shows that at a low step rate the winding current I_L reaches its nominal value V_L/R_L before the direction is changed. However, if the poles of the stator windings are changed more often, which corresponds to a high step frequency, the current no longer reaches its saturating value because of the limited change time ; the power and also the torque diminish clearly at increasing number of revolutions (fig. 5).

MORE TORQUE AT A HIGHER NUMBER OF REVOLUTIONS

Higher torque at faster speeds are possible if a current generator as shown in Fig. 4b is used. In this application the supply voltage is chosen as high possible to increase the current's rate of change. The current generator itself limits only the phase current and becomes active only the moment in which the coil current has reached its set nominal value. Up to this value the current generator is in saturation and the supply voltage is applied directly to the winding.

Fig. 6, shows that the rate of the current increase is now much higher than in Figure 5. Consequently at higher step rates the desired current can be maintained in the winding for a longer time. The torque decrease starts only at much higher speeds.

Fig. 7 shows the relation between torque and speed in the normal graphic scheme, typical for the stepper motor. It is obvious that the power increases in the upper torque range where it is normally needed, as the load to be driven draws most energy from the motor in this range.

EFFICIENCY - THE DECISIVE FACTOR

The current generator combined with the high supply voltage guarantees that the rate of change of the current in the coil is sufficiently high.

At the static condition or at low numbers of revolutions, however, this means that the power loss in the current generator dramatically increases, although the motor does not deliver any more energy in this range ; the efficiency factor is extremely bad.

Help comes from a switched current regulation using the switch-transformer principle, as shown in fig. 8. The phase winding is switched to the supply voltage until the current, detected across R_S, reaches the desired nominal value. At that moment the switch, formerly connected to + V_S, changes position and shorts out the winding. In this way the current is stored, but it decays slowly because of inner winding losses. The discharge time of the current is determined during this phase by a monostable or pulse oscillator. After this time one of the pole changing switches changes back to + V_S, starting an induction recharge and the clock-regulation-cycle starts again.

Figure 6 : With a Step Current Slew, it is not a Problem to Obtain, even at High Step frequencies Sufficient Current in Windings.

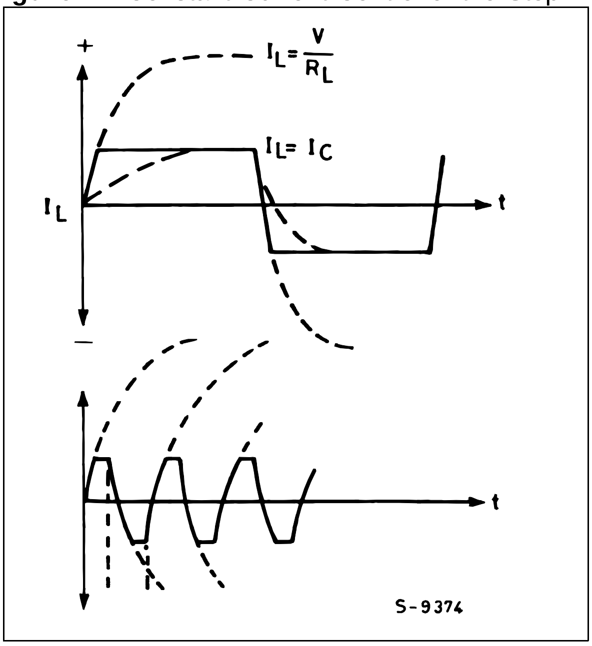
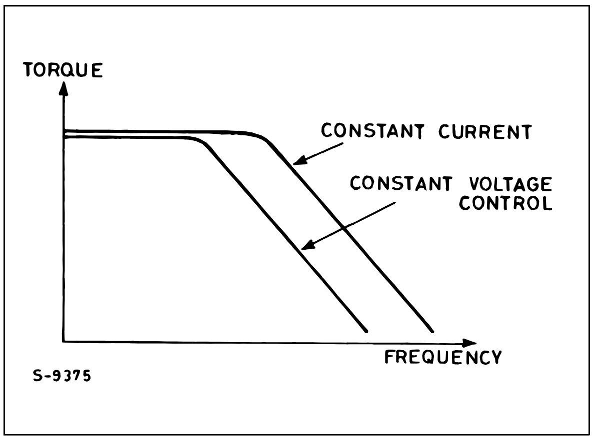


Figure 7 : Constant Current Control of the Stepper Motor Means more Torque at High Frequency.

Since the only losses in this technique are the satu-



ration loss of the switch and that of the coil resistance, the total efficiency is very high.

The average current that flows from the power supply line is less than the winding current due to the concept of circuit inversion. In this way also the power unit is discharged. This king of phase current control that has to be done separately for each motor phase leads to the best ratio between the supplied electrical and delivered mechanical energy.

POSSIBLE IMPROVEMENTS OF THE UNIPOLAR CIRCUIT

It would make no sense to apply the same principle to a stabilized current controlled unipolar circuit, as two more switches per phase would be necessary for the shortening out of the windings during the free phase and thus the number of components would be the same as for the bipolar circuit ; and moreover, there would be the well known torque disadvantage.

From the economic point of view a reasonable and justifiable improvement is the "Bi-Level-Drive" (fig. 9). This circuit concept works with two supply voltages ; with every new step of the motor both windings are connected for a short time to a high supply voltage. This considerably increases the current rate of change and its behaviour corresponds more or less to the stabilized power principle. After a pre-determined the switch opens, a no a lower supply voltage is connected to the winding thru a diode.

This kind of circuit by no means reaches the performance of the clocked stabilized power control as per fig. 8, as the factors : distribution voltage oscillation, B.e.m.f., thermal winding resistance, as well as the separate coil current regulation are not considered, but it is this circuit that makes the simple unipolar R/L-control suitable for many fields of application.

Figure 8 : With Switch Mode Current Regulation Efficiency is Increased.

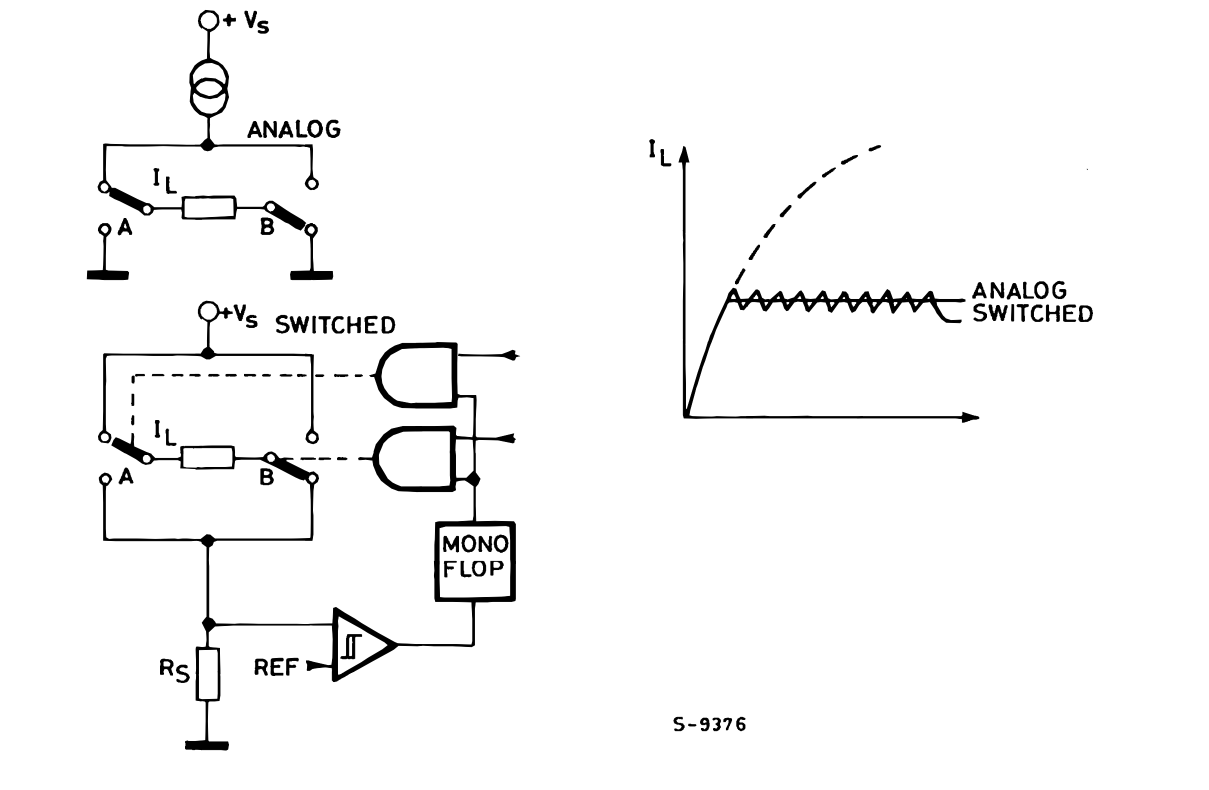
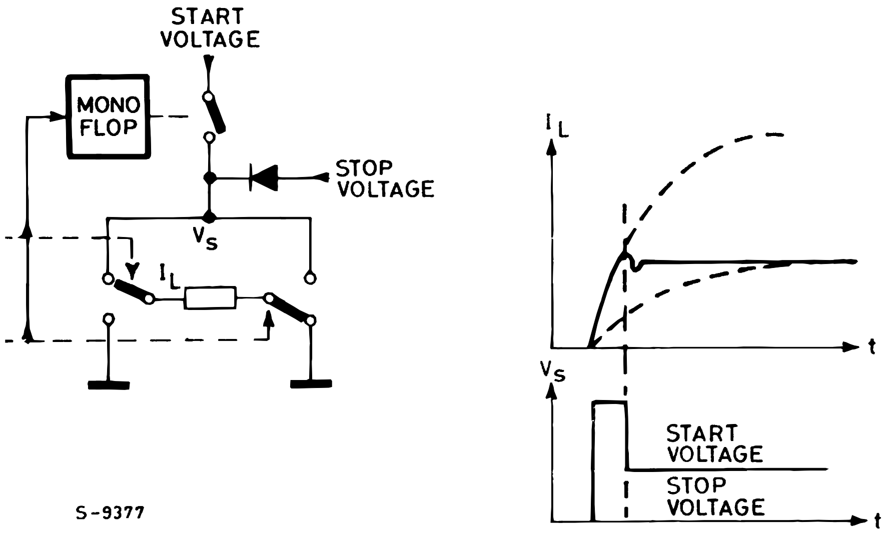


Figure 9 : At Every New Step of the Motor, it is Possible to Increase the Current Rate with a Bilevel Circuit.



ADVANTAGES AND DISADVANTAGES OF THE HALF-STEP

An essential advantage of a stepper motor operating at half-step conditions is its position resolution increased by the factor 2. From a 3.6 degree motor you achieve 1.8 degrees, which means 200 steps per revolution.

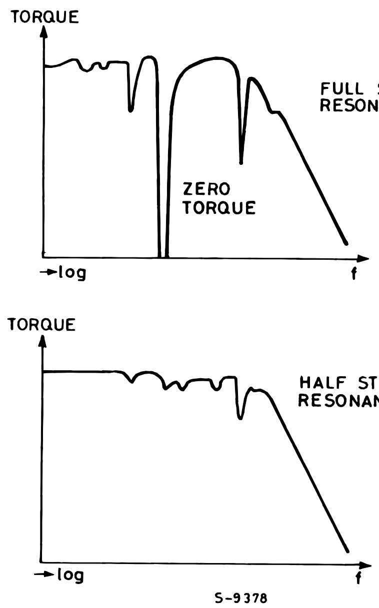
This is not always the only reason. Often you are forced to operate at half-step conditions in order to avoid that operations are disturbed by the motor resonance. These may be so strong that the motor has no more torque in certain step frequency ranges and looses completely its position (fig. 10). This is due to the fact that the rotor of the motor, and the changing magnetic field of the stator forms a spring-mass-system that may be stimulated to vibrate. In practice, the load might deaden this system, but only if there is sufficient frictional force.

In most cases half-step operation helps, as the course covered by the rotor is only half as long and the system is less stimulated.

The fact that the half-step operation is not the dominating or general solution, depends on certain disadvantages :

- the half-step system needs twice as many clock-pulses as the full-step system ; the clock-frequency is twice as high as with the full-step.
- in the half-step position the motor has only about half of the torque of the full-step.

Figure 10 : The Motor has no More Torque in Certain Step Frequency Ranges with Full Step Driving.



For this reason many systems use the half-step operation only if the clock-frequency of the motor is within the resonance risk area.

The dynamic loss is higher the nearer the load moment comes to the limit torque of the motor. This effect decreases at higher numbers of revolutions.

TORQUE LOSS COMPENSATION IN THE HALF-STEP OPERATION

It's clear that, especially in limit situations, the torque loss in half-step is a disadvantage. If one has to choose the next larger motor or one with a double resolution operating in full-step because of some insufficient torque percentages, it will greatly influence the costs of the whole system.

In this case, there is an alternative solution that does not increase the coats for the bipolar chopping stabilized current drive circuit.

The torque loss in the half-step position may be compensated for by increasing the winding current by the factor $\sqrt{2}$ in the phase winding that remains active. This is also permissible if, according to the motor data sheet, the current limit has been reached, because this limit refers always to the contemporary supply with current in both windings in the full-step position. The factor $\sqrt{2}$ increase in current doubles the stray power of the active phase. The toal dissipated power is like that of the full-step because the non-active phase does not dissipate power.

The resulting torque in the half-step position amounts to about 90 % of that of the full-step, that means dynamically more than 95 % torque compared to the pure full-step ; a neglectable factor.

The only thing to avoid is stopping the motor at limit current conditions in a half-step position because it would be like a winding thermal phase overload concentrated in one.

The best switch-technique for the half-step phase current increase will be explained in detail later on Fig. 11 shows the phase current of a stepping motor in half-step control with an without phase current increase and the pertinent curves of stap frequency and torque.

Figure 11 : Half Step Driving with Shaping Allows to Increase the Motor's Torque to about 95 % of that of the Full Step.

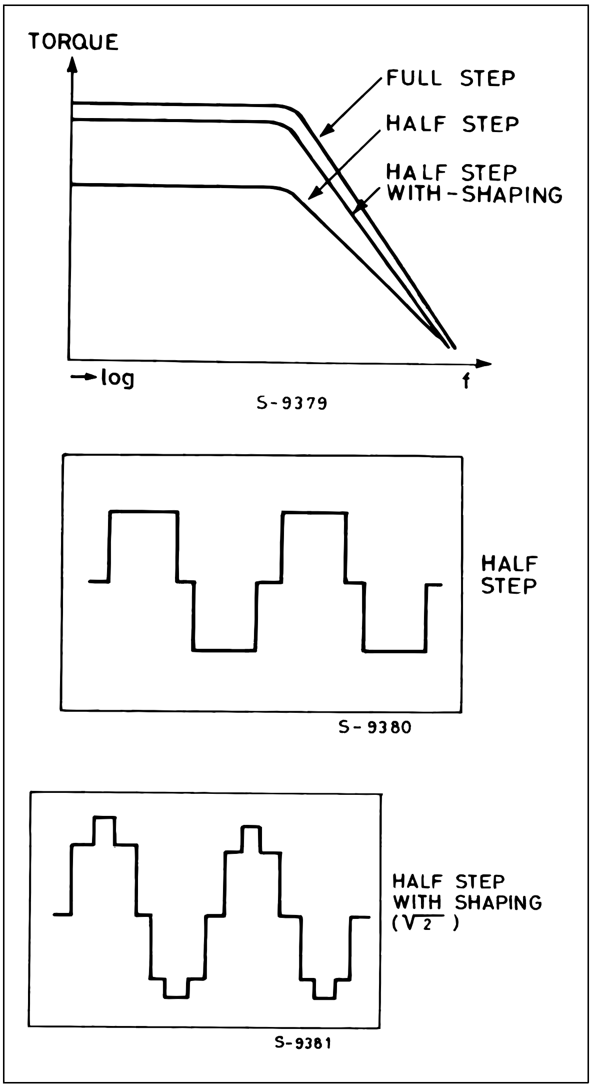
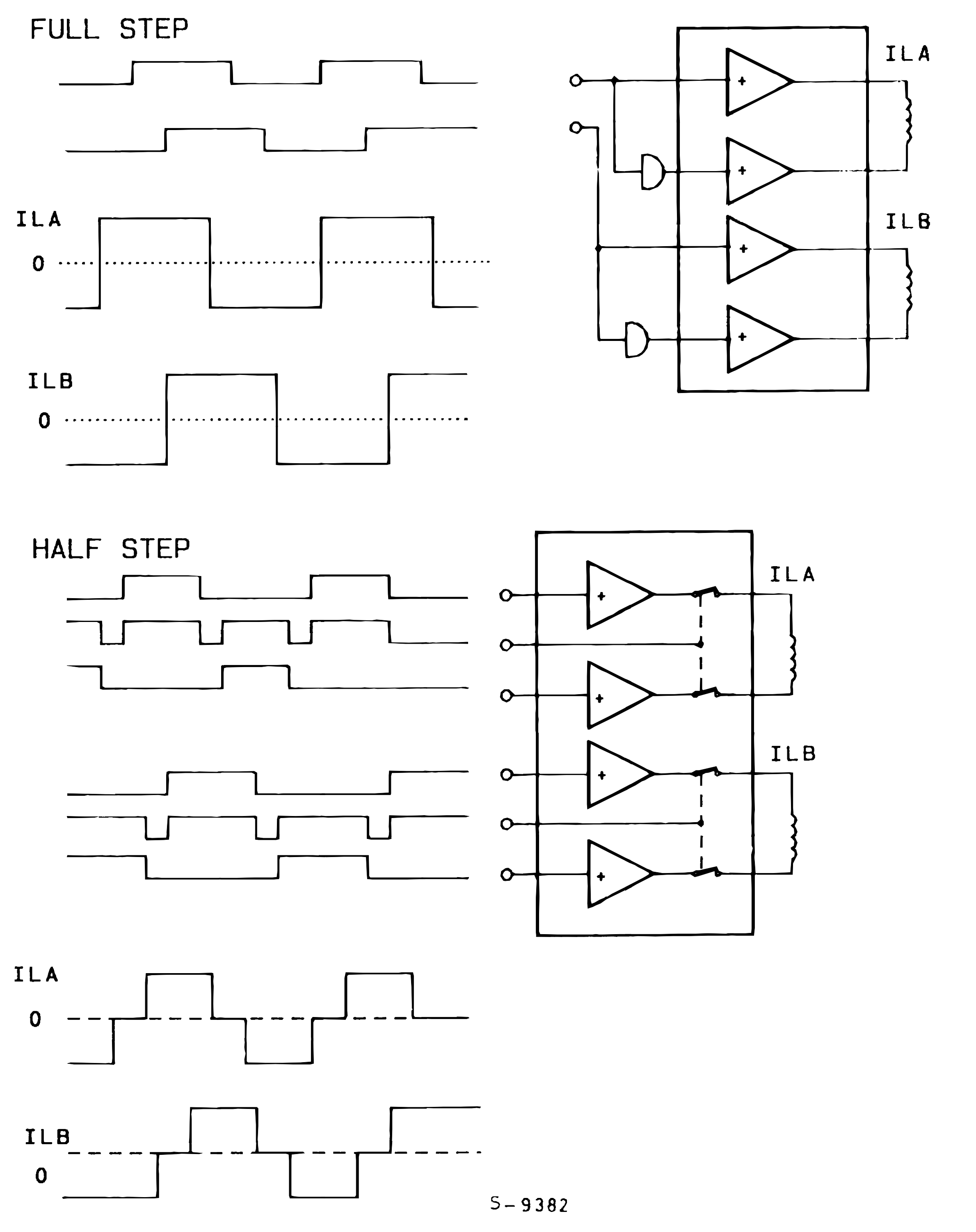


Figure 12 : Only Two Signals for Full Step Driving are Necessary while Four (six if three-state is needed on the output stages) for half Step.



DRIVE SIGNALS FOR THE MICRO ELECTRONIC

A direct current motor runs by itself if you supply if with voltage, whereas the stepping motor needs the commutation signal in for of several separated but linkable commands. In 95 % of the applications today, the origin of these digital commands is a microprocessor system.

In its simplest form, a full-step control needs only two rectangular signals in quadrature. According to which phase is leading, the motor axis rotates clockwise or counter-clockwise, whereby the rotation speed is proportional to the clock frequency.

In the half-step system the situation becomes more complicated. The minimal two control signals become four control signals. In some conditions as many as six signals are needed. If the Tri-state-command for the phase ranges without current, necessary for high motor speeds, may not be obtained from the 4 control signals. Fig. 12 shows the relationship between the phase current diagram and the control signal for full and half-step.

Since all signals in each mode are in defined relations with each other, it is possible to generate them using standard logic. However, if the possibility to choose full and half-step is desired, a good logic implementation becomes quite expensive and an application specific integrated circuit would be better. Such an application specific integrated circuit could reduce the number of outputs required from a microprocessor from the 6 required to 3 static and dynamic control line.

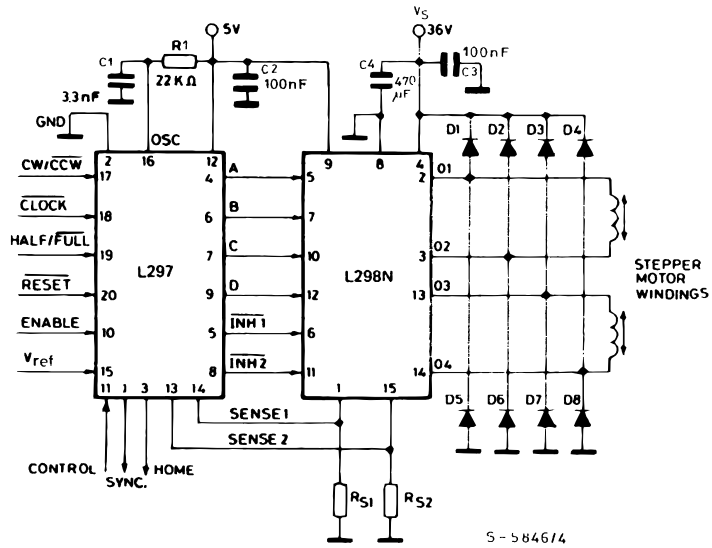
A typical control circuit that meets all these requirements is the L297 unit (fig. 13).

Four signals control the motor in all operations :

1. CLOCK : The clock signal, giving the stepping command
2. RESET : Puts the final level signals in a defined start position
3. DIRECTION : Determines the sense of rotation of the motor axis.
4. HALF/FULL : Desides whether to operate in full or in half-step.

Another inhibit input allows the device to switch the motor output into the Tri-state-mode in order to prevent undesired movements during undefined operating conditions, such as those that could occur during.

Figure 13 : The L297 avoids the Use of Complicated Standard Logic to Generate Both Full and Half-step Driving Signals Together with Chopper Current Control.



R_{S1} R_{S2} = 0.5 Ω

D1 to D8 = 2 A fast diodes { $V_F \leq 1.2$ V @ i = 2A; trr ≤ 200 ns

SWITCH-MODE CURRENT REGULATION

The primary function of the current regulation circuit is to supply enough current to the phase windings of the motor, even at high step rates.

The functional blocks required for a switchmode current control are the same blocks required in switching power supplies ; flip-flops, comparators ; and an oscillator are required. These blocks can easily be included in the same IC that generates the phase control signals. Let us consider the implementation of chopper current control in the L297.

The oscillator on pin 16 of the L297 resets the two flip-flops at the start of each oscillator period. The flip-flop outputs are then combined with the outputs of the translator circuit to form the 6 control signals supplied to the power bridge (L298).

When activated, by the oscillator, the current in the winding will raise, following the L/R time constant curve, until the voltage across the sense resistor (pin 1, 15 of L298) is equal to the reference voltage input (pin 15, L297) the comparator then sets the flip-flop, causing the output of the L297 to change to an equiphase condition, thus effectively putting a short circuit across the phase winding. The bridge is activated into a diagonally conductive state when the oscillator resets the flip-flop at the start of the next cycle.

Using a common oscillator to control both current regulators maintains the same chopping frequency for both, thus avoiding interference between the two.

The functional block diagram of the L297 and the power stage (L298) are shown in Figure 14 alone with the operating wave forms.

An important characteristics of this circuit implementation is that, during the reset time, the flip-flops are kept reset. The reset time can be selected by selecting the impedance of the R/C network or pin 16. In this way, the current spike and noise across the sense resistors that may occur during switching will not cause a premature setting of the flip-flop. Thus the recovery current spike of the protection diodes can be ignored and a filter in the sense line is avoided.

THE RIGHT PHASE CURRENT FOR EVERY OPERATING CONDITION

The Chopper principle of the controller unit reveals that the phase current in the motor windings is controlled by two data : the reference voltage at pin 15 of the controller and the value of the sense resis-tance at pins 1 and 15 of the L298, that is $I_L = V_{REF}/R_S$. By changing V_{REF} it is very easy to vary the current within large limits. The only question is for which purpose and at which conditions.

More phase current means more motor torque, but also higher energy consumption.

An analysis of the torque consumption for different periods and load position changes shows that there is no need for different energies.

There is a high energy need during the acceleration or break phases, whereas during continuous operation or neutral or stop position less energy has to be supplied. A motor with its phase current continuously oriented at the load moment limit, even with the load moment lacking, consumes needlessly energy, that is completely transformed into heat.

Therefore it is useful to resolve the phase current in at least two levels controllable from the processor. Fig. 18 shows a minimal configuration with two resistance and one small signal transistor as changeover switch for the reference input. With another resistance and transistor it is possible to resolve 2 Bits and consequently 4 levels. That is sufficient for all imaginable causes.

Fig. 16 shows a optimal phase current diagram during a positioning operation.

Figure 14 : Two ICs and very Few External Components Provide Complete Microprocessor to Bipolar Stepper Motor Interface.

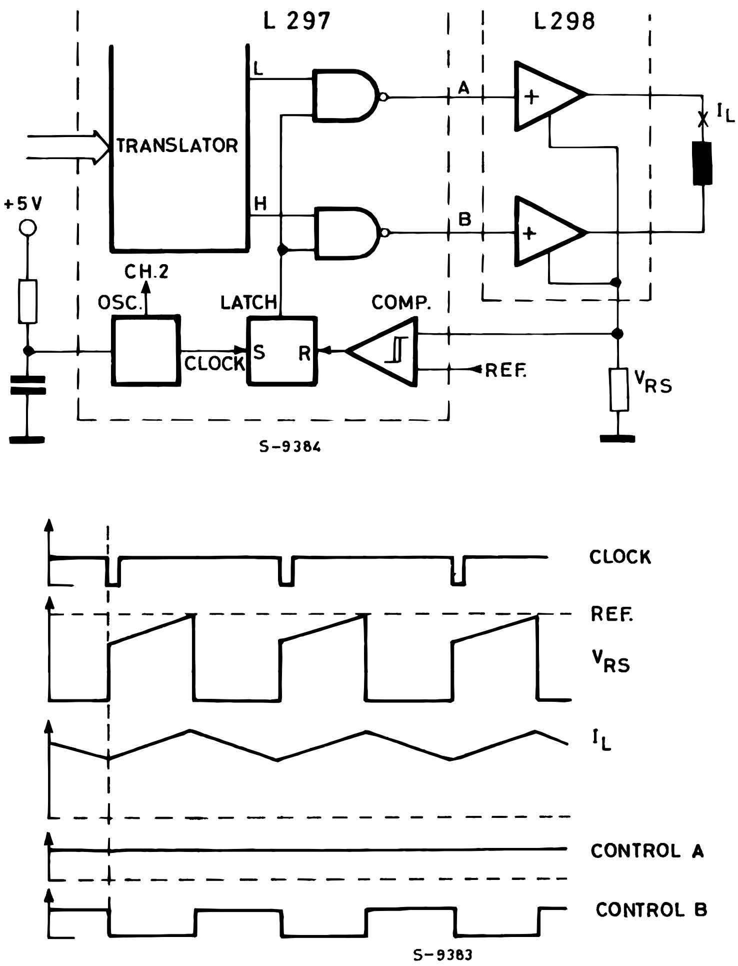


Figure 15 : Because of the Set-dominant Latch Inside the L297 it is Possible to Hide Current Spikes and Noise Across the Sense Resistors thus Avoiding External Filters.

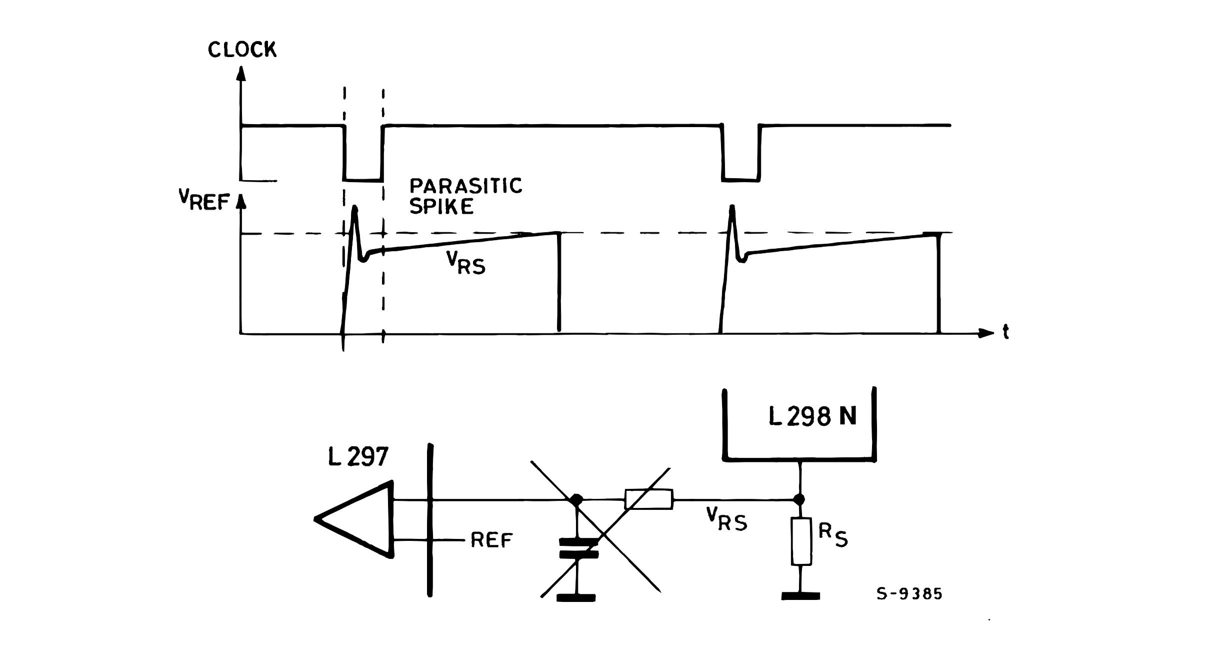
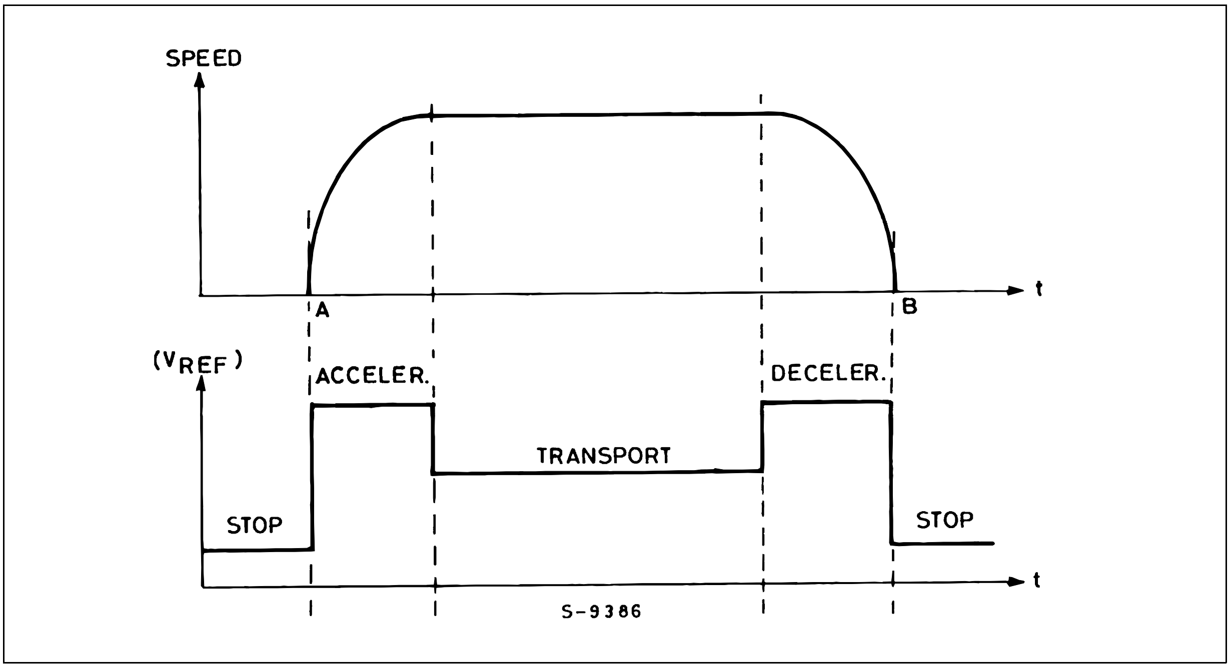


Figure 16 : More Energy is needed During The Acceleration and break Phases Compared the Continuous Operation, Neutral or Stop Position.



HIGH MOTOR CLOCK RESETS IN THE HALF-STEP SYSTEM

In the half-step position one of the motor phases has to be without current. If the motor moves from a full-step position into a half-step position, this means that one motor winding has to be completely discharged. From the logic diagram this means for the high level bridge an equivalent status of the input signals A/B, for example in the HIGH-status. For the coil this means short circuit (fig. 17 up) and consequently a low reduction of the current. In case of high half-step speeds the short circuit discharge time constant of the phase winding is not sufficient to discharge the current during the short half-step phases. The current diagram is not neat, the half step is not carried out correctly (fig. 17 center).

For this reason the L297 controller-unit generates an inhibit-command for each phase bridge, that switches the specific bridge output in the half-step position into Tri-state. In this way the coil can start swinging freely over the external recovery diodes and discharge quickly. The current decrease rate of change corresponds more or less to the increase rate of change (fig. 17 below).

In case of full-step operation both inhibit-outputs of the controller (pin 5 and 8) remain in the HIGH-status.

Figure 17 : The Inhibit Signal Turns Off Immediately the Output Stages Allowing thus a Faster Current Decay (mandatory with half-step operation).

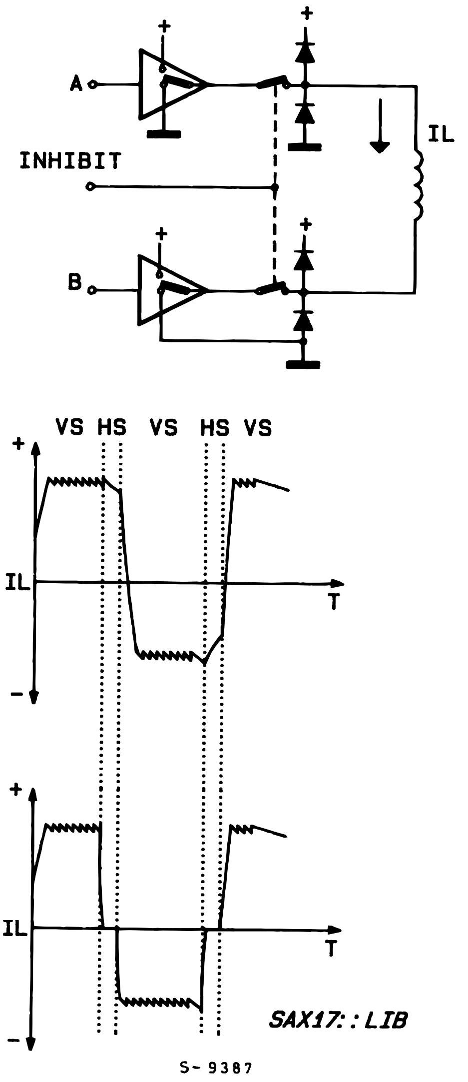
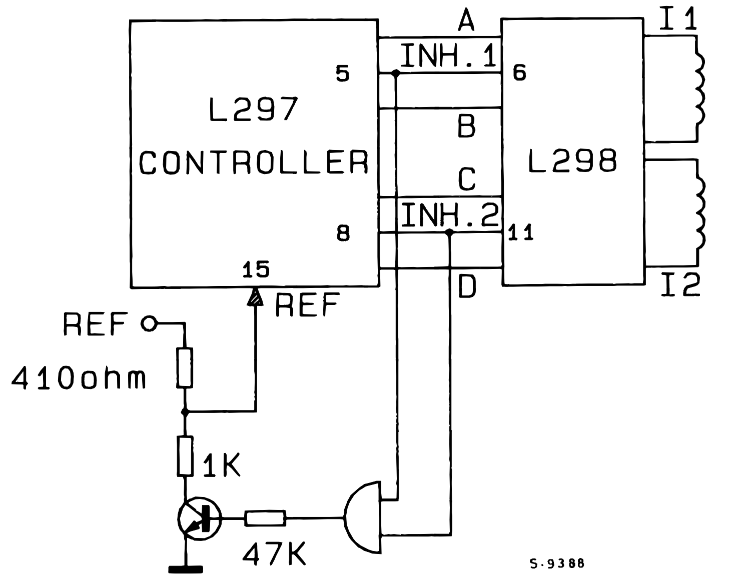


Figure 18 : With This Configuration it is Possible to Obtain Half-step with Shaping Operation and Therefore More Torque.



MORE TORQUE IN THE HALF-STEP POSITION

A topic that has already been discussed in detail. So we will limit our considerations on how it is carried out, in fact quite simply because of the reference voltage controlled phase current regulation.

With the help of the inhibit-signals at outputs 5 and 8 of the controller, which are alternatively active only when the half-step control is programmed, the reference voltage is increased by the factor 1.41 with a very simple additional wiring (fig. 18), as soon as one of the two inhibit-signals switches LOW. This increases the current in the active motorphase proportionally to the reference voltage and compensates the torque loss in this position. Fig. 19 shows clearly that the diagram of the phase current is almost sinusoidal, in principle the ideal form of the current graph.

To sum up we may say that this half-step version offers most advantages. The motor works with poor resonance and a double position resolution at a torque, that is almost the same as that of the full-step.

BETTER GLIDING THAN STEPPING

If a stepper motor is supposed to work almost gliding and not step by step, the form of the phase current diagram has to be sinusoidal.

The advantages are very important :

- no more phenomena of resonance
- drastic noise reduction
- connected gearings and loads are treated with care
- the position resolution may be increased further.

However, the use of the L297 controller-unit described until now is no longer possible of the more semplicated form of the phase current diagram the Controller may become simpler in its functions.

Fig. 20 shows us an example with the L6505 unit. This IC contains nothing more than the clocked phase current regulation which works according to the same principle as L297. The four control signals emitting continuously a full-step program are now generated directly by the microprocessor. In order to obtain a sinusoidal phase current course the reference voltage inputs of the Controller are modulated with sinusoidal half-waves.

The microprocessor that controls the direction of the current phase with the control signals also generates the two analog signals.

For many applications a microprocessor with dedicated digital to analog converters can be chosen. Eliminating the need for separate D/A circuits.

About 5 bit have proved to be the most suitable suddivision of the current within one full-step. A higher resolution brings no measurable advantages. On the contrary, the converter clock frequency is already very high in case of low motor revolutions and very difficult to process by the processor-software. It is recommended to reduce the D/A resolution at high step frequencies.

In case of higher motor revolutions it is more convenient to operate only in full-step, since harmonic control is no longer an advantage as the current has only a triangular waveform in the motor winding.

PRECISION OF THE MICRO STEP

Any desired increase of the position resolution between the full step position has its physical limits. Those who think it is possible to resolve a 7.2° - stepper motor to 1.8° with the same precision as a 1.8° - motor in full-step will be received, as there are several limits :

The rise rate of the torque diagram corresponding to the twisting angle of the rotor for the 7.2° - motor is flatter by a factor of 4 then for the original 1.8° - motor. Consequently with friction or load moment, the position error is larger (fig. 21).

For most of the commercial motors there isn't a sufficiently precise, linear relationship between a sinusoidal-current-diagram and an exact micro step angle. The reason is a dishomogeneous magnetic field between the rotor and the two stator fields.

Above all, problems have to be expected with motors with high pole feeling. However, there are special stepper motors in which an optimized micro step operation has already been considered during the construction phase.

Figure 19 : The Half-step with Shaping Positioning is Achieved by Simply Changing Reference Voltages.

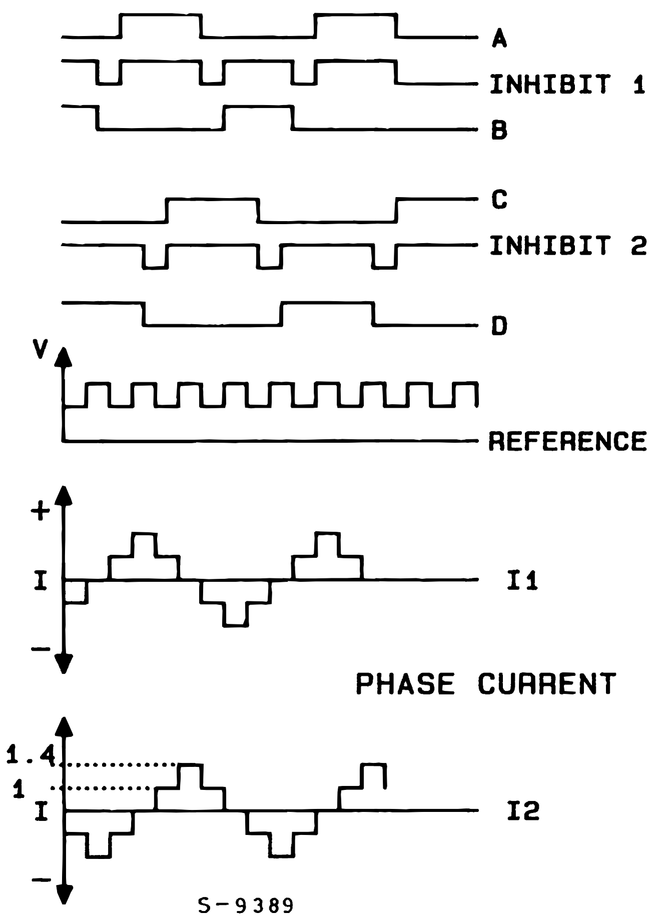
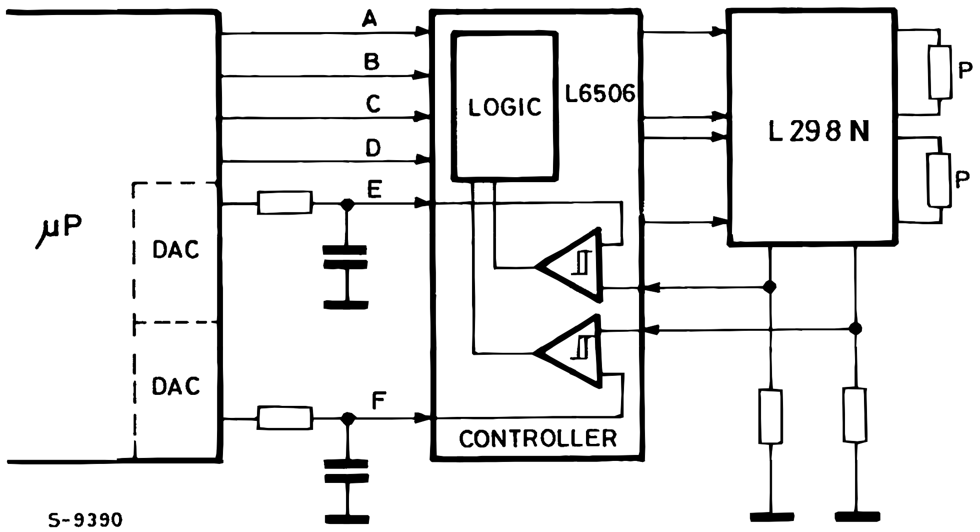


Figure 20 : L6506 Unit Gives The Possibility to Modulate Separately the Two Reference Voltage Inputs in Order to obtain a Sinusoidal Phase Current.



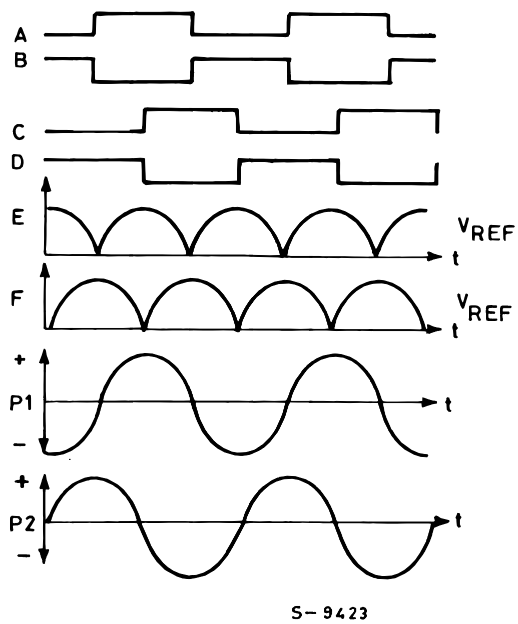
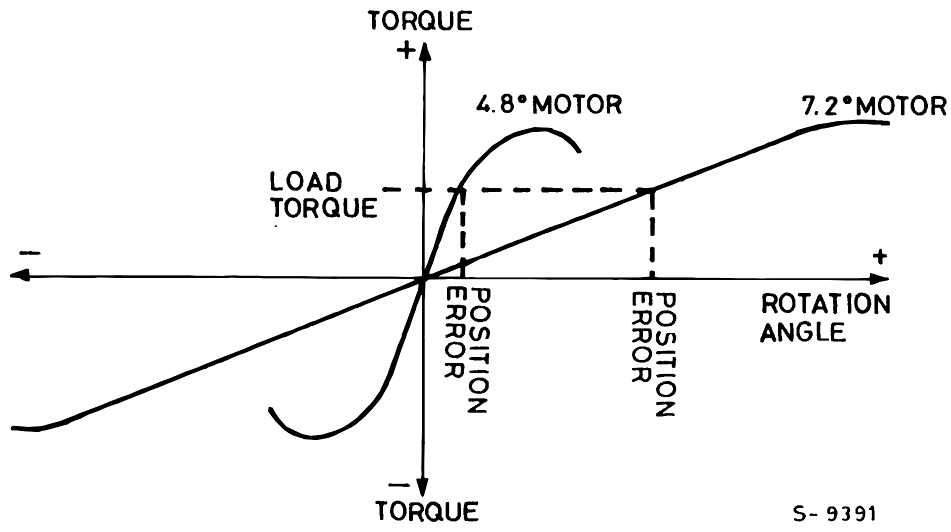


Figure 21 : Better Resolution is achieved with Low Degree Motor but More torque is delivered with high Degree Motor.

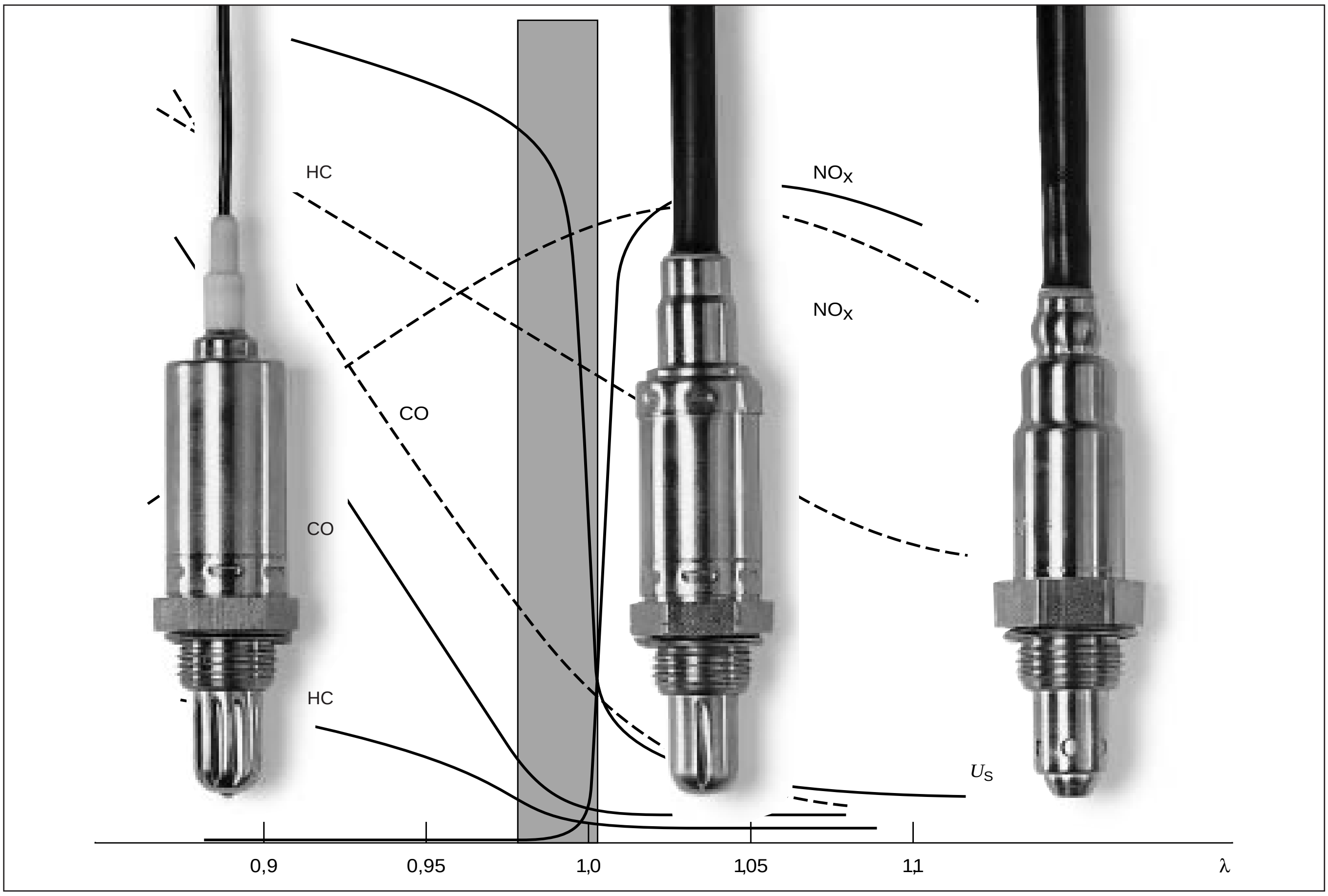


CONCLUSIONS

The above described application examples of modern integrated circuits show that output and efficiency of stepper motors may be remarkably increased without any excessive expense increase like before.

Working in limit areas, where improved electronics with optimized drive sequences allow the use of less expensive motors, it is even possible to obtain a cost reduction.

Lambda Sensor



Application

Together with the 3-way catalytic converter, the Lambda oxygen sensor and the Lambda closed-loop control represent today's most effective exhaust-emissions control system for the spark-ignition (SI) engine. At present, there is no alternative available which even approaches the low exhaust-emission figures obtained with this system.

Since 1976, Bosch has been producing the Lambda sensor for exhaust-emission control systems in the USA and Europe.
The Bosch Lambda sensor was the world's first oxygen sensor to go into operation, and played a decisive role in the breakthrough of exhaust-emissions control using the closed-loop-controlled 3-way catalytic converter. In the meantime, this sensor has proved itself in millions of vehicles.

The Lambda sensor is screwed into the exhaust system. It is a detecting element for measuring the residual oxygen in the exhaust gas which, since it provides a precise indication of whether combustion is complete or not, is highly suitable as the measured quantity for closed-loop control of the A/F ratio.
The Lambda-sensor output signal not only provides an indication of instantaneous A/F mixture composition, but it also follows any A/F mixture changes.
The mixture-formation system controls the supply of fuel to the engine in accordance with the signal from the Lambda sensor so that a stoichiometric A/F ratio "Lamda" of $\lambda = 1$ is maintained.

Lambda is the dimension used to define the mixture's A/F ratio.

$$\lambda = \frac{\text{instantaneous A/F ratio}}{\text{stoichiometric A/F ratio}}$$

Referred to the stoichiometric ratio $\lambda = 1$, a lean mixture ($\lambda > 1$) contains more air, and a rich mixture ($\lambda < 1$) contains less air.
Heated or unheated Lambda sensors are used depending upon exhaust-system design and operating conditions. The extensive Bosch Lambda sensor program covers a wide variety of variants.

The Lamda sensor is also used outside the automotive sector. For instance, for the closed-loop control of gas engines or of gas/oil burners.

Design (Fig. 1)

The Lambda sensor operates according to the principle of a galvanic oxygen concentration cell with solid electrolyte (Nernst principle). The solid-state electrolyte comprises a gas-impermeable ceramic element of circonium dioxide which is stabilized with yttrium oxide and closed at one end.

The ceramic element's inside and outside surfaces are provided with electrodes composed of a thin, gas-permeable, porous layer of platinum which on the one side has an influence on the sensor characteristic due to its catalytic effects, and on the other serves for electrical contacting. On the outside surface of the sensor ceramic which protrudes into the exhaust-gas stream, the platinum layer is itself coated with a highly porous ceramic layer. This robust layer prevents the catalytic platinum layer being attacked by the corrosive and erosive effects of the deposits in the exhaust gas, and thus ensures long-term sensor stability.

Fig 1: Arrangement of the Lambda sensor in the exhaust pipe (schematic)
1 Sensor ceramic, 2 Electrodes, 3 Contact, 4 Housing contact, 5 Exhaust pipe, 6 Ceramic protective layer (porous), 7 Exhaust gas, 8 Air.

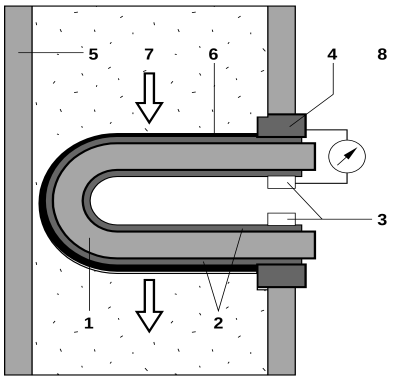


Fig. 2: Voltage characteristic of the Lambda sensor at 600°C working temperature
a Rich mixture (air deficiency)
b Lean mixture (air surplus)

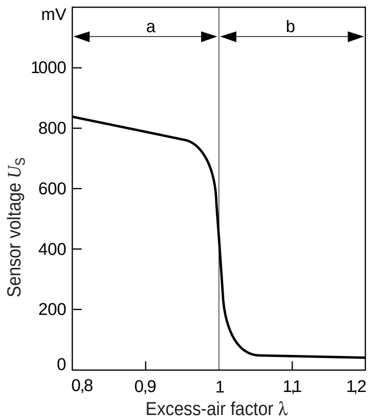
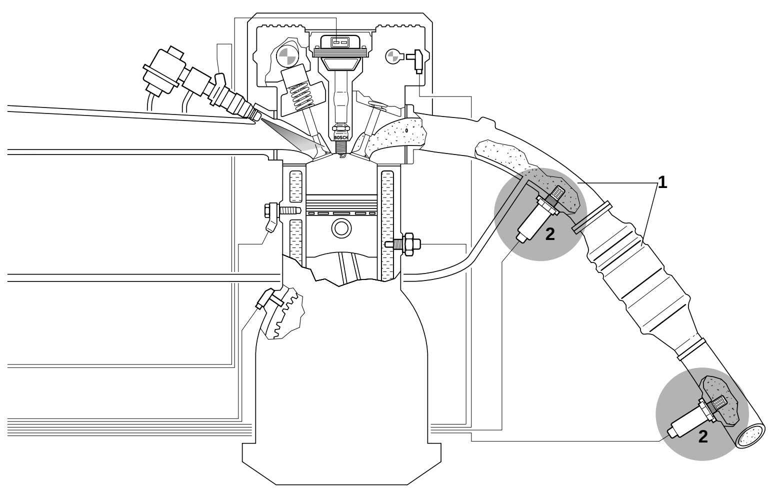


Fig. 3: Engine with exhaust-gas system
1 Exhaust-gas system with catalytic converter, 2 Lambda sensor(s)



Operation (Fig. 2)

The Lambda sensor is installed in the engine's exhaust-gas system at a point which throughout the engine's complete operating range provides the temperature which is necessary for efficient sensor functioning. The sensor protrudes into the exhaust gas, design being such that one electrode surface is surrounded by the exhaust gas and the other is connected to the atmosphere. Even under excess-fuel conditions, there is always residual oxygen in the SI engine's exhaust gas (at λ = 0.95, approx. 0.1 ... 0.3% by volume). The use of porous platinum electrodes means that at the electrode surface, catalytic conversion of this residual oxygen can take place with the carbon monoxide (CO), hydrocarbons (HC), and the hydrogen present in the exhaust gas. The residual oxygen remaining after complete conversion is a function of the exhaust-gas Lambda value, and is measured by the Lambda (oxygen) sensor. During transition from a lean mixture (high residual-oxygen content) to a rich mixture (very low residual-oxygen content), the residual-oxygen content reduces abruptly by several powers of 10 in the stoichiometric region λ = 1 of air-fuel mixture. This results in the sudden jump of sensor voltage output at λ = 1. The sensor voltage and its internal resistance depend upon temperature. Reliable closed-loop control takes place at temperatures above 350°C (for the unheated sensor) and above 150°C (for the heated sensor).

Installation (Fig. 3)

The Lambda sensor is installed in the exhaust system at a point which, besides featuring exhaust-gas composition which is representative for all cylinders, must also be hot enough (at least 350°C for the unheated sensor and 150° for the heated sensor). A sensor life corresponding to more than 160,000 km as driven by the vehicle can be achieved if the specifications for sensor loading are complied with.

The Lambda closed-loop (feedback) control

The control loop comprises the engine (controlled system), the Lambda sensor (measuring element), the controller in the ECU, and the injectors (actuators).

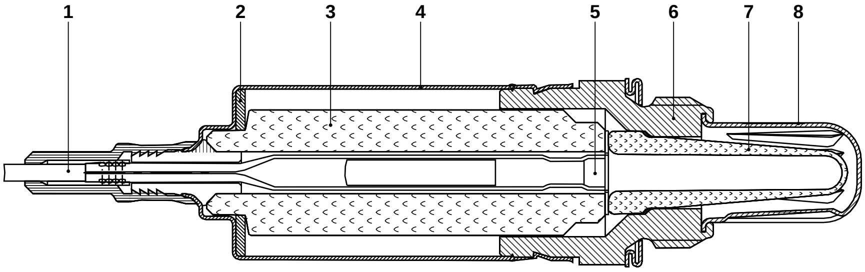
The controlled variable is the residual oxygen in the exhaust gas. The object of the closed-loop control is to generate an optimal A/F mixture by adjusting the quantity of fuel (manipulated variable) injected by the injectors (actuators).

The Lambda closed-loop control automatically takes into account special modes such as start, acceleration, and full load.

Unheated Lambda sensor LS (Fig. 4)

The sensor's active ceramic body is held in position and sealed in the housing by means of a "finger-shaped" ceramic support tube and a disc spring.
A contact element between the support tube and the active ceramic body is used to provide contacting from the inner electrode to the connection cable.
The outer electrode is connected to the sensor housing by the metal seal ring. The sensor's internal elements are fastened and aligned by a protective metal sleeve which, apart from serving as a support for the disc spring, also protects the interior of the sensor against contamination. The cable is crimped to the end of the contact element which protrudes from the sensor, and is sealed off against dampness and mechanical damage by means of a temperature-resistant PTFE cap.
In order to keep the exhaust-gas combustion deposits away from the sensor ceramic, the end of the housing which protrudes into the exhaust-gas flow is protected by a specially shaped tube having slots designed to provide highly effective protection against the effects of excessive thermal and chemical stresses.

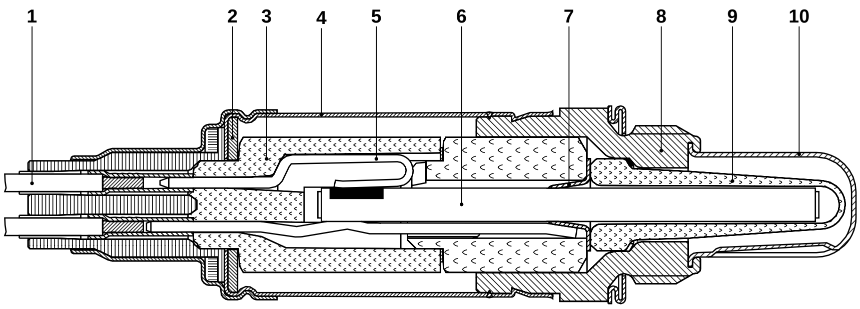
Fig. 4: Unheated Lambda sensor LS
1 Connection cable, 2 Disc spring, 3 Ceramic support tube, 4 Protective sleeve, 5 Contact element, 6 Sensor housing, 7 Active sensor ceramic, 8 Protective tube.



Heated Lambda sensor LSH (Fig.5)

Design
Basically, the heated Lambda sensor is identical to the unheated version.
The active sensor ceramic is heated from the inside by a ceramic heating element so that it remains above the 350°C function limit independent of the exhaust-gas temperature. The ceramic heating element has a PTC characteristic so that it heats up quickly and needs only very little power when the exhaust gas has heated up. The heating-element connections are fully decoupled from the sensor signal line ($R \geq 30$ MΩ).
In contrast to the unheated version, the heated sensor is equipped with a protective tube with small slots for exhaust-gas passage.
This increases the protection against contamination and prevents the sensor ceramic cooling down excessively when the exhaust gas is still "cold".

Fig. 5: Heated Lambda sensor LSH
1 Connection cable, 2 Disc spring, 3 Ceramic support tube, 4 Protective sleeve, 5 Clamp connection for the heating element, 6 Heating element, 7 Contact element, 8 Sensor housing, 9 Active sensor ceramic, 10 Protective tube.



Versions

Bosch has a number of versions of its heated Lambda sensor available:
– 3-pole version,
– 3-pole version with additional grounding by cable,
– 3-pole version with additional grounding by cable for lean-burn applications (LSM11), and
– 4-pole version, isolated ground.

Advantages

– Efficient closed-loop control even at low exhaust-gas temperatures (e.g. at idle),
– Flexibility of installation, considerable latitude regarding mounting method,
– Efficient functioning depends less on exhaust-gas temperature,
– Lambda control comes into effect more quickly after engine start,
– Improved exhaust-gas figures due to improved sensor dynamics,
– Reduced danger of contamination leads to longer service life.

Planar Lambda sensor (LSF)
(Fig. 6)

The planar Lambda sensor has been developed from the proven tube-type ("finger-version") sensor. Functionally, with its voltage curve jump at λ = 1, it corresponds to the heated finger version, while at the same time providing the basic technology for further ceramic-type sensors. In contrast to the finger sensor though, the planar sensor uses ceramic foils as the solid-state electrolyte. Screen-printing techniques are employed for producing the individual functional layers (electrodes, protective layers, etc.). The printed foils are laminated one on top of the other, and this principle enables a heater to be integrated in the sensor element (Figs. 7 and 8).

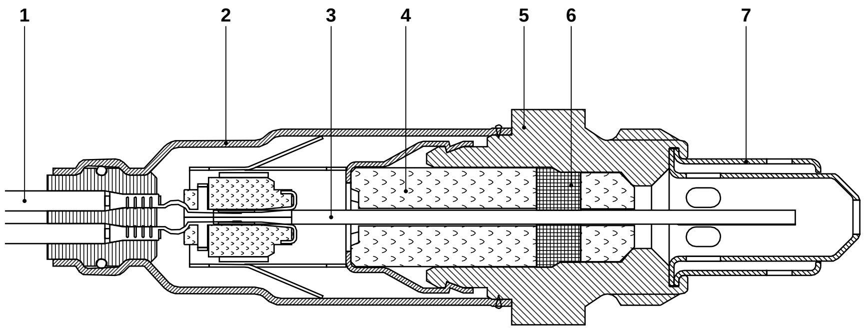


Fig. 6: Planar Lambda sensor LSF
1 Connection cable , 2 Protective sleeve, 3 Planar sensor element, 4 Ceramic support tube, 5 Sensor housing, 6 Ceramic seal packing, 7 Protective tube.

From the construction viewpoint, the major differences between the LSF sensor and the LSH sensor are as follows:
– The LSF sensor element is fixed in the sensor housing by means of a ceramic seal packing.
– The double-wall protective tube was specially designed for the planar sensor and provides the sensor element with highly effective protection against excessive thermal and mechanical stresses.

Special characteristics:
– Short start-up times for the Lambda closed-loop control,
– Stable control characteristics,
– Lower heater rating,
– Small size,
– Low weight, and
– Isolated-ground design.

Planar broadband Lambda sensor LSU

The broadband Lambda sensor is a planar dual-cell limit-current sensor. Its modular construction, combined with planar techniques, makes it possible to integrate a number of additional functions.
The fact that the LSU sensor is a combination of a Nernst concentration cell (sensor cell) and a pump cell for oxygenion transport, means that it can also measure accurately in lean and rich regions, not only at λ = 1 (Fig. 9). Each sensor is individually calibrated.
Special control electronics are required for the LSU sensor (evaluation circuit) This contains not only the internal control electronics for the pump and sensor cells as required for generation of the sensor signal, but also the control electronics for controlling the sensor's temperature.
As a result, novel applications become possible:
– Control also possible at λ > 1 and λ < 1,
– Continuous Lambda control at λ = 1,
– Diesel-engine control,
– Lean-burn concept for SI engines,
– Gas-engine control.

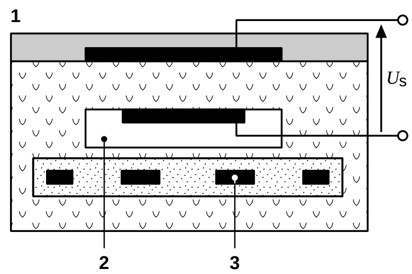


Fig. 8: Planar Lambda sensor LSF (layer build-up)
1 Exhaust gas, 2 Reference-air passage, 3 Heater. US Sensor voltage.

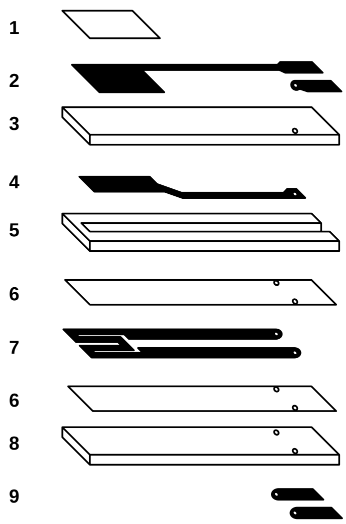


Fig. 7: Planar Lambda sensor LSF (functional layers).
1 Porous protective layer, 2 External electrode, 3 Sensor foil, 4 Inner electrode, 5 Reference-air passage foil, 6 Insulation layer, 7 Heater, 8 Heater foil, 9 Connection contact.

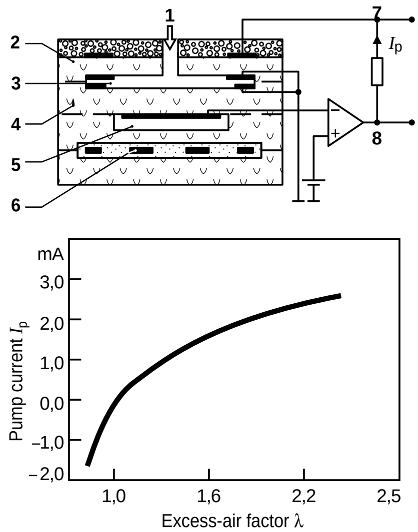


Fig. 9: Planar broadband Lambda sensor LSU (layer build-up and curve)
1 Exhaust gas, 2 Pump cell, 3 Diffusion gap, 4 Sensor cell, 5 Reference-air passage, 6 Heater, 7 Sensor signal, 8 Controller. I_p Pump current.