Flame Ignition,
Flame Monitoring
and Burner Control

- Ignition of Flames
- Flame Monitoring
- Automatic Burner Control Systems

Solutions for Emission and Combustion
Flame Monitoring

## Ignition of Flames

Reliable ignition systems which function without delay are necessary for the ignition of large industrial burners for steam generation or process furnaces. These systems must also have a guaranteed perfect functioning under start and differing load conditions. According to the German TRD (Technical Regulations for Steam Boilers) gas, oil and coal combustion systems must be fitted with a suitable ignition system. The following ignition systems are differentiated according to TRD:

- gas-electric (Hegwein system)
- oil-electric (Hegwein system)
- electric (spark igniters, Durag system)

The main requirement in all cases is that the respective ignition system ignites the flame within the required safety time, stipulated in the TRD. The ignition device can be installed for the following uses:

### Continuous igniters:

The ignition system provides permanent ignition energy, for example for flames which are not stable under all load conditions (e.g. coal burners).

### Intermittent igniters:

The ignition system provides ignition energy only in certain load conditions, for example for flames which require support under low load conditions (e.g. heavy oil burners).

### Interrupted igniters:

The ignition system only provides ignition energy for the start of combustion for easily combustible fuels and stable flames (e.g. gas burners).

It can be seen from the diagram (fig. 1) that ignitor types can be classified according to differing fuels. While electrical ignitor systems are suitable mainly for gas and light oil operations, gas or oil-electrical igniters are suitable mostly for heavy oil and coal operations.

In general the ignitor should have 5-10% of the capacity of the main burner.

NFPA (National Fire Protection Association) categorizes ignition equipment into four different classes according to power output.

### Class 1:

Pilot burners whose heat release is more than 10% of the capacity of the main burner.

### Class 2:

Pilot burners whose heat release lies between 4% and 10% of the capacity of the main burner.

### Class 3:

Pilot burners whose heat release is less than 4% of the capacity of the main burner.

### Class 3 special:

Electrical high-energy ignition devices which are suitable for direct ignition of the main burner.

## High-Energy Ignition Devices

Durag high-energy ignition equipment (fig. 2) ignites oil and gas burners of any capacity in industrial applications and power plants.

The energy required for ignition of the burner is stored in a high-voltage capacitor in the device. The energy is then switched to the ignitor tip via a wear-resistant electronic switch. The resulting spark discharge at the ignitor tip will ignite the fuel. For reliable ignition during the start phase, the ignitor delivers 20 sparks/s for 60 seconds and then switches down to 5 sparks/s. When the operating voltage is switched on, the ignitor will automatically begin to spark. The ignition function of the ignitor is signalled via an LED and the potential-free contacts of the ignitor acknowledgment relay.

The ideal position of the ignitor tip for igniting oil burners is generally at the edge of the atomizing cone directly in front of the swirler. The actual position is determined by adjusting the ignitor tip axially by hand. If heavy oil is being fired, it is necessary to sufficiently preheat it to between 90°C and 130°C. In the case of gas burners, the position of the ignitor tip is not of critical importance. There must, however, be a mixture of fuel and air present at this position. For a soft start, a low flow velocity (start-up position of the burner) should be set.

### Pneumatic Retraction Device

Reliable ignition of a burner using a high-energy ignitor assumes an exact positioning of the ignitor tip at the edge of the fuel-air mixture or in the fuel-air mixture. The temperatures in the area are, in most cases, so high that the ignitor tip would burn off. In order that the ignitor tip does not suffer any unnecessary wear, the ignitor lance should be pulled from the ignition position once the fuel has been successfully ignited.

To automate the ignition process, it is in most cases sensible to install a pneumatic retraction device (fig. 2), which will take over the task of moving the ignitor tip into the area around the burner which during the ignition process has an ignitable fuel-air mixture. It will also pull the ignitor lance out of the area of the flame once successful ignition is achieved.

The retraction device consists of a pneumatic cylinder with a hollow piston rod into which the ignitor lance is inserted. The control of the cylinder occurs via a solenoid valve. The piston of the retraction device is provided with a permanent magnet. Via corresponding switches, which are fixed to the retraction device, the two end of travel positions can be displayed.
Pilot Burners

Fuels that require a higher amount of energy for ignition are generally ignited with an ionization-monitored pilot burner (fig. 4). Pilot burners are principally operated using gas as the fuel. Special designs for light fuel oil (Diesel) are also available.

Compact pilot burners consist of the burner tube with mounting flange and flange for the air line, the gas tube with the nozzle and the electrode support ring, as well as the powerhead, which contains the ignition transformer and flame monitor for intermittent or continuous operation. Installation costs on site are thus reduced to a minimum. Only in plants where pre-warmed air is used or where the ambient temperature is greater than 60°C is it necessary to forego this compact design and mount the ignition transformer and flame monitor separately.

The built-in ionization electrode is used to monitor the flame. The direct current is used as the flame signal. The ionization and rectification effect of the flame allows this current to flow from the burner tube ground, via the flame, to the ionization electrode and, ultimately, to the flame monitor.

Pilot burners are normally only employed for igniting the main burner. There are, however, applications in which the pilot burner is used both as a pilot and support burner. In such cases, it is left on for a longer period of time, or during the entire period of operation of the main burner.

Due to the long, tight flame, these pilot burners can be installed such that, in the vast majority of cases, a retraction device is not required.

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### Table: Safety Times according to TRD

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Burner Type</th>
<th>maximum Furnace Capacity in kW</th>
<th>Maximum Safety Time in Seconds at Start-Up</th>
<th>Maximum Safety Time in Seconds in Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>Main Burner</td>
<td>&gt; 10  ≤ 50  &gt; 120</td>
<td>10  5  2  1</td>
<td>1  1  1</td>
</tr>
<tr>
<td></td>
<td>Ignition Burner</td>
<td>≤ 5%  &gt; 8% of the maximum Furnace Capacity of the Main Burner</td>
<td>10  5  same as Main Burner</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oil</td>
<td>Oil Throughput in kg/h</td>
<td>Safety Times in Seconds (max.)</td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>up to 30</td>
<td>10  5</td>
<td>10  10  1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>over 30</td>
<td>10  5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) The furnace capacity at the end of the safety time at start-up is decisive.

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![Figure 3: Safety Times according to TRD](image)

![Figure 4: Pilot burner (Hegwein System)](image)

![Figure 5: Cross section of a Hegwein Ignitor](image)

![Figure 6: Supply of a Gas Burner](image)
Flame Monitoring

Systems for flame monitoring and evaluation are used in furnace plants. The prime objective of flame monitoring in boiler plants, process heating and the like is the one of complying with the safety-related demand of unequivocal recognition of a flame. A prime precept for this objective is preventing fuels from getting into the combustion chamber unless the combustion process is guaranteed. If the system recognises the extinction of flames, it shall initiate an immediate shut-off of the fuel supply. Apart from and concomitant to this requisite, a highest possible degree of instrument fail safety, reliability and availability must be given, as is established in the relevant instructions. Figure 3 shows the required safety times for oil and gas operation.

Monitoring and evaluation of flames must proceed independently of the type of furnace plant, its operating mode and characteristics; i.e. at:

- variable load conditions,
- gas recirculation tasks,
- oxidation-reducing measures (NOx, SOx),
- multi-burner systems,
- alternating fuel compositions.

All in all, the objective of flame assessment is the one of giving the user of the furnace plant reliable data on his combustion process, thus securing the overall grade of effectiveness, availability, economic efficiency as well as pollutant emission control.

So as to fulfil these tasks, flame detector devices are composed of a flame sensor for detecting and conversion of light into an electric signal and a control unit.

Figure 6 shows the application of an ignition device and a flame monitor in combination with a flame safeguard control on the supply of a gas burner.

Relevance and Importance

The systems employed today accomplish this task using a variety of technical approaches with different optical flame sensors and controllers.

Physical Process

During the process of fossil fuels combustion, carbon monoxide (CO), carbon dioxide (CO2), nitrogen oxide (NOx), sulphur oxide (SOx), water vapour (H2O) and others emanate as combustion products.

In this combustion process, during which complex physical and chemical processes evolve, the aforementioned combustion products, due to their high temperature and energy rates, emit electromagnetic waves in the form of light of different wavelengths. Their span reaches from the short-wave UV up to the long-wave IR-range. In the sense of process time, the radiation emission is not constant. Due to the backflash behaviour of the flame a dynamic process takes place, manifesting itself through intensity fluctuations (flame flicker).

It is only this dynamic portion of the light signal - which lies in the range of between 1 and 200 Hz - that is utilised for flame recognition. The portion of constant light emission of the flame and the signal of light of constant intensity emitted by other, alien radiation sources, e.g. boiler pipes or combustion chamber walls, are not to be included for flame monitoring and valuation and are suppressed.

Requirements for Flame Monitoring Systems

Flame monitoring systems must in principle meet an extensive list of demands. Not only must these systems provide reliable flame monitoring under all operating conditions of a boiler, they must also meet the following criteria:

- system must be safe from the influences of ambient light,
- selective recognition of individual flames during multiple burner operation,
- fail-safe and dependable operation,
- sufficient sensitivity and
- high economy.

A primary requirement is the ability to reliably distinguish between the monitored flame, those of neighbouring or opposing burners, as well as other energy sources in the combustion chamber.

The systems employed today accomplish this task using a variety of technical approaches with different optical flame sensors and controllers.
Flame Monitoring

Flame Monitoring Guidelines

Flame monitoring systems are considered safety equipment and may only be installed once they have been certified by authorized testing laboratories, according to all locally applicable product standards. It is necessary, however, to distinguish between the product standards for the American-oriented market (USA, Canada, and Asia) and those for the European-oriented market (European Union in particular). Making matters more difficult, however, is the fact that many standards within the EU have not yet been brought in to line with one another.

The essential requirements for flame monitoring systems are derived from the European product standards. These are EN 230, “Oil Atomization Burners in a Monoblock Configuration”, and EN 298, “Burner Management Systems for Gas Burners and Gas Devices with and without Blowers”, which each describe requirements for flame monitors on oil and gas burners. These product standards have in the mean time become binding throughout the EU, so that former national regulations for flame monitors (e.g., DIN 4787 and DIN 4788) are no longer meaningful.

The product standards relevant to the American market are UL 372, „Primary Safety Controls for Gas and Oil Appliances“, Canadian Standards Association standard CSA-C22.2 No. 199-M89, „Combustion Safety Controls and Solid-State Igniters for Gas- and Oil-Burning Equipment“, and FM Class 7610, „Combustion Safeguards and Flame Sensing Systems“. The first two standards are comparable to the European standards EN 230 and EN 298. On the other hand, FM Class 7610 basically describes just the function of the devices, without addressing whether they are fail-safe.

CE Label

In addition to the product standards mentioned above, all flame monitoring equipment installed within the borders of the European Union must fulfill the requirements of various EU guidelines. There are three EU guidelines that are of particular meaning for flame monitoring equipment. These include the EMV guideline 89/336/EWG, the low-voltage guideline 73/23/EWG and the gas appliance guideline 90/396/EWG. The latter is, however, only relevant if the flame monitoring equipment is installed on gas burners in hot-water generators with a maximum water temperature of up to 105°C. If the equipment is installed in a steam generating system, e.g., power plants, this guideline does not apply.

The CE symbol is merely an administrative symbol. The manufacturer must confirm in writing via a CE declaration of conformity that the relevant guidelines have been observed. This must be signified by affixing the CE symbol to the device. Testing of the devices is not demanded in every case. If the flame monitoring equipment is also installed in systems which fall under the gas device guideline, the requirements of this guideline must likewise be observed. In general, conformity of the flame monitoring equipment with the gas device guideline must be proven by an authorized testing laboratory using the so-called EG design test certification.

Steam Boilers and Thermoprocess Systems

There is likewise a series of various national and international regulations for equipping and operating steam boilers and combustion systems.

If the flame monitoring equipment is operated in a steam boiler, the related regulations must be observed. In Germany, this would be, for example, the “Technical Rules for Steam Boilers” (TRD 411 to 414 and TRD 604). At present there are efforts underway to harmonize the various national regulations within the EU. One example of this is the pressure device guideline 97/23/EG, which will become binding for all member states of the EU on May 29, 2002. This probably means that plants will no longer then be tested according to TRD. Rather, they will be required to prove conformity with the new regulations prEN 12952 „EN Water Tube Boilers“ and prEN 12953 „EN Large Water Tank Boiler“.

Those regulations for the American market which are comparable to TRD are NFPA 8501 „Standard for Single Boiler Operation“ and NFPA 8502 „Standard for the Prevention of Furnace Explosions /Implosions in Multiple Boiler Burners“.

<table>
<thead>
<tr>
<th>Figure 8: Guidelines for Flame Monitoring and Burner Control</th>
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<tbody>
<tr>
<td>Germany</td>
</tr>
<tr>
<td>Steam Vessels</td>
</tr>
<tr>
<td>TRD 411</td>
</tr>
<tr>
<td>TRD 412</td>
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<tr>
<td>TRD 413</td>
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<tr>
<td>TRD 414</td>
</tr>
<tr>
<td>TRD 604</td>
</tr>
<tr>
<td>Furnaces / Ovens</td>
</tr>
<tr>
<td>VDE 0116</td>
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<tr>
<td></td>
</tr>
<tr>
<td>Burner</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Flame Monitors and Combustion Automation Units</td>
</tr>
<tr>
<td>DIN 4787</td>
</tr>
<tr>
<td>DIN 4788</td>
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</table>
Flame Monitoring

Sensors for Flame Monitoring

Today, mainly four different methods are used to monitor flames. Each method processes a different characteristic of the flame (fig. 11).

Temperature Detectors

Temperature sensors, for example thermocouples, are used nowadays for flame monitoring on small burners and sometimes on flares. For a reliable detection of the flame, a correct positioning of the flame sensor is required. Flame monitors with temperature sensors have only a very poor safety standard, so are not suitable for continuous operation.

Sound Detectors

Flames of single burners can also be detected by sound pressure detectors. This type of detector converts the sound pressure of the flame into an electrical signal. The disadvantages of the sound detector are, that disturbing noises could simulate a flame signal and that this type of flame detector can only be used for single burner furnaces. Furthermore it is not suitable for continuous operation.

Ionization Detectors

Ionization detectors use the ionizing effect of a flame. It can be differentiated between ionization detectors measuring the conductivity of the flame and those, which are using the rectifying characteristic of a flame. Detectors which are estimating the conductivity of the flame are not fail-safe. A short circuit between the electrodes can't be detected. It is better to use those detectors, which are using the rectifying characteristic of the flame. Short circuits between both electrodes can be detected easily. Ionization detectors are used especially on small burners and ignitors. A disadvantage is, that the electrodes can become contaminated or burned and a reliable monitoring of the flame is no longer possible.

Optical Detectors

Today, large burners are monitored only with flame monitors using optical sensors. Depending on the type of fuel and on the combustion technology, different optical detectors with different spectral sensitivities are used.

Infrared detectors (IR) respond only to the heat radiation of the flame with a wavelength more than 800 nm. Only signals corresponding to the flame flickering will be processed. Glowing parts inside the furnace must not simulate a flame signal. Those flames whose short-wave UV energy is absorbed by dust, water vapor or other materials, can be monitored in the infrared range.

Ultraviolet detectors (UV) recognize the radiation of the flame below 400 nm. All gas flames and sometimes even oil flames can be monitored very well by UV detectors. Due to the fact, that UV radiation is only generated by a flame, constant portions of the radiation can also be processed for flame monitoring.

Detectors for visible light (VIS), with a sensitivity between 400 and 800 nm are suitable as well as IR detectors for monitoring of oil and coal flames. According to the relevant product guidelines, gas flame may not monitored within this spectral range.
Flame Monitoring

Optical Flame Sensors

For flame monitoring, photo elements are used, which convert the radiation emitted by the flame into electric signals. To this purpose, UV-sensitive gas discharge cells and semiconductors are used.

The type of the photo element selected determines the spectral sensitivity of the flame sensor. Sensor selecting should be thus, that its spectral sensitivity range be optimally adapted to the radiation spectrum emitted by the flame.

Table 1 shows photo elements used in flame sensors for flame monitoring.

Table 1: Overview of Photo Elements

<table>
<thead>
<tr>
<th>Type</th>
<th>Wavelength</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Semiconductors</td>
<td>300-1100</td>
<td>Oil, Coal</td>
</tr>
<tr>
<td>Germanium Semiconductors</td>
<td>780-1800</td>
<td>Tail Gas</td>
</tr>
<tr>
<td>Silicon 4-Quadrant Semiconductors</td>
<td>400-1100</td>
<td>Oil, Coal with strong fluctuations</td>
</tr>
<tr>
<td>Gallium-Phosphit Semiconductors (w/o filter)</td>
<td>190-520</td>
<td>NO, reduced Combustions</td>
</tr>
<tr>
<td>Gallium-Phosphit Semiconductors (with filter)</td>
<td>280-410</td>
<td>Gas, Oil, Coal, Low UV Signal Levels</td>
</tr>
<tr>
<td>UV-Cells</td>
<td>190-280</td>
<td>Gas</td>
</tr>
</tbody>
</table>

Optical Flame Sensors

Ambient Light Security

The dynamic behaviour of flames is utilised for meeting the requirement of extraneous light security. Flame-inherent frequent fluctuations of intensity result from the flame’s physical backflash behaviour. This dynamic particularity is utilised for distinguishing individual flames against a radiating background. So as to comply with the demand of extraneous light security when analyzing signals for flame monitoring and assessment, flame-caused emissions must be differentiated from those of constant radiation sources such as combustion chamber walls, pipe bundles, etc.

Apart from its suitability for constant radiation sources, the demand of extraneous light security also applies to radiation sources of constant dynamic signals, like, e.g., electric lighting devices of frequencies of 50 Hz and their harmonics.

To that end, adjustable filters of defined cut-off frequencies are used as a high-pass, with which flames and radiation sources below this preselected cut-off frequency can be masked.

Selectivity

Predominantly used at multiburner plants are flame sensors that can process the frequency behaviour of flames. The flame to be monitored must be distinguished from the neighbouring flames. To that purpose, the flame sensors must be fitted with high pass filters with adjustable cut-off frequencies.

The illustration shows the possibility of discriminating two flames with the help of frequency filters.

Although the flame sensors detects both flames, unequivocal recognition of flame #1 is possible. At the distance of A1 from the flame’s root the flames flicker at a higher frequency rate than at the distance of A2. On this basis, a flame sensor that only evaluates frequencies of over 50 Hz can selectively monitor flame #1. In the flame sensor of the D-LE 603 series, several filtering steps for suppressing low-band flame flickering frequencies can be adjusted.
Positioning of Flame Sensors

To begin with, the flame area needed for monitoring and assessing the flame is established by selecting the optical axis of the flame to be captured. The brightest zone in the first third portion should be aimed at, whereby a possible moving away of the flame at varying load conditions should be taken into account.

In the case of several burners in one fire chamber, this sighting position shall collect the least possible radiation of other flames. The viewing direction should fundamentally aim at the gaps between opposing burners and burners of other levels (fig.13).

The better these basic rules of positioning the viewing angle of the flame sensor can be taken into consideration, the more the signals of the respective flame will differentiate from those of the other flames.

The view angle of the DURAG Flame Sensors is six degrees opposed to the optical axis. The longer the viewing pipe, the more limited is the field of vision on the flame and the more attention must be paid to the adequate visual range of a flame sensor.

Design of Flame Monitors and Automatic Burner Control Systems

A system for flame monitoring and evaluation comes into operation in furnace plants with the mentioned objectives. Today, such flame monitors as well as automatic burner control systems are normally equipped with fail safe microprocessor systems (see fig. 14).

Nowadays systems based exclusively on microcomputer operation are developed to realize the demands and function of flame monitors. Figures 9 and 14 show the signal processing in a control unit and a flame sensor equipped with a semiconductor photo-element (GaP). Especially fig. 14 shows clearly that the failure safety of the system is realized through a two channel CPU system.

Various adjustable elements in the control unit and flame sensor enable easy adaption to the specific combustion process to be made.

Adjustments are available for the following parameters:
- switching threshold
- amplification
- cut-off frequency of the high-pass filter

The switching threshold and amplification are used to adapt the flame monitor to the most differing intensities of light emission from various fuels under different load conditions, whilst the adjustment of the cut-off frequency of the high pass filter is used for the selective recognition of specific burners in multi burner system boilers. A remote switching of the amplification and switching threshold is a useful feature.
Flame Monitoring

aid for the different operations of the boiler plant. Fig. 15 shows the adjustment possibilities for the equipment parameters in the flame sensor. A pulse reduction process allows for further adaptions to the selectivity to be made so that alien light signals with a constant frequency can be shut out.

Altogether, the decision as to whether a flame is existent or not is a very complex one, in which extensive analysis and observation is involved. In this respect the following criteria have to be considered (fig. 16):

- **minimum direct light intensity (A)**
  The light emission coming from a flame must have a minimum intensity.

- **minimum alternating light intensity (B)**
  The intensity of the alternating light portion must be above a certain minimum.

- **correct light wavelength area (C)**
  The wavelength of the light emission must be in the UV range (180 - 400 nm) or in IR range (800 - 2000 nm)

- **minimum flicker frequency (D)**
  The flicker frequency must be in a reasonable range (20 Hz < f < 200 Hz) the value of which is specific for every flame.

It is only certain that a flame exists when all these criteria are simultaneously fulfilled.
### Flame Sensor Selecting

Selecting the right flame sensor is critical for optimum flame monitoring. The necessary properties of a flame sensor are established by the conditions under which combustion takes place. These are:

1. The fuel used: coal, oil, gas, wood, etc.
2. Single or multiburner operation/selective monitoring
3. Radiation absorption through steam, waste gas, fuel, etc.
4. Low to high or varying radiation intensities
5. Change of fuels and combi-burner monitoring
6. Change of combustion conditions.

The diagram shows characteristic radiation distributions of coal, oil and gas fuels, on the basis of which flame sensors are selected. The intensity distribution of the fuel curves shows that there is radiation from the UV up to the IR-ranges. The flame sensor can assess this radiation for flame recognition purposes. As a matter of course, a flame sensor will be selected whose spectral sensitivity lies in the range of the most intensive radiation of the fuel in question. Recommended for coal is a flame sensor with a Germanium photocell. Oil can be monitored with a Germanium photo cell in the IR-range as well as with a Silicon photocell in the visible to infrared areas. UV-cells or UV-sensitive semiconductors can be used for evaluating shortwave flame radiations. Particular combustion conditions may require monitoring the fuel in its zone of low radiation intensity. These conditions include, for example, absorption through steam, recirculation of combustion waste gases, or radiation shielding through nonburned fuel at unfavourable placement of the flame sensor (interfered sighting on the flame).

It is the short-wave UV-radiation that, to a high degree, is affected by absorption. If for these reasons UV monitoring is not possible, one has to recourse to other spectral ranges. In this sense, monitoring of gas, usually done in the UV-range, often offers better results if done with an IR flame sensor. Inversely, for reasons of selectivity a UV flame sensor can be applied for monitoring coal fires.
Flame Monitoring

**Flame Detector Devices**

The D-UG 110 / 120 and D-UG 660 control units, in combination with any DURAG flame sensor of the D-LE 103 and D-LE 603 series, supervise flames of coal, oil, gas, wood and other fuels. This is made possible by the uniform signal processing in the flame sensor.

A flame flame detector device can be run at any burner control system. A potential free switching contact reports the state of the flame to the control system in the form of a binary signal. The combustion conditions are decisive on the optimum composition of a flame detector device.

**D-UG 110/120 Control Units**

The uncomplicated and cost-saving combination of a D-UG 110 / 120 and a flame sensor of the D-LE 103 series is often used in single-burner plants, i.e., where selectivity (extraneous-light suppression) is not a requirement on the flame sensor.

The flame sensor sends pulses to the D-UG 110 / 120, whereby the number of pulses is a measure for the flame's intensity. The number of pulses needed for a 'Flame ON' message can be adjusted in 10 steps. A potential free contact reports 'Flame ON' and/or 'Flame OFF'. An indicator instrument for information on the flame's intensity can be connected to the current output in the 0..20 mA range.

**D-UG 660 Control Unit**

More information and more adjustment options can be had from a combination of the D-UG 660 control unit and a flame sensor of the D-LE 603 series. It is recommended for use in furnace plants with several burners, which make great demands on selectivity at, simultaneously, high sensitivity levels.

A display for actual values and status information and an additional current output at the D-UG 660 offer comprehensive information on the flame and with it, on the combustion as a whole. Sensitivity can be set in 100 equal steps. At fuel change or to compensate for strong movements of the flame, a secondary flame sensor connected in parallel can take over flame monitoring. Three switches in the unit’s front panel are provided for changing the sensitivity setting which can be retained for three operating states (ranges). This operating convenience makes the D-UG 660 universally suitable for use in plants of varying fuel types and/or load conditions. Reversible electronic filters, fitted in the flame sensor of the D-LE 603 series permit enhancing their selectivity rate.

![Figure 20: Flame Monitoring with D-UG 660 und D-LE 603](image)

![Figure 21: Signal Transmission between the Control Unit and the Flame Sensor](image)
The new DURAG D-LX 100 Compact Flame Monitor is the first system of its kind to meet current American and European flame monitoring standards. The D-LX 100 was designed for continuous, intermittent and 72-hour operation. The flame monitor’s compact design integrates the flame sensor and control unit into one compact housing. This greatly reduces overall cost and simplifies installation. Additional costs normally required for mounting the control electronics in a service cabinet or separate housing unit are no longer applicable.

The D-LX 100 Compact Flame Monitor has been developed to monitor flames in single burner systems. The integrated relay output may be used to interface with the fuel control valve. Applications for the D-LX 100 range from small heating plants to process combustion systems.

Figure 22: D-LX 100 System

Figure 23: Application with Fibre Optics
Flame Monitoring

Fibre Optics for Flame Detecting Devices

The direct installation of conventional optical flame sensors on a burner is often limited due to high ambient temperatures or too little available space. The view of the flame is frequently obstructed by mechanical components of the burner or materials around the sighting tube that absorb the radiant energy of the flame. In such cases, it is advisable to employ flame sensors with fiber optics. By installing a fiber optic system in the burner, it is possible to monitor the radiant intensity in direct vicinity of the flame and bridge the sometimes long distances to the burner wall.

In principle, all burners can be equipped with flame sensors using fiber optics. Such flame sensing systems, however, are particularly suited for the following applications:

- burners with only a narrow opening for monitoring the flame.
- burners whose burner plate or site of installation allows very little room for the flame sensor.
- burners whose ambient temperature around the sighting tube is so high that the use of flame sensors with electronic components is not possible.
- tiltable bucket burners; the flame sensor must be positioned on the tiltable bucket in order to follow the movement of the flame.
- burners in which the space between the sighting tube opening and the flame contains particles which absorb the radiant energy of the flame (e.g., cement kilns).

Ignition and Flame Monitoring in Claus Plants

Over the years, Claus plants have developed into a special area of application for flame monitoring equipment and ignition devices. Claus plants are used in all refineries remove sulfur from fuels and contribute, among other things, to reducing acid rain.

Due to the high toxicity and aggressiveness of the fuel burned (H₂S), there are special requirements for equipping a burner in a Claus plant. Also, measures must be in place in the Claus plant to provide explosion-proof protection. The area around the burner is generally classified as Zone 1 with respect to explosion protection. All electrical equipment must therefore meet the particular requirements for explosion protection.

Fig. 24 shows a typical layout of flame monitoring and ignition equipment in a Claus furnace. For flame ignition, the D-HG 400 High-Energy Spark Ignitor has proven itself to be the most effective. The pressure-proof model of the D-VE 500 Pneumatic Retraction Device guarantees at all times that no toxic gases from the burner chamber are released into the atmosphere. A protective hood over the retractor shields it from the ambient environment and also protects personnel from any possible injuries from the moving piston rod.

The transparent flame of the Claus furnace is best monitored using UV flame scanners. The highest level of energy emitted from the flame admittedly does not lie in the classic UV-C range, rather in the somewhat longer wavelength UV-A and UV-B range. UV flame scanners in the D-LE 603 UA series are particularly well-suited for for monitoring such flames. These are equipped with a semi-conductor photoelement and have a spectral sensitivity that covers the UV-A and UV-B range. However, very good results may also be achieved with a highly sensitive UV-C flame scanner from the D-LE 603 US series. As a controller, a D-UG 660 should be installed in this application. This device offers the user a high degree of flexibility when making the settings.

Since the outage of a Claus furnace can bring an entire refinery to a standstill, and generate very high resulting costs, the flame monitoring in a Claus plant is generally performed in a redundant manner. This enables the flame to be reliably monitored without any problems, in every situation. Even if an outage occurs in one of the flame monitoring systems, the plant can continue to operate without interruption.

Figure 24: Claus Plant Sample Application
Automatic Burner Control System

The DURAG Automatic Burner Control Systems comprise of

- the flame sensor and
- the programming unit.

The DURAG D-GF 100 Burner Control System controls and monitors gas and oil burners of any capacity. The control functions of this system cover the tasks of prepurge, ignition and solenoid valve control, through to the enabling of the output regulation. Thanks to its flexibility, the program sequence for prepurge, ignition, fuel supply and air supply may be adjusted to the requirements of the plant, with simultaneous consideration given to applicable guidelines. These units may be used in applications ranging from large power stations to small remote heating plants, or in chemical processes or thermal flue gas combustion systems. By employing microprocessors with corresponding software and hardware, this burner management system offers improved evaluation capability and a heightened degree of safety and availability. In combination with flame sensors from either the D-LE 103 or D-LE 603 series, the burner management system is fully suited to monitor flames of different fuels and combustion techniques, in single burner or multi-burner systems. Different UV and IR flame sensors are available to optimally adapt the flame monitoring system to local conditions. The response threshold (sensitivity) of the flame monitoring system may be set to one of ten different levels using a rocker switch on the front panel of the Programming Unit. The safety time may be fixed between 1 and 5 seconds, depending on fuel and operating conditions.

Function Summary

The automation unit accomplishes all necessary steps from burner start-up up to control function releasing. Fundamentally, this includes:

- Pre-purge with air damper control
  (not applicable at non-master burner operations)
- Flame simulation controlling
- Ignition
- Solenoid valve control
- Switching-off with post-purge
  (not applicable at non-master burner operations)

Boiler pre-purge is adjustable in 10 steps. A further switch permits adjusting the control unit’s sensitivity threshold to the flame sensor signal. An LED indicator bank serves as a program step and interference code indicator.

Inputs and Outputs

- Control outputs for:
  - Air damper ON/OFF
  - Solenoids MV1, MV2, MV3
  - Fan
  - Ignition transformer

- Signal outputs for:
  - Flame ON/OFF
  - Failure

- Control inputs for:
  - Fuel type
  - Pre-purge suppression
  - Air pressure
  - Air damper positioning (end-of-travel switch)
  - External flame monitor
  - Controller as a contact chain for regular switching-off
  - Limiter as a contact chain for incident-based switching-off

Figure 25: Integrating an Automatic Burner Control System into the Process
**DURAG Information and Evaluation System D-IAS**

This system, designed for long-term monitoring of multi-burner furnace plants, is used for combustion quality assessment and, at the same time, for a clear layout presentation of different function groups. Up to 80 measuring signals are read. This makes it possible to recognise at one glance a correlation between the flame sensor signals of an entire block of 16 or more burners, and the fuel supply, the oil quantity, the dosing speed or other influential quantities.

Whereas video-monitoring and spectrometer analyzing are applied only in special cases, the DURAG Information and Evaluation System is conceived as a useful completion of a central control station for continuous state-of-operation monitoring. Its clear and user-specific diversely adjustable presentation and storage of data are of great help in judging present operational conditions and those prevailing up to several days ago.

**Figure 26:** DURAG D-IAS Information and Evaluation System

![Diagram of D-IAS System](image-url)
The ORFEUS System

In addition to monitoring temperature and fluctuations in the burner, the ORFEUS System (locally determined combustion chamber spectroscopy) enables thermally excited particles surrounding the burner, and present in the combustion chamber, to be detected online without making direct contact. This is achieved using a combination of emissions spectroscopy, modern video technology and knowledge-based systems. With spectroscopy, particle radiation is used to determine temperature and detect thermally excited particles (e.g. \( \text{SO}_2 \), \( \text{S}_2 \), \( \text{OH} \), \( \text{CH} \), etc.). The wavelength of the radiation may be located anywhere from the UV range to the near IR, depending upon the particular combustion process. Geometric flame characteristics such as position, size and form are gained using special video technology and online evaluation.

Localized and chronological characteristics result from these evaluations, which in turn allow analysis of the combustion chamber to be made.

The detected changes are recorded using special software and, after a training phase, used to establish an optimized control strategy for the combustion chamber.

With ORFEUS, new insights may be gained into process techniques, for which until now only models were available. There is tremendous potential for operating combustion systems more economically, and ORFEUS technology makes exploitation of it possible.

Recorded data may also be evaluated to optimize the performance of plant components or the normal operation of the combustion system. Mobile systems may also be used at prepared measuring locations to monitor combustion, record data or, for example, shorten or simplify the commissioning process. Such systems are also used by the TÜV Süddeutschland in Mannheim, among others, for inspecting industrial combustion systems.

**Figure 27: Flame Analysis and Combustion Control with the ORFEUS System**