



## Practical tips

Oil nozzles

## Dear Danfoss partner

Dear Danfoss partner

As one of the most important oil nozzle manufacturers Danfoss wants with this booklet to be of assistance to you in your daily work.

With this booklet you can choose and fit Danfoss oil nozzles for all purposes and for any demand.

In addition to that you get valuable tips and references to how to fit oil nozzles in your working area.

How important the function of the oil nozzle is to the oil burner appears clearly from this booklet.

Danfoss assists you in handling these mechanically complicated products which are of vital importance for the function and the output of the oil nozzle.

For further help in your work with oil burner components Danfoss refers to our Service handbook about burner components and to our homepage *[burner.danfoss.com](http://burner.danfoss.com)*



# Practical tips about Danfoss oil nozzles

## Table of contents:



|  | Page |
|--|------|
| The oil nozzle and the complete oil heating plant.....         | 3    |
| What you should know at least about oil nozzles .....          | 4    |
| How does an oil nozzle work? .....                             | 5    |
| Spray patterns and spray angles of oil nozzles.....            | 6    |
| Marking on the oil nozzle.....                                 | 7    |
| How is the correct oil nozzle chosen?.....                     | 8    |
| Boiler capacity and nozzle sizing.....                         | 9    |
| Calculation of oil nozzle capacity.....                        | 10   |
| Is it possible to compare oil nozzles of different makes?..... | 11   |
| Conversion table for oil nozzles .....                         | 12   |
| For how long can an oil nozzle be used? .....                  | 13   |
| What effects the function of the oil nozzle?.....              | 14   |
| Tips about replacement of the oil nozzle.....                  | 15   |
| What effect have dirt and sediments in fuel oil? ..            | 16   |
| What causes an oil nozzle to drip? .....                       | 17   |
| What causes an afterdrip of oil when the burner stops? .....   | 18   |

## Practical tips about Danfoss oil nozzles

### Table of contents:

|  |        |
|--|--------|
| What causes the oil to coke on the oil nozzle and the ignition electrodes? ..... | 19     |
| What is the cause of no oil from the oil nozzle?...                              | 20     |
| What to do with the old oil nozzles? .....                                       | 21     |
| What matters are the details.....  | 22, 23 |

## The oil nozzle and the complete oil heating plant

A complete oil heating plant begins at the oil tank filling connection and ends at flue or the chimney pipe.

Almost at the heart of the plant, hidden from all eyes, is a small interesting gadget – the oil nozzle. The oil nozzle plays a vital role in combustion, because it would be absolutely impossible to get CLEAN, STABLE and ECONOMIC plant operation if it is not handled correctly.

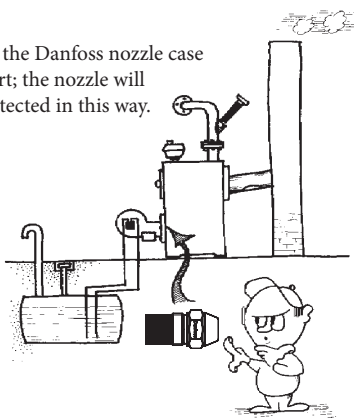
The oil nozzle should be treated like a dear friend, i.e. protectively and considerately. Be careful never to touch the tip of the nozzle and the nozzle orifice with dirty fingers, as this might cause the nozzle orifice to clog. To pick up the nozzle, always grip the spanner flats only.

### Storing:

Always leave the nozzle in its protective covering until it is to be installed in the burner.

### Transport:

Always use the Danfoss nozzle case for transport; the nozzle will be well-protected in this way.



## What you should know at least about oil nozzles

The oil nozzle is of vital importance to the combustion. It is only possible to get at clean, stable and economical plant operation when the oil nozzle functions to perfection.

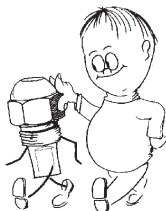
### **The best result is obtained when the oil nozzle is replaced once a year**

The reason is that in the course of the heating season, dirt particles gather in the nozzle filter and in the oil nozzles and ruin or hinder a perfect atomizing.

Both the environment and the oil account will profit from a perfect oil atomizing. Further service visits due to clogged oil nozzles should not be necessary.

### **Danfoss oil nozzles are extremely precise and meet the requirements of the actual EN-norm of a capacity tolerance of $\pm 4\%$**

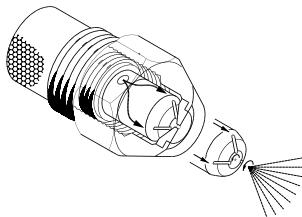
Nozzles produced by Danfoss are tested 100% in test oil for keeping the tolerances permitted. Beyond this, the atomizing patterns are tested visually for regularity and atomizing faults, if any.



Has a new Danfoss oil nozzle  
been installed?

## The function of the oil nozzle

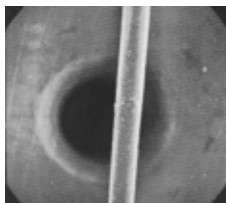
Fig. 1 shows the way the fuel oil runs through the oil nozzle: The fuel oil is put under pressure by the oil pump and runs into the oil nozzle and is filtered in the nozzle filter. In the swirl chamber the fuel oil “rotates” and leaves the oil nozzle for being burst in many fine small drops. The orifice and the cone slots determine the spray characteristics.



*Fig. 1: The way the fuel oil travels through the oil nozzle*

Burners used today, designed exactly to the heat requirement of the house, have resulted in a reduction of the burner capacities. So the cross section in the oil nozzle had to be reduced, too.

The orifice diameter on an oil nozzle is thus only a few tenths of a millimetre (fig. 2 ), which means that non-professional treatment may cause immediate operational problems.



*Fig. 2: Nozzle orifice compared with a hair from a human being*

## Spray patterns and spray angles of oil nozzles

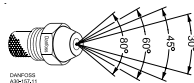
The properties of the oil nozzle appear from the nozzle markings. Oil nozzles are available with different spray patterns and spray angles. These must fit the burner in question and of course also the combustion chamber of the boiler.

The designations of the spray patterns on Danfoss oil nozzles are **S** (Solid); **H** (Hollow) and **B** (Universal = semi solid). Other marks have similar designations.



*Fig. 3: Spray patterns of the oil nozzle  
From left to right: Spray patterns B, S and H.*

The sizes of the spray angles are normally 30°, 45°, 60° and 80°.



*Fig. 4: Spray angles 30°, 45°, 60° and 80°*



## Marking on the oil nozzle

From the marking on Danfoss oil nozzles it is easy to read the capacity, spray pattern and spray angle. Danfoss oil nozzles types EH and ES for kerosene are available with 60° and 80° S and H. The nozzles are marked with the following information:

|         |              |    |     |      |        |
|---------|--------------|----|-----|------|--------|
| Danfoss | Kg/h<br>1.80 | OK | [ ] | 0.60 | 60° ES |
|---------|--------------|----|-----|------|--------|

*Marking on an oil nozzle type ES with a capacity of 1.80 kg/h*

- 1.80 kg/h = specified capacity at 8 bar, 1.65 cSt, 790 kg/h
- OK = OFTEC certification
- The figures in the square brackets [ ] are an internal series code
- 0.60 = reference capacity in USgal/h
- 60° ES = spray angle and pattern

Some countries have specific demands on capacity definition (e.g. Japan and the USA). Some types also provide information on norm specific properties according to the norm in question, e.g. EN 293 and 299.

|         |              |              |     |                 |       |
|---------|--------------|--------------|-----|-----------------|-------|
| Danfoss | Kg/h<br>2.37 | EN<br>80° II | [ ] | USgal/h<br>0.60 | 60° S |
|---------|--------------|--------------|-----|-----------------|-------|

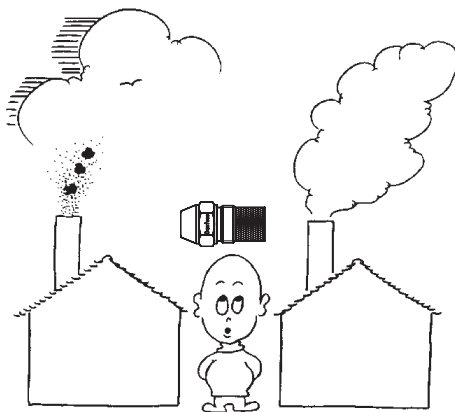
*Marking on an oil nozzle type OD with a capacity of 2.37 kg/h*

- 2.37 kg/h = specified capacity at 10 bar, 3.4 cSt, 840 kg/m<sup>3</sup>
- EN states that the oil nozzle is in accordance with the norms EN 293 and EN 299.
- 80° II states the angle index and atomizing index according to EN Norm.
- The figures in the square brackets [ ] are an internal series code.
- 0.60 USgal/h = reference capacity at 7 bar, 3.4 cSt, 820 kg/m<sup>3</sup>



## How is the correct oil nozzle chosen?

When a Danfoss nozzle needs replacing and all that has to be done is swap old for new, it is a simple matter to make sure that the numbers and letters on each nozzle correspond. If the designation on the old nozzle has become illegible, something that happens most often because of clumsy handling, the instruction book will contain details as to the right type and size to use. Should the nozzle designation be illegible and the instruction book lost, the size of nozzle must be chosen to match the boiler capacity. This information will be on a type plate fitted on the boiler, failing this it is recommended that you contact the boiler manufacturer.



## Boiler capacity and nozzle size

The capacity of a boiler is normally stated either as kcal/h or as kW

### *a) kcal/h = kilo calorie per hour*

As each kilogram of fuel oil at combustion yields 10,000 kcal = 10 Mcal, it is easy to calculate what nozzle size to choose.

### Example:

For a boiler stamped 25,000 kcal/h, choose an oil nozzle of 2.5 kg/h at a pump pressure of 10 bar. (25,000 : 10,000 = 2.5 kg). This unit capacity was also introduced in the nozzle standard.

### *b) kW = kilowatt*

The designation kW will be used more frequently in future, as the unit forms part of the SI-system of measurements.

1 litre of fuel oil yields at combustion approx. 10 kW. It is therefore easy to choose the right size of a Danfoss oil nozzle for a boiler if the capacity is stated in kW. As Danfoss oil nozzles are marked with kg/h, a conversion must be made.

1 litre of fuel oil = 0.84 kg, e.g. 20 kW boiler capacity = 2 litres or 1.68 kg/h at a pump pressure of 10 bar.

The examples overleaf show how simple it is to calculate the nozzle sizes for a different pressure.

## Calculating examples for choice of oil nozzles

### Example 1:

Here we want the required pressure setting with an oil nozzle of 2.11 kg/h to obtain a flow rate of 2.5 kg/h.

V2 = 2.5 kg wanted flow rate

V1 = 2.11 kg/h nozzle capacity at 10 bar

P1 = pump pressure at 10 bar

P2 = the wanted pump pressure

$$V2 = V1 \times \sqrt{P2:P1} ; P2 = V2^2 : V1^2 \times P1 ;$$

$$P2 = 2.5^2 : 2.11^2 \times 10 = 14 \text{ bar}$$

Pressure setting with an oil nozzle of 2.11 kg/h must be 14 bar to obtain a flow rate of 2.5 kg/h.

### Example 2:

Here we want the flow rate of an oil nozzle of 2.11 kg/h at a pump pressure of 12 bar.

V2 = wanted flow rate

V1 = 2.11 kg/h flow rate at 10 bar

P2 = pump pressure at 12 bar

P1 = pump pressure at 10 bar

$$V2 = V1 \times \sqrt{P2:P1} = 2.11 \times \sqrt{P2:P1} = 2.31 \text{ kg/h}$$

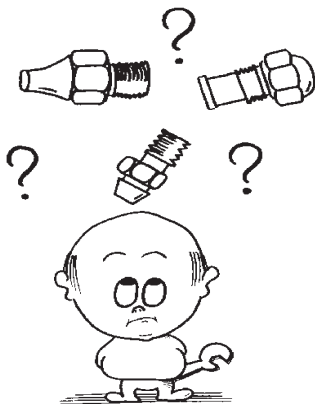
At a pump pressure of 12 bar it is possible to obtain a flow rate of 2.31 kg/h with an oil nozzle of a capacity of 2.11 kg/h.

A further help for quick determination of a suitable oil nozzle is the nozzle calculator or the nozzle capacity table.

Danfoss has thus placed a nozzle calculator on the internet, with which the right oil nozzle can be found quickly (see [burner.danfoss.com](http://burner.danfoss.com)).

Is it possible  
to compare  
oil nozzles of  
different makes?

The situation may arise where a nozzle of another make is to be replaced by a Danfoss oil nozzle and the question arises how to compare the different makes. The instruction book of the oil heating plant often contains advice and gives information on the different makes and types to use. Capacities given for the different nozzle types can be directly compared. Spray angles too can be compared as the size of the angle is stamped on the oil nozzle.



## Conversion tables for oil nozzles

### Conversion to Danfoss EH/ES nozzles

|                    |   |            |
|--------------------|---|------------|
| Hago H,SS          | ➡ | Danfoss EH |
| Hago P, ES         | ➡ | Danfoss ES |
| Delavan A          | ➡ | Danfoss EH |
| Delevan B, W       | ➡ | Danfoss ES |
| Monarch NS         | ➡ | Danfoss EH |
| Monarch PLP, AR, R | ➡ | Danfoss ES |
| Steinen H, PH      | ➡ | Danfoss EH |
| Steinen SS, Q      | ➡ | Danfoss ES |

### Conversion to Danfoss OD nozzles

|                |   |             |
|----------------|---|-------------|
| Delavan A      | ➡ | Danfoss H   |
| Delavan B      | ➡ | Danfoss S   |
| Delavan W      | ➡ | Danfoss B   |
| Fluidics SF    | ➡ | Danfoss S   |
| Fluidics HF    | ➡ | Danfoss H   |
| Fluidics S     | ➡ | Danfoss S   |
| Fluidics H     | ➡ | Danfoss H   |
| Monarch PL     | ➡ | Danfoss H/B |
| Monarch NS     | ➡ | Danfoss H   |
| Monarch PLP    | ➡ | –           |
| Monarch AR     | ➡ | Danfoss S   |
| Monarch R      | ➡ | Danfoss S   |
| Hago B         | ➡ | Danfoss S   |
| Hago H         | ➡ | Danfoss H   |
| Hago SS        | ➡ | Danfoss H/B |
| Hago P         | ➡ | Danfoss S   |
| Hago ES        | ➡ | Danfoss S   |
| Steinen PH     | ➡ | Danfoss H/B |
| Steinen H, HAT | ➡ | Danfoss H   |
| Steinen SS     | ➡ | –           |
| Steinen Q      | ➡ | Danfoss S   |
| Steinen S, ST  | ➡ | Danfoss S   |

The stated values are based on experience and are thus only to be considered as a guideline. When replacing oil nozzles, first and foremost use oil nozzles with the same shape of head.

## For how long can an oil nozzle be used?

An oil nozzle can be used for as long as a reasonable carbon dioxide percentage ( $\text{CO}_2\%$ ) and a suitably low soot number can be maintained. Whether the life of an oil nozzle will be 1 year or more is hard to predict, as it depends very much on how many hours the plant has been operating and how clean the oil is and the condition of the tank.

The life of an oil nozzle is shortened considerably if, say, nozzle filter and pump filter, if any, are missing or these parts are defective or dirty. If the oil nozzle is exposed to strong radiant heat from, say, heavily glowing incombustible material, the life will be shortened too, as the strong heat may cause the oil to coke and collect around the nozzle.

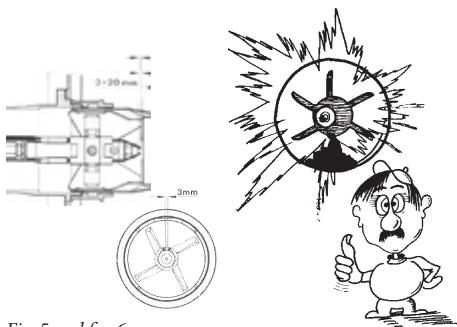


## What can disturb the function of the oil nozzle?

In connection with service visits the question is often asked what has caused the oil nozzle to fail? We will here try to describe some of the most frequent faults and how they can be rectified.

### Setting of the burner

The most frequent fault is probably wrong setting of the burner. The values stated by the burner manufacturer must be observed, such as pump pressure, adjustment of ignition electrodes, etc. It is especially important that the adjustment of the two ignition electrodes is strictly accurate (fig. 5 and fig. 6). It is of frequent occurrence that the ignition electrodes are not adjusted correctly and the ignition goes from an electrode to the oil nozzle. This is clearly seen from burned spots or from advanced grooves in the oil nozzle. Nowadays the location of the oil nozzle in relation to the baffle plate is often optimized with firm impact rims in the burner. The right spray angle is also very important, both to prevent the oil from the oil nozzle spraying against the baffle plate and to prevent the mixture proportion between air and oil mist to change because of a too small spray angle.



*Fig. 5 and fig. 6:  
Examples of distance between electrodes*



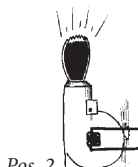
## Tips for change of the oil nozzle

### The right way to change an oil nozzle

When changing an oil nozzle, it is especially important that the nozzle holder is bled well and the oil passages are cleaned. After demounting of the old oil nozzle in a horizontal position (pos. 1), the nozzle holder is cleaned with a clean, flockfree cloth. Then the burner is placed in service position (pos. 2) and in this position, vertically upwards, the nozzle holder is filled to the rim with fuel oil.



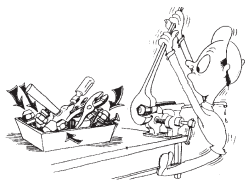
Pos. 1



Pos. 2

Now the new oil nozzle is slowly screwed in so that the air in the oil nozzle can be let out. After the new oil nozzle has been inserted, the nozzle plate should not be touched with the fingers any more to prevent dirt in the nozzle orifices.

By doing so, it is prevented that dirt loosened during demounting of the oil nozzle stays in the nozzle holder and later causes the nozzle to fail. Never use aggression when mounting the nozzle as this can ruin the sealing surface between the oil nozzle and the nozzle holder.



### Tightening torque for oil nozzles

|                    |          |
|--------------------|----------|
| Recommended torque | 15-20 Nm |
| Maximum torque     | 25 Nm    |

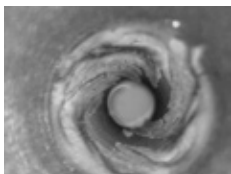
## What effect have dirt and sediments in fuel oil?

### Dirt/sediments in fuel oil

The oil nozzle is equipped with different filters, dependent on the size of the nozzle. These nozzle filters are normally always sintered bronze filters in the lowest capacity area and have very good properties, especially where rod-shaped and thready dirt particles are concerned.

When such particles have reached the interior of the nozzle, they will soon ruin the nozzle (fig. 7).

Therefore, the right choice of prefilter is of decisive importance for the life of the oil nozzle (fig. 8).



*Fig. 7: Dirt sediments in the swirl chamber*



Ruined/dirty – new

*Fig. 8: Ruined cartridge filter*



Nowadays cartridge filters of different fineness and sizes are available. Thus the fineness for normal use is ranging from 100  $\mu$  over 50-75  $\mu$  to 25-40  $\mu$ . But also cartridges with finenesses of 5  $\mu$  are offered. A finer pre-filter is always to be preferred to a coarse pre-filter. Measure max. vacuum regularly! A too high value indicates a choked filter.

## What causes an oil nozzle to drip?

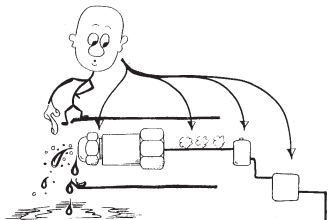
In fairness it has been maintained from the beginning that in most cases the oil nozzle is not the cause of after dripping. But whatever the cause may be, after dripping from the oil nozzle must in any circumstances be stopped as quickly as possible to prevent sooting up of the burner head or the area around it or the combustion chamber.

### **Oil drips when the burner starts**

This can happen during preheating in the oil preheater when the oil expands or during prepurge due to a dirty or defective closing valve in the oil pump.

### **Oil is dripping during operation**

- The oil nozzle is located too far from the baffle plate or the burner head.
- Ignition electrodes protrude into the oil mist, so they are placed incorrectly.
- Dirt in the oil nozzle or oil coke in and on the nozzle orifice.
- The nozzle orifice is defective, because of attempts to clean it.
- Too low oil pressure. Remember to check now and then.



## What causes after-drip of oil when the burner stops?

### **Afterdrip of oil when the burner stops**

When the burner stops and the oil nozzle sprays a jet of oil instead of cutting off the oil supply with lightening rapidity, the most likely reasons are: A slight leak in the suction line may result in tiny amounts of air getting into the oil pump, the pressure line or the oil nozzle.

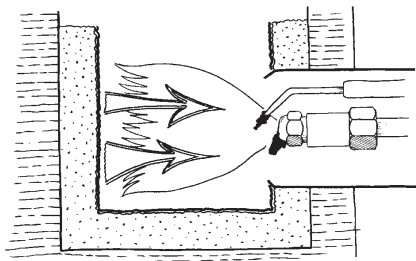
Such an amount of air is, however, not sufficient to disturb the function of the burner, but large enough to produce an afterdrip and even an oil jet when the burner stops. This will eventually lead to the parts getting dirty and cause malfunction.

The oil in the oil pressure line between the pump and the oil nozzle contains air.

Even with a perfectly operating closing valve and a thorough bleeding of the pressure lines, afterdrip of oil can be seen because of the radiation of heat from the combustion chamber, which expands the oil and forces it into the oil nozzle after the burner has stopped.

## What causes oil coke on the oil nozzle and ignition electrodes?

When liquid oil is heated above a certain temperature a process takes place called “cracking” and a stone-hard black carbon settles. Under normal operating condition, the amount of carbon deposited on the nozzle and ignition electrodes will be unnoticeable. But just a slight scratch on the tip of the nozzle can create a path along which small amounts of oil can find their way. This oil is exposed to a very strong radiant heat and will, consequently, produce carbon on the tip of the nozzle and cause interference with the atomizing process and can cause poorer combustion. The same thing happens when the oil nozzle drips.



If the ignition electrodes are placed incorrectly, so that they can be hit by the injected oil, the heat from the flame will in time start carbon deposits to build up on the tip of the electrodes. Eventually, the electrodes will short circuit and there will be no ignition spark and plant restart will be impossible. Coke formation on oil nozzle and ignition electrodes will inevitably lead to operating problems and poor combustion and must at all costs be avoided.

## What is the cause of no oil from the nozzle?

To say the least, it is irritating if not one drop of oil emerges from the nozzle. To eliminate the problem, follow the rules below for “immediate help” step by step.

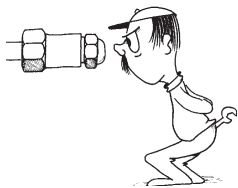
- Is there oil in the tank?
- Is the valve on the suction line open or closed?
- Is the check-valve on the suction line the wrong way round?
- Does the pump shaft rotate?
- Is the connection between pump and motor ok?
- Can any suction effect of the pump be seen?
- How much vacuum does the vacuum meter show?
- Can the presence of air be seen in one of the transparent test hoses on the suction side of the pump?

The reason may be a too high vacuum or a leaky suction line.

- Is the pump filter clean and in good order?
- Are the valves (the hydraulic valve or the solenoid valve of the pump) open and working properly?
- Is there dirt in the oil pressure line to the oil nozzle?
- Is the nozzle filter clean and in good order?
- Is the oil nozzle blocked?
- Is the oil very cold and thick?

Perhaps some water in the oil has turned into ice.

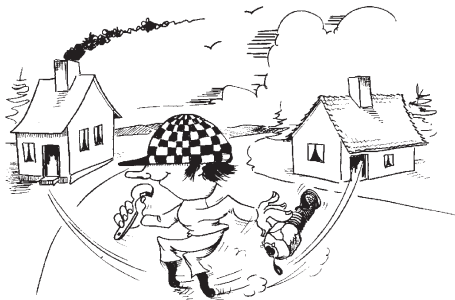
If all these factors are checked and ordered as necessary, the oil nozzle should spray oil.



## What to do with the oil nozzle?

Waste and re-use are topical subjects at the moment and though there are many things which can be used again and again, it cannot be expected that an old and dirty oil nozzle will be of use to anybody. So re-use of an oil nozzle must therefore be deprecated.

For safety's sake, old oil nozzles must be thrown away immediately.



# What matters are the details

The simple appearance of the oil nozzle throws its complicated mechanism into the shade.

The narrow tolerances of the oil nozzle and the fine details play a decisive role for function and performance.



## Accurate tools

Accuracy is the key to an optimum function. So does the production demand the highest precision. Danfoss takes many measures to ensure the quality. These also include production of embossing arbors which are grinded with tolerances of only a few  $\mu\text{m}$ . This ensures the form in the inlet and the outlet of the nozzle.



## Maximum repetition

The fine cone slots are cut with a real diamond to ensure highest precision and the best surface. The precise manufacture of the nozzle plate and measurements with the paternator ensure maximum repetition of spray pattern, spray angle and performance.





### **Compliance with the strictest standards**

Danfoss oil nozzles are second to none when compliance with international norms and standards are concerned.

This appears from the list below:

- First manufacturer of the EN-oil nozzle (1992)
- First oil nozzle manufacturer who met the requirements of the OFTEC-standards (1995)
- The oil nozzles have been approved according to CSA-standard

Danfoss has also been ISO-9001 certified and our production plants meet the environmental authorities' conditions in ISO 14001.



We are a leading global producer of components for combustible liquid burners used in domestic, commercial and industrial applications. Our position has been achieved by exceeding the expectations of our customers; by responding quickly to their needs, by providing top quality in all respects and by offering competitive prices – all this and still with due consideration to the environment.

Our range of products for oil burners and boilers comprises oil pumps, oil nozzles, preheaters, ignition units, burner controls and thermostats.



## The Heart of Heating

[burner.danfoss.com](http://burner.danfoss.com)

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