I. How the HAGO Nozzle Works

The function of a high pressure atomizing oil burner nozzle is to meter the fuel in very precise amounts, deliver these droplets in a series of specific spray angles and spray patterns and simultaneously "atomize" the oil into extremely tiny droplets so they can burn cleanly. As the oil breaks into these mist-like droplets, each drop becomes surrounded by air. It is this intimate bonding of air and oil that enables a burner to achieve clean combustion.

The first thing to understand is the path the oil takes as it flows through the nozzle. Figure #1 shows the oil being pushed through the nozzle from the pressure provided by the pump. As it reaches the nozzle filter, the oil passes through it, from outside to inside, then works its way up through the nozzle until it reaches the metering slots.

The metering slots have two functions. The first is to precisely limit the amount of oil that can pass toward the nozzle's orifice. The tolerances on the width and depth of the metering slots are microscopic, about 1/40 the width of a human hair. You can see that these slots are cut on an angle across the seat of the nozzle's disc.

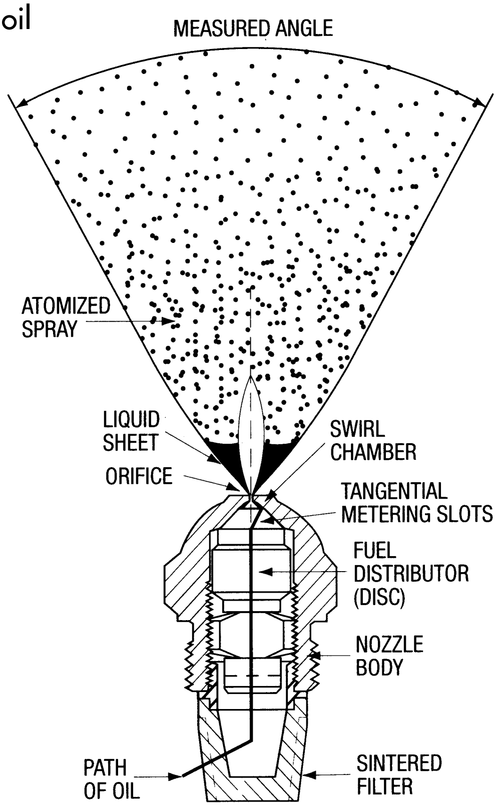


Figure #1
Oil Path Through Nozzle

These angular metering slots perform the second function by directing the oil into the nozzle swirl chamber, thereby creating a rapidly whirling rotation. (See Figure #2)

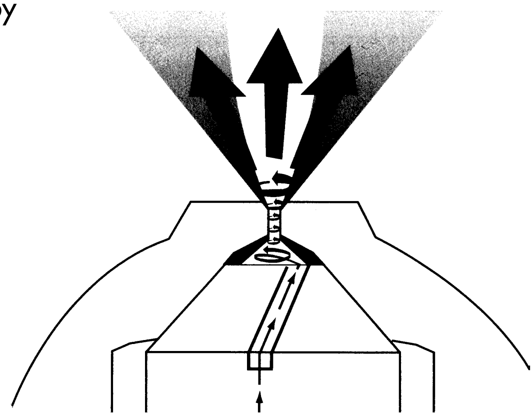


Figure #2
Metering Slots

This swirling oil actually forms into a "hollow tube" of oil and is shaped and behaves much like a cyclone with a central air core. This spinning tube of oil is pressed against the walls of the orifice as it makes its way toward the exit. The air core's relevance will be explained later. Fig#3 shows how the oil behaves as it leaves the nozzle.

When the oil departs the lip of the orifice it continues to spin, but only for a very tiny distance. The liquid sheet is the part of the spray after it has exited the orifice, but not yet begun to break into droplets.

After leaving the orifice (within a distance of just 1/64-inch), the spinning oil firm is shared apart by centrifugal force. Immediately the droplets are formed. Think of what happens if you tie a rock on a string and spin it around your head, and then let go. The rock launches out in a straight line. Certain laws of physics dictate that this must occur, and the same happens with the oil droplets.

Because the oil droplets are not spinning, there is no reason to be concerned if you notice the slots of one brand of nozzle are cut to make the oil rotate in the opposite direction of another brand of nozzle. The only thing that can make the droplets continue to spin after they break off from the liquid sheet is the influence of the air from the oil burner's air mixing head.

Always remember: there are no moving parts in an oil nozzle. The only thing spinning inside the nozzle is the oil. Therefore, it stands to reason that is a nozzle is installed properly and good combustion results are measured, if the nozzle later falls it can only be as the result of some outside force such as oil sludge or overheating.

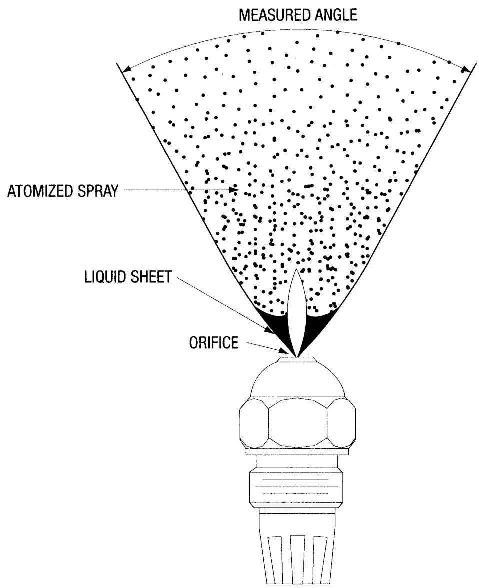
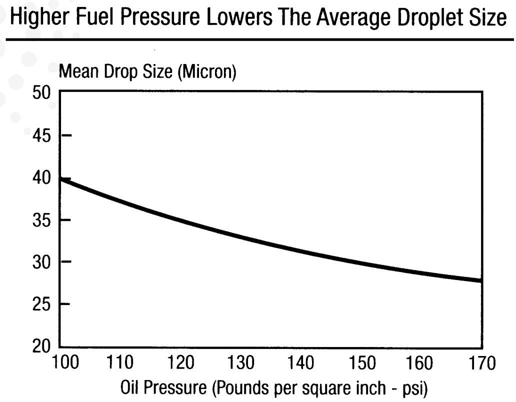


Figure #3
Oil Spray Leaving Nozzle

II. Factors Influencing Nozzle Performance

Pressure

All oil burner nozzles, worldwide, are rated for their flow rate, spray pattern and spray angle at 100psi. However, modern oil burners are increasingly operating at 135, 140, 150 and even up to 200 psi. This is because higher pressure oil delivery provides more energy with which to break the oil into even finer droplets. Finer droplets bring about cleaner, quieter combustion, and minimize undesirable emissions. Figure#4 shows the relation



Figure#4
Oil Pressure vs. Droplet Size

ship between oil pressure and average droplets size for a typical 1.00 gph nozzle. You can see that as pressure increases from 100 to 150 psi, the average droplet size decreases by about 20%. (Chart courtesy Brookhaven National Laboratories.)

Unlike what you might expect, the flow rate through the nozzle does not increase proportionately with increases in pressure. Instead, it changes roughly in relation to the square root of the pressure change. In a nutshell, this means the pressure would have to be quadrupled in order to approximately double the nozzle's throughput. Handy pocket calculator cards are available to show quickly what the resultant flow rate is through a nozzle at various pressures. (See Figures #5 and #5A.)

If you are on a job and don't have the correct flow rate nozzle with you, it may be possible (as a temporary fix) to install the next lower nozzle size and adjust the pressure upward to bring it to approximately the desired flow rate. Pump pressure should never be adjusted downward below 100 psi operating pressure. This would cause incomplete atomizing and unsatisfactory combustion. To be certain of the operating conditions, a precise pressure gauge should be used on all installations.

Figure #5 **Nozzle Flow Rate vs. Pressure (Approx.)**

Flow Rating USGPH@ 100PSI	Flow Rates in US GPH Pressures PSI					
GPH	**125**	**145**	**175**	**200**	**250**	**300**
0.40	0.45	0.48	0.53	0.57	0.63	0.69
0.50	0.56	0.60	0.66	0.71	0.79	0.87
0.60	0.67	072	0.79	0.85	0.95	1.04
0.65	0.73	0.78	0.88	0.92	1.03	1.13
0.75	0.84	0.90	0.99	1.06	1.19	1.30
0.85	0.95	1.02	1.12	1.20	1.34	1.47
1.00	1.12	1.20	1.32	1.41	1.58	1.73
1.10	1.23	1.32	1.48	1.56	1.74	1.91
1.20	1.34	1.44	1.59	1.70	1.90	2.08
1.25	1.40	1.51	1.65	1.77	1.98	2.17
1.35	1.51	1.63	1.79	1.91	2.13	2.34
1.50	1.68	1.81	1.98	2.12	2.37	2.60
1.65	1.84	1.99	2.18	2.33	2.81	2.86
1.75	1.96	2.11	2.32	2.47	2.77	3.03
2.00	2.24	2.41	2.65	2.83	3.16	3.46
2.25	2.52	2.71	2.98	3.18	3.56	3.90
2.50	2.80	3.01	3.31	3.54	3.95	4.33
2.75	3.07	3.31	3.84	3.89	4.35	4.76
3.00	3.35	3.61	3.97	4.24	4.74	5.20
3.25	3.63	3.91	4.30	4.60	5.14	5.63
3.50	3.91	4.21	4.63	4.95	5.53	6.06
3.75	4.19	4.52	4.96	5.30	5.93	6.50
4.00	4.47	4.82	5.29	5.66	6.32	6.93
4.50	5.03	5.42	5.95	6.36	7.12	7.79
5.00	5.60	6.00	6.60	7.10	7.91	8.66
5.50	6.10	6.60	7.30	7.80	8.70	9.53
6.00	6.70	7.20	7.90	8.50	9.49	10.39
6.50	7.30	7.80	8.60	9.20	10.28	11.26
7.00	7.80	8.40	9.30	9.90	11.07	12.12
7.50	8.40	9.00	9.90	10.80	11.86	12.99
8.00	8.90	9.60	10.60	11.30	12.65	13.88
8.50	9.50	10.20	11.20	12.00	13.44	14.72
9.00	10.10	10.80	11.90	12.70	14.23	15.59
10.00	11.20	12.00	13.20	14.10	15.81	17.32
11.00	12.30	13.20	14.80	15.60	17.39	19.05
12.00	13.40	14.40	15.90	17.00	18.97	20.78
13.00	14.50	15.70	17.20	18.40	20.55	22.52
14.00	15.70	16.90	18.50	19.80	22.14	24.25
15.00	18.80	18.10	19.80	21.20	23.70	25.98

Test Oil Standards: 35 SSU @ 100˚F. Specific Gravity .825 @ 60˚F.
1 US Gallon = 3.122 Kg/Gal. Test Pressure 100PSI = 7.03 Bars.
Flow rates are estimated as equal to the square root of the pressure ratio.

Figure #5A

Pressure vs. Flow

For general purposes, change in flow rate due to change in pressure can be estimated as being approximately equal to the square root of the pressure ratio. Therefore:

Flow @ the desired pressure = rated flow @ 100 psi x $\sqrt{\frac{\text{DESIRED PRESSURE}}{100}}$

or....$F_2 = F_R \times \sqrt{P_2 / P_R}$

Example 1: To determine the flow rate of a 1.25 gph nozzle @ 145 psi, multiply 1.25 the square root of 145/100....or $1.25 \times \sqrt{\frac{145}{100}}$

Therefore the flow rate would be about 1.50 gph.

TIP: Another way to describe the relationship of pressure vs. flow is to remember that in order to double the nozzle flow, you would have to quadruple the line pressure.

But what if you want to make the reverse calculation?
Suppose you have a 1.25 gph nozzle but you want to adjust the pressure to obtain a flow rate of 1.50 gph and you are wondering what pressure is required.......

Example 2: Required pressure = (Desired flow rate/Rated nozzle flow rate)2 or...
P2 = (F2/FR)2. Divide the desired flow (1.50 gph) by the nominal flow (1.25 gph). The answer is 1.46 or approximately 145 psi.

Viscosity

Viscosity is a measure of the relative thickness of the oil. As oil is heated it becomes thinner and less viscous. Conversely, colder oil becomes thicker and more viscous. Think of molasses ar room temperature versus molasses in your refrigerator to understand the difference. As oil becomes colder, larger droplets result which cause inferior performance. Figure #6 shows that the average droplet size increases in size by around 15% as the oil temperature drops from 80˚F to 20˚F. (Chart courtesy Brookhaven National Laboratory.) Always remember that if you set up a burner during the summer when the oil in the tank is relatively warm, it may perform differently in the winter when the oil will be colder, especially if there is an outdoor tank in use.

Viscosity is usually measured by the length of time it takes, in seconds, for a certain amount of oil to drain through a funnel-like device with an outlet orifice of a precise diameter. In the USA we use a unit of measure called 'SSU" - Seconds Staybolt Universal.

Since No.2 heating oil normally measures about 35 SSU at 100˚F, that means it takes 35 seconds for a certain quantity of oil to drain completely through this measuring orifice. Other countries use different, but nonetheless similar, systems. Figure #7 shows comparisons of various commonly used systems.

We know from common experience that thicker (more viscous) oil runs more slowly than thinner (less viscous) oil. Contrary to what logic would lead you to expect, the opposite actually occurs within the normal range of viscosities encountered with the use of No.2 heating oil. That means colder, unheated oils actually make a nozzle produce a higher flow rate than normal. Why would this be?

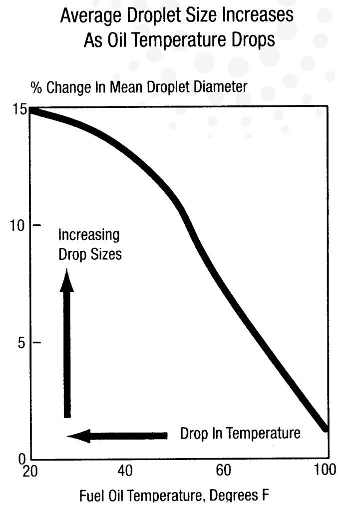


Figure #6
Temperature vs. Droplet Size

Remember the hollow core of air inside the spinning tube of oil as it spins out through the orifice?

When oil is more viscous, the wall thickness of this spinning tube of oil becomes thicker and the oil spins more slowly. This, in turn, reduces the diameter of the air core. Since the orifice now contains more oil and less air core than normal, more oil passes through and the flow rate actually increases. This rule holds true only up to about 45 SSU. Above that, the oil becomes too viscous and flow rates start to drop.

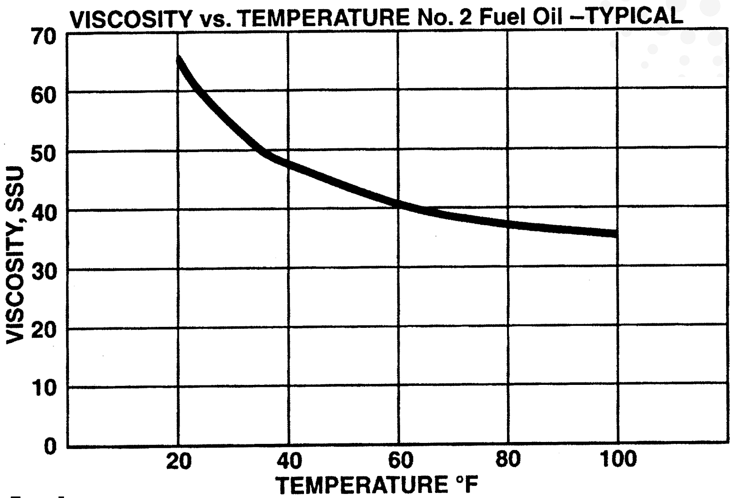
Figure #8 shows how the viscosity of No.2 heating oil changes at different temperatures. Within normal temperature ranges, it can be roughly estimated that nozzle flow will change about 1% for every 1 SSU change in viscosity. (Graph provided courtesy R.W. Beckett Corp., Elyria, Ohio.)

Figure #7

Viscosity Conversions: Viscosity Values For Different Scales

Viscosity Saybolt Seconds Universal @100°F (38°C)	Viscosity Kinematic Centistokes @100°F (38°C)	Viscosity Redwood No. 1 Seconds @100°F (38°C)	Viscosity Engler Degrees @100°F (38°C)
30.0	1.00	28	1.00
32.6	2.00	31	1.14
33.0			
34.0	2.40	32	1.15
35.0	2.70	34	1.16
36.0	3.00		1.22
37.0	3.30		
38.0	3.60	35	1.27
39.0	3.90		
40.0	4.24	36	1.31
41.0	4.60		
42.0	4.90	38	1.39
43.0	5.20		
44.0	5.50		
45.0	5.81	40	1.45
46.0	6.20	41	1.50
47.0	6.50		
48.0	6.80	43	1.55
49.0	7.10		
50.0	7.37	44	1.58
55.0	8.87	48	1.73
60.0	10.32	53	1.88
65.0	11.72	57	2.03
70.0	13.08	61	2.17
75.0	14.38	66	2.31
80.0	15.66	71	2.46
85.0	16.90	76	2.59
90.0	18.12	80	2.72
95.0	19.32	85	2.86
100.0	20.55	87	3.00
125.0	26.30	111	3.63
150.0	31.90	130	4.40
175.0	37.70	156	5.10
200.0	43.00	173	5.78
250.0	53.70	216	7.31
300.0	64.60	259	8.65

Figure #8
Viscosity vs. Temperature Changes in No.2 Oil



Spray Angle

Refer back to Figure #3. You will note that as the oil exits the nozzle the outer edge of the spray does not move outward in a straight line. Instead, it gradually curves inward before straightening. This is because there is a small area of vacuum inside the spray that pulls the droplets slightly inward. Most manufacturers measure the angle of the spray at a a point about 1″ - 2′ from the orifice. This us where the "effective angle" is formed.

Measuring spray angles is very tricky and subjective. The amount and angle of illumination can make a spray angle look very different under varying conditions. The fineness of the atomization can make the outer edge of the spray difficult to see and measure. Particularly in small gallonage nozzles, where the droplets at the edge of the spray seem to gradually fade away into nothing, there is no clearly defined edge. Thus, spray angles can be accurately measured only under laboratory conditions.

The most important factor to remember about spray angles is that the spray must no impinge on either the burner's turbulator head or the combustion chamber's back wall. If the spray angle is too wide, it can lead to wetting of the turbulator, the ignition electrodes, or the chamber side wall.

Always try to follow the equipment manufacturer's recommendation for spray angle when replacing nozzles.

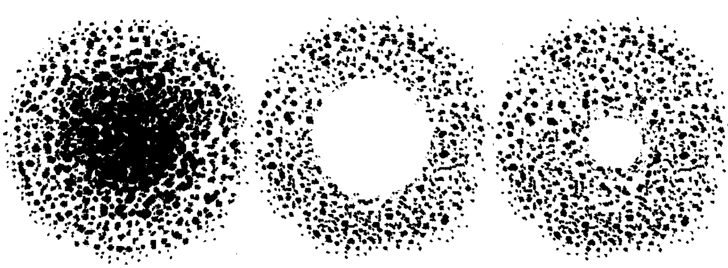
Spray Patterns

By changing minor dimensions in the nozzle's internal geometry, such as the number and the angularity of the metering slots, length of the orifice, swirl chamber dimensions and others, the spray pattern produced by the nozzle can be altered.

To understand spray patterns, Imagine yourself standing behind a window with a garden hose spraying on it. You would be able to see the pattern with which the water is hitting the glass. It may show the droplets uniformly hitting the glass or you might see a hollow area in the middle of the spray where less water is hitting. The middle of the spray coverage area may be much heavier, or more solid.

Oil burner nozzles are designed to produce many types of patterns in a similar way. They are usually described as "Hollow". "Solid, or "Semi Solid" Figure #9 shows illustrated representations of different types of spray patterns. These different patterns are needed by burner manufacturers - so they can find and specify the nozzle that most exactly matches the air pattern produced by their burner turbulator head -- to get the best intermingling of oil and air.

Figure #9 Burner Nozzle Spray Patterns



Solid **Hollow** **Semi Solid**

All nozzles of a certain spray pattern are manufactured with a similar internal geometry but all do not, in fact, produce the same pattern. A number of things influence spray patterns, including viscosity, pressure, flow rates and spray angles. When spray patterns are compared, it should only be to other nozzles of the same flow rate and spray angle. In general, low flow rates tend to be more solid, and higher flow rates tend to be more hollow. For example, a .30 GPH nozzle, even in a nominally "hollow cone" spray pattern, will actually produce a solid cone pattern and a 8.00 GPH "solid cone" nozzle will tend to be mostly hollow.

You can imagine that the pattern of a hollow spray pattern at 80° when constricted down into a 30° angle, will be altered dramatically. At 30°, no spray pattern can be truly hollow and at every spray angle the pattern is different than at the other angles of the same flow rate.

Increasing pump pressure above the spray angle's rating pressure of 100 psi will gradually make the spray become more hollow. Conversely, if the viscosity of the oil is increased above the rating point of 35 SSU, the spray will tend to become more solid.

Nozzle Design and Materials

Various nozzle manufacturers use constructions of brass with pressed-in orifice nibs, or brass with nickel plating, and often with several component pieces internally.

HAGO's 100% stainless construction assures consistent expansion and contraction of all the nozzle components as they repeatedly heat and cool with each firing cycle, thereby maintaining consistent firing results. Our design with a one-piece nozzle tip is beneficial because it assures leak proof results since there is no separate, pressed-in orifice piece.

Another primary benefit of HAGO's unique design comes from our one-piece internal construction. Although more costly than multiple piece internal construction, our one-piece design assures more precise centering of each nozzle. This, in turn, results in a better, more precise, and well balanced spray.

Burner Head and Electrodes

Oil burner turbulator heads are manufactured very precisely today and their designs are the result of hundreds of hours of painstaking tests in the laboratory to achieve the very best possible combustion results. But even the most perfect nozzle will not give optimum results if it is not installed exactly in accordance with the burner manufacturer's recommendations. With every installation, complete combustion tests with instruments must be made to assure maximum operating efficiency.

Positioning of the ignition electrodes is also a precise task. If electrodes are set too close to the nozzle tip, the spark may jump to the nozzle, causing poor ignition. We have even seen examples of nozzle tips that have partially melted from the spark jumping from the electrode to the nozzle's dome due to improperly positioned electrodes. If you have difficulty getting a good burner star-up and/or have frequent call backs, it is a safe assumption that you are not setting the electrodes properly

III. Service Tips - General Information
Handling Nozzles

Even though they are made of metal, nozzles are delicate and should be handled very carefully. The nozzle's orifice is precisely contoured like the mouth of a trumpet, with a very highly polished surface.

The least small bump or scratch to this surface of the orifice's tip can irreparably damage the nozzle and result in a badly distorted spray. Even the dirt or grease from our fingers could lodge on the orifice and disrupt the spray or it could be unknowingly forced into the filter and lead to clogging or premature nozzle failure. For this reason, nozzle should be kept in their individual plastic tubes until the moment of installation. You should handle nozzles only on the flat sides of the hexagon.

All HAGO nozzles are tested with a special solvent to prevent congealing of the test oil. This means our nozzles can be stored almost indefinitely without fear or anything going wrong while in storage. Needles or pins should never be used to try to clean a nozzle as they will cause immediate and severe damage to the polished orifice surface.

Installing Nozzles

When reopening the oil valve at the tank, after replacing the nozzle, pump strainer, and the filter cartridge, you can expect some contamination to break loose from the oil line, particularly on older installations. When the filter has been replaced, we recommend that you run about a pint of clean oil through the line to purge it of loose particles before installing the new nozzle. If any dirt or sludge is allowed to remain, the first surge of oil passing through the oil line can force this contamination through the nozzle's filter and into the nozzle where it can enter the metering slots. This leads to clogging, often immediately, sometimes later, and is to be avoided at all costs.

Tiny particles of dirt or carbon particles can clog a nozzle, even if they are individually smaller than the internal openings of the nozzle. If they are present in some abundance, they can "log jam" to clog the orifice or a metering slot - they same way a bunch of BB's poured rapidly through a funnel would clog the funnel's channel. Cleanliness is of the utmost importance when handling nozzles.

Complete combustion tests with accurate instruments are always needed to verify a good installation. Remember that nozzles have tolerances on their flow rates and spray angles, so every one is not exactly the same. (Figure #10)

Additionally, pumps, gauges and all manufactured components have tolerances, plus the oil's viscosity can vary from the delivery to delivery. These are all reasons why through and complete combustion tests are needed, even if replacing a nozzle with a new one that is "identical." Today's oil burners have been exhaustively tested and manufacture's recommendations should be followed meticulously when installing or tuning them up.

Figure #10 Hago Specifications

Nozzle Specifications

Nozzles are provided with Hago's unique ribbed sintered bronzed filters on sizes up through 1.35 gph. Larger sizes are equipped with 120 mesh strainers. Large Capacity (LC) nozzles are supplied as "tips only." All nozzle components are fabricated entirely of a special high chrome, heat resistant grade of stainless steel. Sintered filters are made of bronze and are nominally rated for filtration to 40 microns. Mesh screens are of Type 304 stainless steel on brass support pieces.

Test Specifications

All Hago oil burner nozzles are 100% tested on oil for accuracy of flow rate, spray angle, concentricity and spray quality. This individual testing is your assurance of top quality and consistency. (Test oil has an operating viscosity of 35 SSU @ 100˚F (2.7 Cstk). Specific gravity = .825 @ 60˚ 60˚F)
Flow Tolerances:

.30 - 0.35 -2% - +8%
.40 - 1.50 -2% - +6%
1.65- and up = -2.5% - + 2.5%

Cleaning Nozzles

The internal openings of a nozzle are only about 11/2 times the size of a human hair. It has been said that a gnat's eyelash is sufficient to clog them.

Experience has shown that nozzles can only be cleaned and assembled under very clean conditions, such as at the factory. It cannot be done reliably in the field and should be attempted only in absolute emergency conditions. Even when successful, you should obtain a new nozzle as soon as possible failure and a servicing callback.

Though not recommended, there may come a time when you have no choice but to try to clean and reinstall an old nozzle. It should be done by first rinsing all the parts in clear oil or kerosene. Do not intermix parts from different nozzles. Do not wipe parts with a rag, as it is likely to leave lint or dirt that will lead to clogging. (Note: Nozzles 1.00 gph and under should not be cleaned under any circumstances, as it is impossible to do so reliably.) Screw the parts together gently with only an extra 1/4 turn to tighten the internal parts. Too much torque can crush the metering slots and alter the flow rate. Do not blow through the nozzle with your mouth, but if you have compressed air available you could use it to blow off the flame with an inspection mirror and then with test instruments to verify that everything looks OK. Proceed cautiously.

Nozzle Longevity

Nozzles are almost never wear out. Instead, they eventually fail due to outside forces such as varnishing of the metering slots and orifice from overheating or from accumulations of oil sludge. A build up of varnish residue will gradually alter the flow rate and spray pattern over time. Severe overheating can cause the oil inside the nozzle to break down and undergo a secondary cracking that precipitates tiny carbon particles that can lead to eventual clogging. Improperly set electrodes, dirty oil or damage to the orifice lip area can all cause nozzle failures. For these reasons, considering the very low cost of nozzles it is considering the very low cost of nozzles, it is considered to be a wise investment to automatically replace the nozzle each year, usually as part of the spring tune up.

IV. Accessories

Adapters

The underside of the nozzle has a smooth surface that seals onto the top surface of the brass nozzle adapter. This becomes a metal to metal seal, so be sure neither surface is marred. When changing the nozzle, remember to also check the adapter and replace it, too, if the seat has become damaged or crushed from previous nozzle over tightening.

Only a small amount of force is necessary when screwing the nozzle onto the adapter. Brass is a relatively soft metal and over tightening of the nozzle onto the adapter. Brass is relatively soft metal and over tightening of the nozzle onto the adapter will ruin its smooth and square seating surface. The reason why nozzle remover tools have short handles is because this reduces the leverage and prevents too much torque from being applied. If you are using box wrenches, you only need to snug the nozzle to the adapter finger tight, and then turn it about another 1/4 - 3/8 turn. This is sufficient to seal the nozzle against leakage. Adapters are available in lengths of 1″, 13/8 (standard size) and 2″

Double nozzle adapters, that allow two nozzles to spray simultaneously, and dual adapters, that allow two nozzles on the same line to spray independently of each other, are available. Special nozzle adapters are also available for use with bypassing nozzles. The HAGO bypassing adapter is designed to allow its use with bypass nozzles of all other brands.

Nozzle Boxes

These provide a convenient way to carry nozzles to the job site while also protecting them against dirt and damage. HAGO offers a single layer box that holds 50 nozzles and also a double layer box holding 100 pieces. Both are made of heavy gauge steel with strong, reliable hasps.

Inspection Mirrors.

You will find a lot of uses for these handy mirrors with telescoping steel handles that extend from 101/2" closed, to 281/2'fully extended. The mirrors are made of a special optical grade stainless steel for best visibility. When used for observing flame quality they should be held to the side of the flame - not directly into it. If the metal becomes overheated it can burn and turn a bluish color that hinders viewing. Mirrors are available in several sizes to allow access to small or large openings.

Nozzle Racks

If you have a need to store greater quantities of nozzles, either in your service truck or in your parts storage area, a nozzle rack is a convenient way to do it. Hung on the wall, these racks have several vertical channels that hold nozzles in their plastic tubes, so the nozzle caps with their markings can be seen clearly. The plastic version holds 144 nozzles and features a transparent plastic snap-on lid to prevent against dust and to keep nozzles from falling out when mounted in a truck. The steel rack holds 680 nozzles.

V. Special Nozzles

Bypass Nozzles (Type BPS)

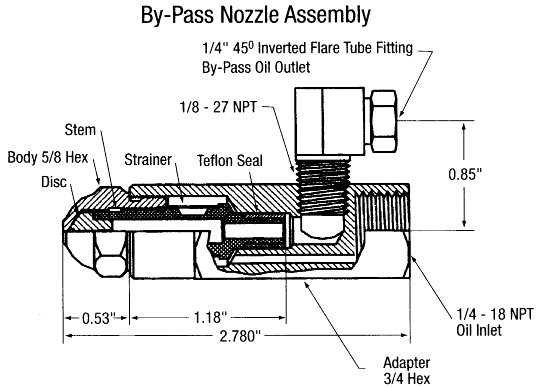
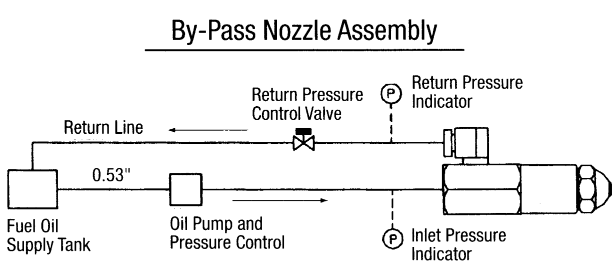


Figure #11
Bypass Nozzle

You will not encounter Bypass nozzles (also known as return flow nozzles) in residential burners, but it is helpful to understand how they function. These special nozzles allow the flow rate to be varied from the full nominal flow rate down to about 1/3 of the rated capacity. They are mounted in a special adapter that has a side port to allow some of the incoming oil to be bled off or "bypassed" back to the tank. Figure #11 shows the unique design of these nozzles and their adapter. Normal nozzles cannot be used in these adapters.

The return oil line in a bypassing burner is normally set up to include a hand or automated valve and a pressure gauge. When the valve is opened it allows a portion of the incoming oil to return (bypass) to the tank. This reduces the flow rate through the nozzle orifice because opening the valve has reduced the pressure of th oil reaching the nozzle orifice. As the valve opening is increased, the flow through the orifice continues to drop. By



Figure#12
Bypass Nozzle Installation

reading the gauge and matching the pressure readings against flow charts supplied with each nozzle, the serviceman can determine approximately how much oil is passing through the orifice. Of course, since the orifice flow is changing, it means the air delivery to the burner must also be adjusted accordingly. This is normally accomplished automatically with a linkage built into these special burners.

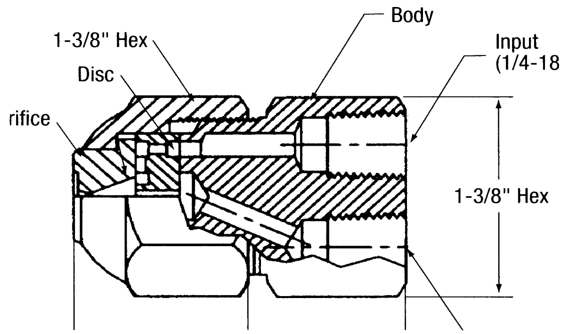


Figure #13
Type RFL Nozzle

A larger commercial version of the variable flow nozzle is also available from HAGO. The Type RFL nozzle features a turn down ration of up to 5:1 and flow rates from 50.0 to 300 gph. (Figure #13).

Performance charts for all the BPS (Bypass) and RFL nozzle sizes are available on request.

Heavy Oil Nozzles (for residual fuel oils)

These are another type of nozzle, used primarily in commercial and industrial burners. They look exactly like standard nozzles, but they have been rated fro their spray angle and tested for spray quality at 430 psi on 70 SSU oil. Flow rates, like HAGO 5/8-inch nozzles, are rated at 100 psi on No. 2 oil. Heavy oil nozzles must be specially tested because most nozzles will flutter, change their spray angle or show flaws in the spray when used on high pressure with heavier viscosity oils. The special testing assures against these possibilities.

Air Operated Nozzles

For commercial and industrial use only, these nozzles use compressed air, together with the oil pressure, to atomize both light and heavy oils. Frequently the heavy oil is preheated to lower the viscosity before it is delivered to the nozzle. Flow rates are available from 40 gph up to 220 gph in our patented, highly efficient Type AS and Type ASL series air operated nozzles. A series of complete charts showing nozzle performance under various operating conditions are available for those servicing these nozzles. (Figure #14)

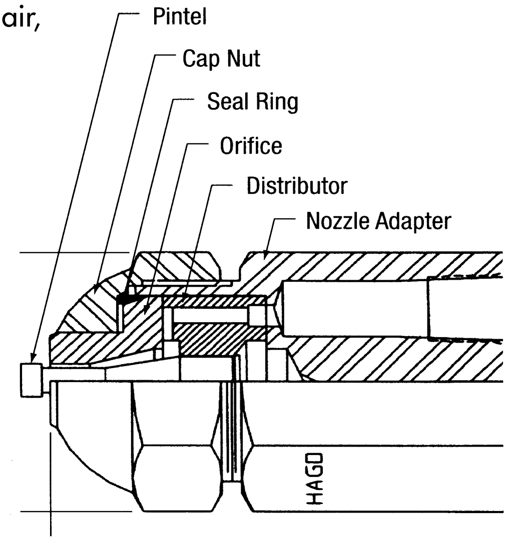


Figure #14
Air Operated Nozzle

Siphon Nozzles

These nozzles operate on the same principle on the same principle as a perfume atomizer. As low pressure air is pushed through the nozzle it sucks liquid from a tank into a nozzle and out through the orifice. The large internal openings and very fine atomization of siphon nozzles make them desirable for very low flow rate applications. Flows down to 0.20gph and even 0.10 gph can be achieved. Another advantage is their resistance to flow rate changes with varying viscosities. Thus far, they have been used only experimentally in residential applications primarily because the requirement for compressed air makes the burners expensive and usually noisier than conventional burners. You will often find these nozzles used in commercial waste oil burners and the portable kerosene heaters that are typically used at construction sites.

VI. "Anti-Drip" Valves

Devices such as HAGO's Eco Valve, Figure #15. which incorporate a nozzle filter or strainer, are typically purchased separately from the nozzle as an accessory.

EcoValves are easily screwed directly onto the nozzle in the position normally occupied by the standard nozzle filter or strainer. They function to eliminate the several drops of oil that typically dribble out of the nozzle's orifice at shut down of the operating cycle. Dribbling occurs because the pressure in the oil line leading to the nozzle always drops to zero psi at shut down, causing the nozzle's spray to gradually close down as the pressure diminishes - resulting in incomplete atomization. At pressures from about 50psi and lower. insufficient pressure remains to atomize the oil, so the spray degrades into a stream, and, finally, a few final drips of oil.

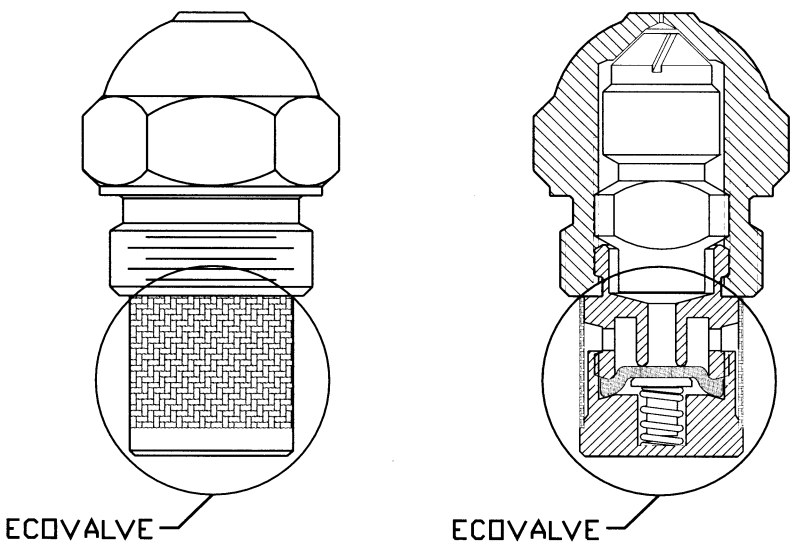


Figure #15
HAGO EcoValve; Shown in position and internal to nozzle.

This raw oil fouls the burner's air turbulator blades with carbon and soot deposits. Oil after-drip can also for puddles in the combustion chamber, causing excess soot and allowing oil to flow back into the burner housing and fan area. This situation can result in a stain on the basement floor as oil exits the drain hole in the burner housing, can foul ignition, can lead to complaints of an odor.

All these detrimental results are eliminated by the use of an anti-drip device. Since EcoValves are located right at the nozzle, and retain 85 psi or more in the oil feed line, they effectively eliminate all of these undesirable effects. The latest series of anti-drip valves are unique, in that they have an ingenious design that eliminates any pressure drop through them. This is very advantageous because a technician does not have to make any adjustments to the pump pressure when using these valves. Anti-drip devices are a quick and inexpensive way to solve a multitude of service problems.

Because our EcoValves can dramatically reduce soot production, their use helps avoid service callbacks and saves time and money because spring cleanout times can be shortened dramatically. The property owner gains with fuller, cleaner, combustion. Plus, everyone benefits when our air is kept cleaner as a result of fewer unfavorable emissions from burners equipped with EcoValves. That's why we named them EcoValves...they are Economical and Ecologically beneficial!

VII. About the HAGO Manufacturing Company

A tradition of service to Oilheating and industry.

Founded in 1937, HAGO has devoted itself exclusively for all these related products. Since its founding, the management of HAGO has been virtually under the direction of two families who continue operations under joint ownership today. Company President Richard Theurer continues the family-owned tradition that has been so successful.

At HAGO, we pride ourselves on maintaining a state-of-the-art production capability. Many of our production machines are computer controlled and several machines are completely designed, manufactured and assembled for our own use. These specialized machines provide immense flexibility and a wide range of capabilities - unmatched, we believe, by any other nozzle manufacturer.

We are progressive company, committed to reinvestment in our business and the ongoing development of new product lines and ever improved products. Our engineering department and our spray technology lab, including droplet size research and measurement instrumentation, give us the means to develop and provide the highest possible quality products... from oil burner nozzles to special nozzles for the United States' NASA sponsored Space Shuttle. A second factory, added in 1996, further expanded our production capabilities and facilities our continued growth.

When you buy and use HAGO nozzles you are always assured of having selected the best and most precisely manufactured nozzle for the application at hand. As always, we value and appreciate your purchase of hago nozzles and welcome your comments and suggestions.

Nozzle knowledge & Services Tips.

Vacuum- When the vacuum reaches near the pumps rating, this can cause the nozzle pressure to drop below the 100 PSI. This will provide poor nozzle performance.

Handling- When handling the nozzle, avoid touching the filter as this could cause contamination.

Nozzle tightness- When installing the nozzle in the adapter, once the nozzle bottoms in the adapter tighten 1/4 to 3/8th of an inch more. (100 inch pound torque)

Spray angles- 30-60 degree for long and narrow chambers & 70-90 degree for round or square chambers.

Pump testing- Always verify the correct pressure, cut-off and vacuum as all effect nozzle performance.

Avoid Ignition Delays- Verify the ignition setting with the burner manufacture's specifications. (General settings 1/8- 3/16ths apart, 1/2 from nozzle center to the electrodes, and 1/8 inch from the face of the nozzle to the tip of the electrode).

After-drip - Check for proper pump cut-off. (General rule, the pressure should not drop below 20% of the pumps pressure rating at shut down) See manufacture's specifications). If cut off rating is correct, install a Hago Eco-Valve.

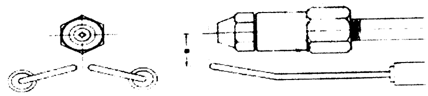
How long should a nozzle last? Approximately 2600 hours based on the consumption of 1300 gallons per year from .50GPH nozzle with proper filtration of the fuel.

Why do small nozzles fail? Generally because of slot and orifice contamination caused from poor or poorly filtered fuel. (Install a Hago Duel Filtered nozzle and 10 micro fuel filtration).

Are all nozzles tested? All Hago nozzles are tested for pattern, angle and flow rate accuracy. (Not fire tested). This is done by the burner manufacturer during nozzle application testing in a heating appliance).

Combustion Testing- Perform complete test after replacing a nozzle to be sure that the unit is operating at the manufacturers peak performance rating.

Divide...	by...	to obtain:
BTU input	140,000	GPH #2 Oil
Gross Sq. Ft. Steam	360	GPH #2 Oil
Net BTUH (Output)	112,000	GPH #2 Oil
Net MBH (Output)	112	GPH #2 Oil
Net Sq. Ft. Steam	466	GPH #2 Oil
Sq. Ft. Heating Surface	27	GPH #2 Oil



Nozzle	GPH	A	B	C
45°	(.75 to 4.00)	1/8″ to 3/16″	1/2″ to 9/16″	1/4″
60°	(.75 to 4.00)	1/8″ to 3/16″	9/16″ to 5/8″	1/4″
70°	(.75 to 4.00)	1/8″ to 3/16″	9/16″ to 5/8″	1/8″
80°	(.75 to 4.00)	1/8″ to 3/16″	9/16″ to 5/8″	1/8″
90°	(.75 to 4.00)	1/8″ to 3/16″	9/16″ to 5/8″	0