A Total Look at Combustion Nozzles

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People Trusted.

DELAVAN®
SPRAY TECHNOLOGIES

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DELAVAN®
SPRAY TECHNOLOGIES

The nozzle is one of the most important pieces of hardware within a liquid fuel burner system.

Secion 1: Introduction

A Reference Guide for the Burner Service Technician

The complete liquid fuel heating system begins at the tank and ends at the chimney. At the heart of the system is a tiny yet important piece of hardware — the nozzle. It performs the vital functions that keep the flame generating warm, comfortable heat. In fact, it plays such a significant role in the entire system that we feel the technician should know all about the nozzle. In this reference guide, we'll explore how the nozzle works with other components of the system and give you some liquid fuel nozzle facts that can help you maintain a clean, reliable, and economical heating system.

NOTE: The information in this pamphlet is based on experience and is to be used as a general guide only.

Warning

Improper modification to combustion units may create a fire hazard resulting in possible injury. Contact the original equipment manufacturer before modifying the combustion unit.

Section 1: Why Use Nozzles

Atomizing nozzles are an efficient way to deliver liquid fuel to heating equipment

For a better understanding of how a nozzle fits into the performance of an liquid fuel burner, let us first review the steps in the process of efficient combustion.

1. Like all combustible matter, the fuel must first be vaporized—converted to a vapor or gas—before combustion can take place. This is usually accomplished by the application of heat.
2. The fuel vapor must be mixed with air in order to have oxygen present for combustion.
3. The temperature of this mixture must be increased above the ignition point.
4. A continuous supply of air and fuel must be provided for continuous combustion.
5. The products of combustion must be removed from the combustion chamber.

The simplest way to burn liquid fuel is the old vaporizing pot type burner in which heat is applied to a puddle of fuel to vaporize it.These vapors are then burned after mixing with the proper amount of air.

In most applications, this method of vaporizing is too slow for high rates of combustion and cannot be controlled in the low rates, which leads back to the original question of why nozzles are used. One of the functions of a nozzle is to atomize the fuel, or break it up into tiny droplets which can be vaporized in a much shorter period of time when exposed to high temperatures. This booklet will be concerned primarily with the high-pressure atomizing nozzle since it is the most common in the fuel heat industry.

What the Nozzle Does

The atomizing nozzle performs three vital functions for an liquid fuel burner:

1. **Atomizing** The nozzle speeds up the vaporization process by breaking up the liquid fuel into tiny droplets, around 55-billion per gallon of fuel at a pressure of 100-psi (standard in the industry). The exposed surface of a gallon of fuel is thereby expanded to approximately 690,000 square inches of burning surface. Individual droplet sizes range from .0002 inch to .010 inch. The smaller droplets are necessary for fast, quiet ignition and to establish a flame front close to the burner head. The larger droplets take longer to burn and help fill the combustion chamber.
2. **Metering** A nozzle is designed and dimensioned to deliver a fixed amount of atomized fuel to the combustion chamber within approximately plus or minus 5% of rated capacity. This means that functional dimensions must be controlled very closely. It also means that nozzles must be available in many flow rates to satisfy a wide range of industry needs. Under 5.00 GPH, for example, over 20 different flow rates and 6 different spray angles are considered standard.
3. **Patterning** A nozzle is expected to deliver the atomized fuel to the combustion chamber in a uniform spray pattern and spray angle best suited to the requirements of a specific burner.

Section 1: How A Nozzle Works

The functional parts of a Delavan nozzle control how the nozzle works. The flow rate, spray angle, and pattern are directly related to the design of the tangential slots, swirl chamber, and orifice.

First, a source of energy is needed to break up the liquid fuel into small droplets. Therefore, pressure is supplied to the nozzle, usually from a motor-driven pump at 100-150 psi ***(Fig. 2)***. But pressure energy alone doesn't do the job. It must first be converted to velocity energy by directing the pressurized fuel through a set of slots which are cut in the distributor at an angle, or tangentially, to create a high velocity rotation within the swirl chamber. At this point, about half of the pressure energy is converted to velocity energy.

As the fuel swirls, centrifugal force is exerted against the sides of the chamber, driving the fuel against the orifice walls, leaving a void or core of air in the center. The fuel then moves forward out of the orifice in the form of a hollow tube. The "tube" becomes a cone shaped film of fuel as it emerges from the orifice, ultimately stretching to a point where it ruptures and throws off droplets of liquid.

Figure 1:
Cutaway view of a Delavan® nozzle.

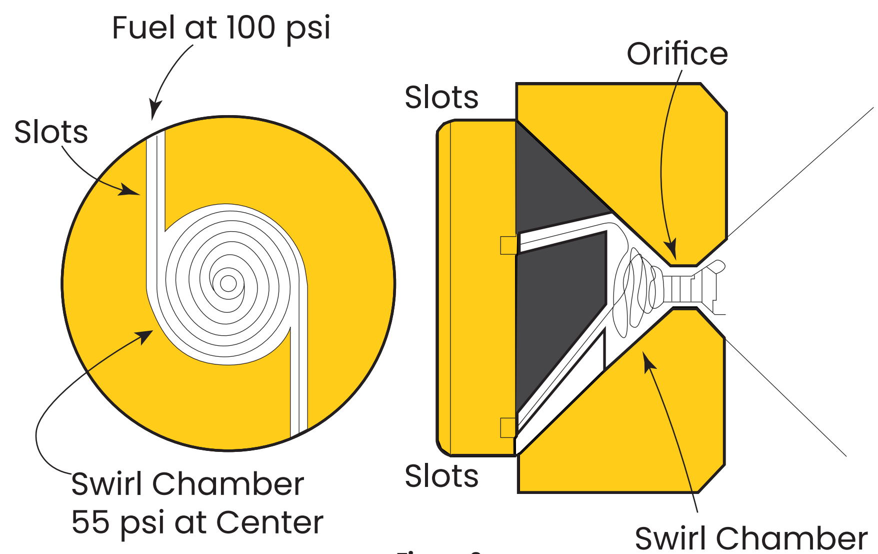


Figure 2:
How a nozzle works.

Section 2: Nozzle Selection

Matching a nozzle to a burner takes trial and error, or a good understanding of angles, rates, and patterns. With any service, always follow the appliance manufacturer's published instructions and recommendations for proper nozzle selection.

Nozzle Ratings and Testing

To ensure consistent quality, every Delavan nozzle is tested for flow rate and spray angle on modern, high instrumented test stands. Spray quality is observed during testing for uniformity, balance, and flutter.

Advanced, automated machinery allows us to produce high-quality nozzle solutions.

Delavan® Nozzles

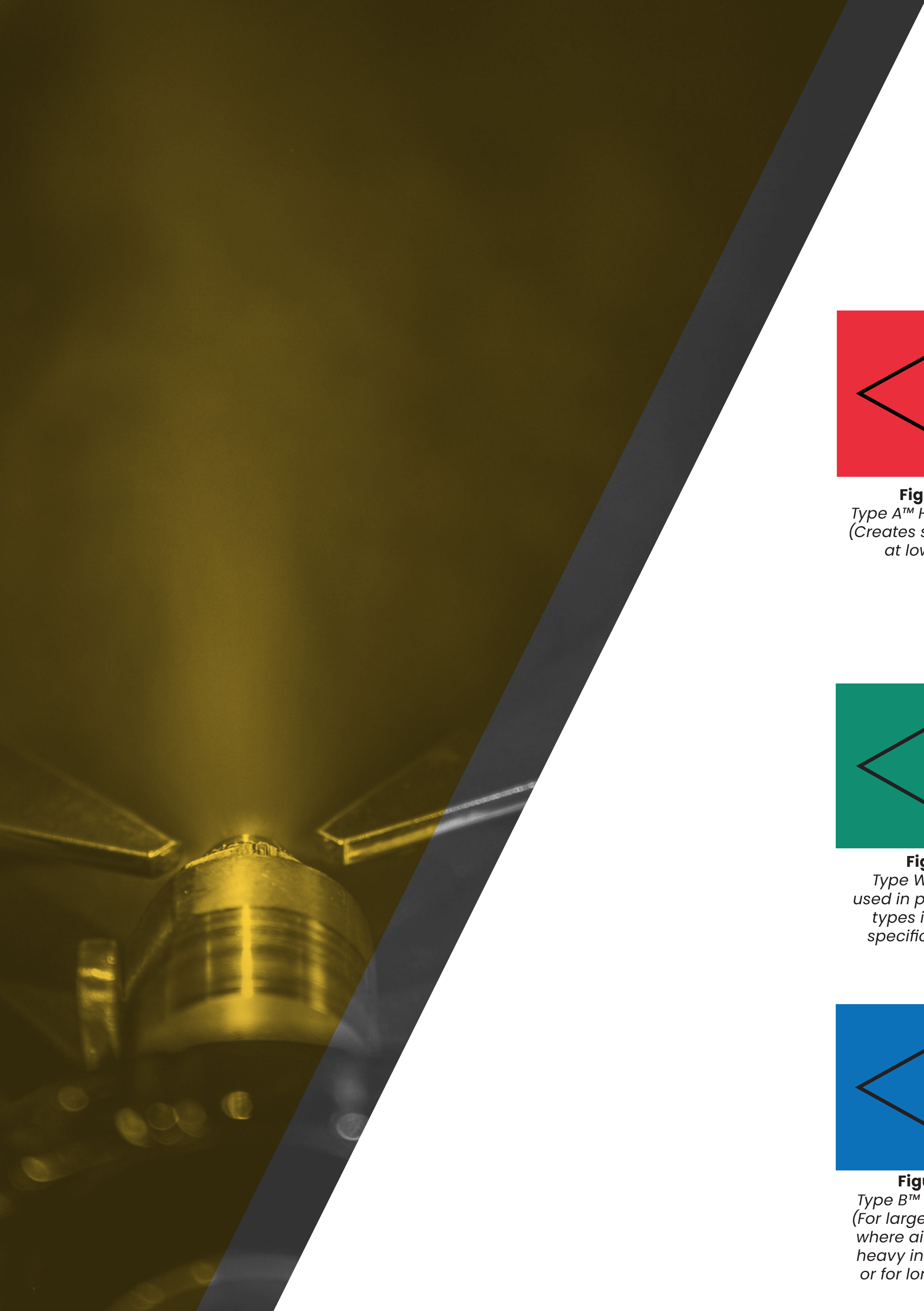
Test oils are calibrated to meet the following specifications and any others on request.

Typical Test Fuel Equivalents.
PS-111 US fuel 2.9 Cst
PS-1204 EN fuel 3.4 Cst, Per EN293/EN299
PS-790 JIS Fuel 1.6 Cst

All these conditions are continuously monitored, and instrument accuracy is maintained to calibrated standards.

Delavan Color Coding System

Nozzle Type	Vial Color
A	Red
Del-O-Flo™ A	Black
B	Royal Blue
Del-O-Flo™ B	Yellow
W	Green



Section 2: Delavan® Types

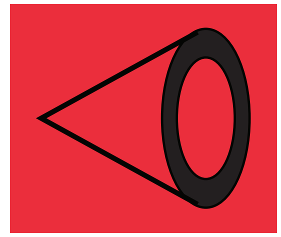


Figure 3:
Type A™ Hollow Cone (Creates stable flame at low flows)

Type A Hollow Cone Nozzle

Hollow cone nozzles generally have more stable spray angles and patterns under adverse conditions than solid cone nozzles of the same flow rate. This is an important advantage in fractional gallonage nozzles where high viscosity fuel may cause a reduction in spray angle and an increase in droplet size.

Type A nozzles produce a spray which delivers fine droplets outside the periphery of the main spray cone. These fine droplets greatly enhance ignition and create a stable flame for use with flame retention burners.

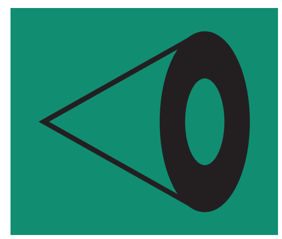


Figure 5:
Type W™ (Can be used in place of A or B types in reducing specific problems)

Type W Semi-Hollow Cone Nozzle

Type W nozzles produce a spray which is neither truly hollow nor solid. Adhering to the appliance manufacturer's specifications, these nozzles may be used in place of either solid or hollow cone nozzles between .40 GPH and 8.00 GPH, regardless of the burner's air pattern. The lower flow rates tend to be hollower. Higher flow rates tend to be more solid.

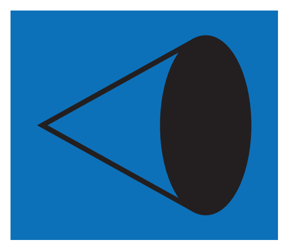


Figure 4:
Type B™ Solid Cone (For larger burners & where air pattern is heavy in the center or for long flames)

Type B Solid Cone Nozzle

Type B nozzles produce a spray which distributes droplets fairly uniformly throughout the complete pattern. This spray pattern becomes progressively more hollow at high flow rates, particularly above 8.00 GPH. These nozzles may be used in larger burners (those firing above 2.00 or 3.00 GPH) to provide smoother ignition. They can also be used where the air pattern of the burner is heavy in the center or where long flames are required.

For Type B Del-O-Flo™ low flow nozzles **see pages 18-19.**

Delavision™ is a proprietary automated process which test flow rate, spray angle, and pattern to ensure 100% conformity in each of our products.

Section 2: Spray Angle

Spray angles are available from 30º through 90º in most nozzle sizes to meet the requirements of a wide variety of burner air patterns and combustion chambers.

Usually, it is desirable to fit the spray angle to the air pattern of the burner. In today's flame retention burner, it is possible to fire more than one spray angle with good results.

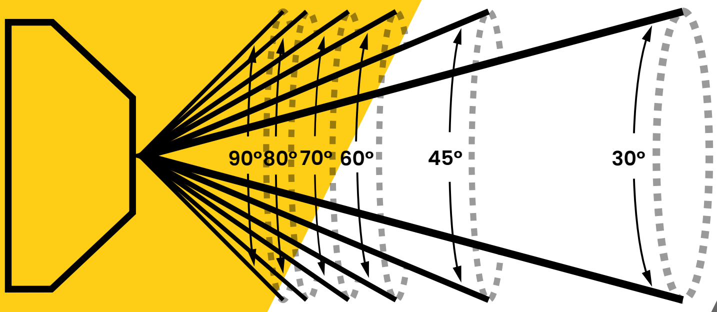


Figure 6a

Generally, round or square combustion chambers should be fired with 70º to 90º nozzles.

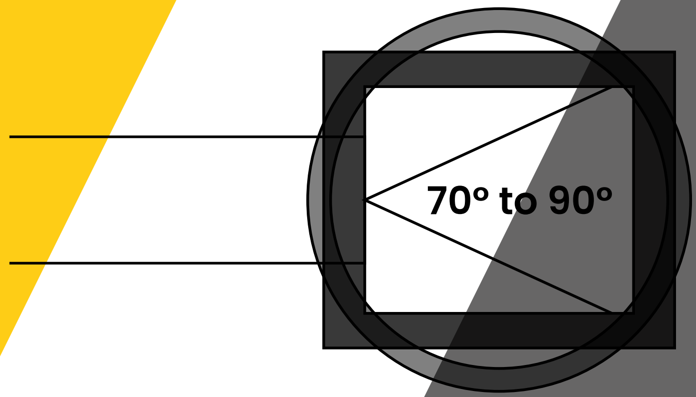


Figure 6b

Long, narrow chambers usually require 30º to 60º spray angles.

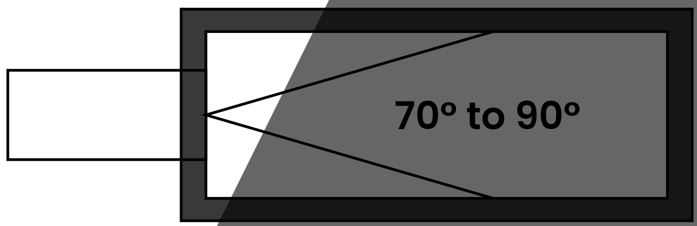
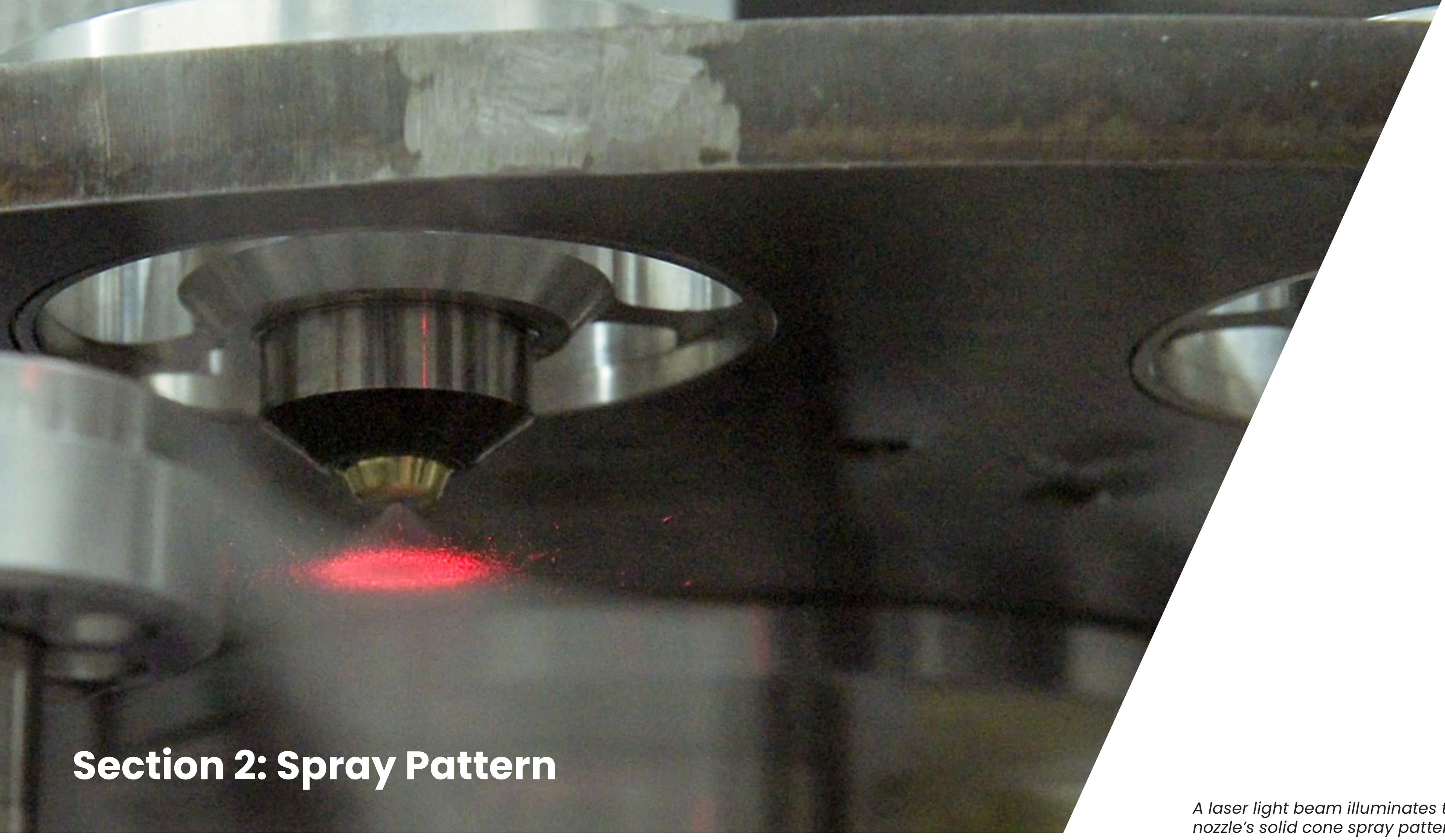


Figure 6c



Section 2: Spray Pattern

A laser light beam illuminates this nozzle's solid cone spray pattern.

Spray pattern is another consideration in determining which nozzle to use. There's a great difference between the solid pattern on the left and the hollow pattern on the right ***(See Fig. 7)***. These patterns were photographed as a laser light beam passed through the spray. Lasers are used at the Delavan test laboratory to study patterns and spray characteristics.

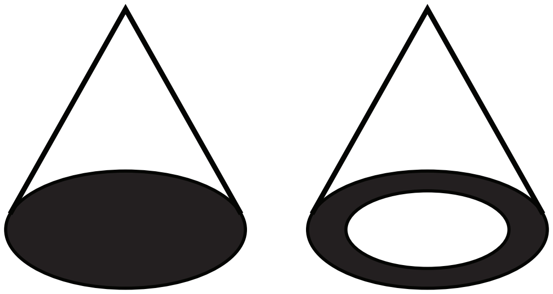
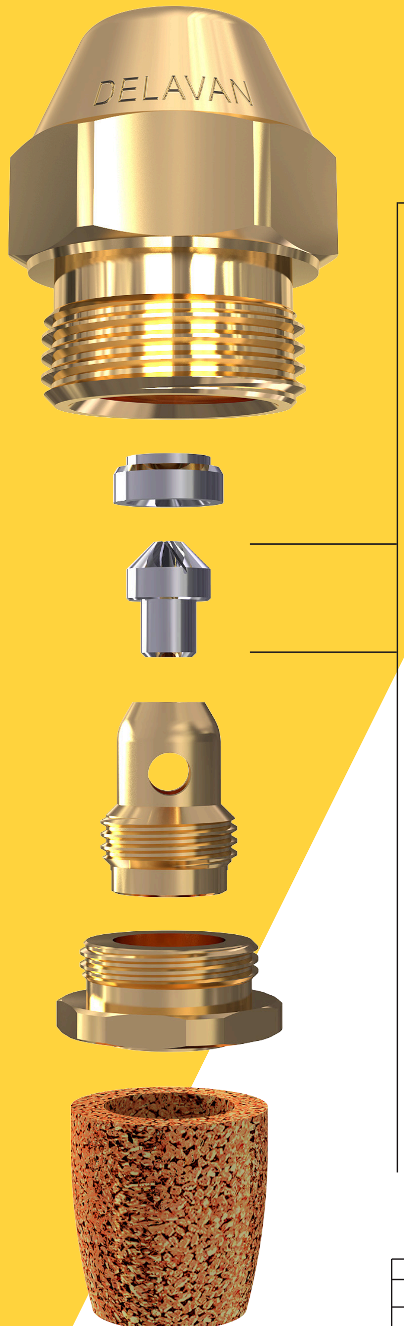
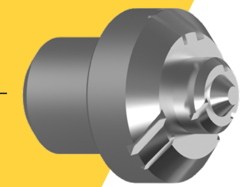


Figure 7:
(Left) Solid cone pattern, (Right) Hollow cone pattern

Section 2: Del-O-Flo™ Nozzle

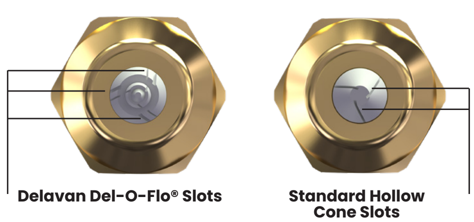




Del-O-Flo™ Nozzle

Del-O-Flo nozzles are low-capacity nozzles designed to minimize the usual nozzle plugging problems associated with low flow rates. Del-O-Flo nozzles are available in A and B types.

With the Del-O-Flo™ nozzle, fluid flows through the filter, into the slots, and is metered prior to exiting. The slots are designed for force fluid into a swirling motion where particles are kept in suspension. The nozzle contains short slot openings that are perpendicular to fluid flow. These short slots keep the fluid from slowing and maintain turbulence, which keeps particulates from collecting, settling, or clogging the nozzle.



Delavan® performed a test in which a .50 gph Del-O-Flo nozzle and a .50 gph standard hollow cone nozzle were run continuously for 23 hours from a double adapter using the same fuel supply. Engineers contaminated clean fuel with a controlled amount of iron oxide, rust, and sand. The pictures to the left show the nozzles after the test (these views are looking inside the nozzle body from the filter end). You can see the iron oxide contamination build up in the standard nozzle ***(Fig. 8)***.

Fig. 9 shows the same view of the Del-O-Flo nozzle. Although the dark streaks show a discoloration from sand, there is no contamination build up.

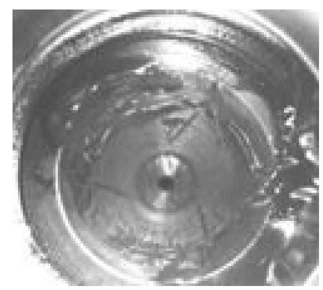


Figure 8:
Standard hollow-cone (Standard)

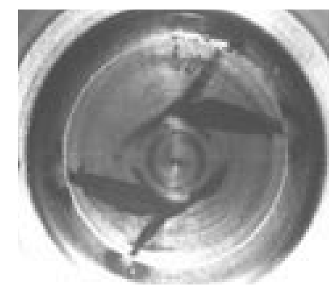


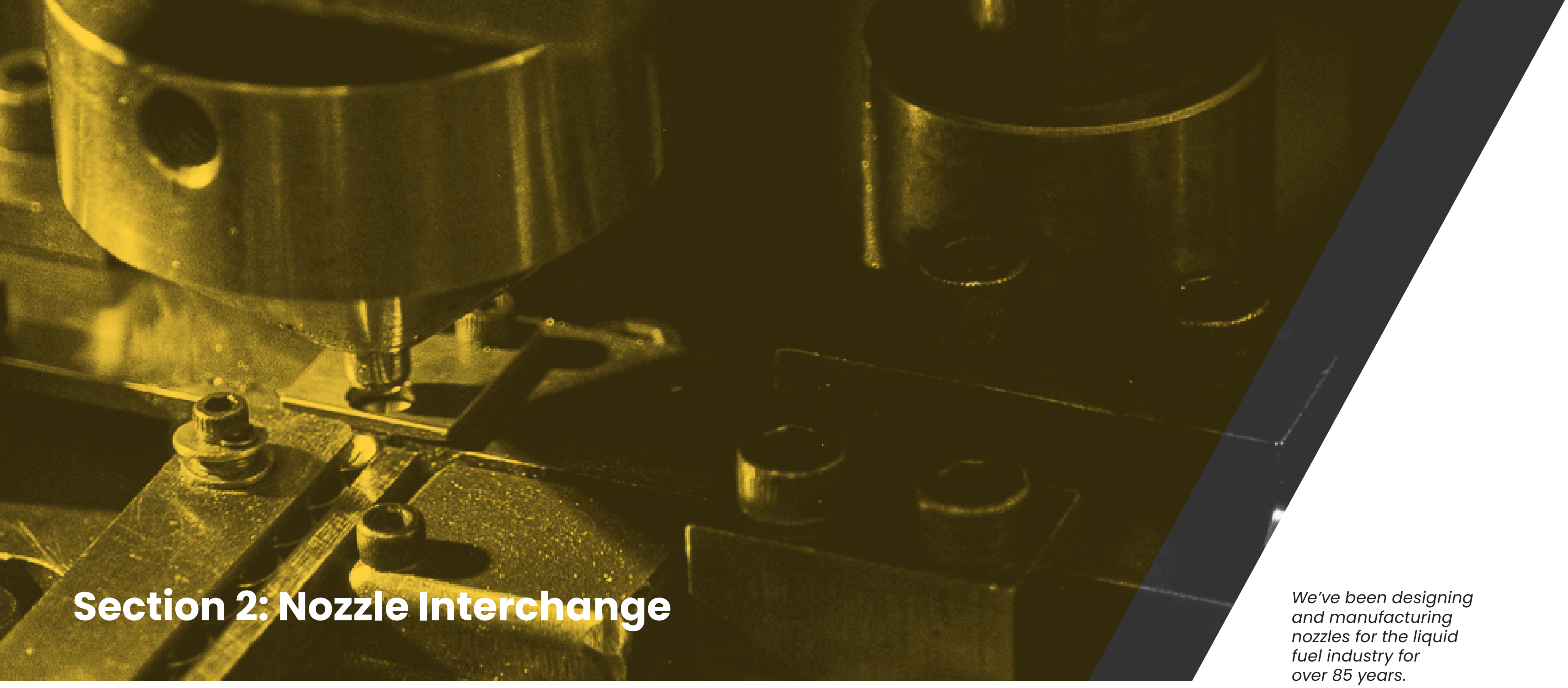
Figure 9:
Delavan Del-O-Flo

Under identical test situations, a standard nozzle produced contamination buildup which causes plugging while the Del-O-Flo™ remained contaminant-free.

Burner Manufacturer's Recommendations

Please refer to the OEM spcification sheets or contact the burner manufacturer. Always follow the appliance manufacturer's instructions for the correct nozzle specification.

R.W. Beckett: www.beckettcorp.com or www.beckettcorp.com/protect/tech2.asp



Section 2: Nozzle Interchange

We've been designing and manufacturing nozzles for the liquid fuel industry for over 85 years.

Delavan Recommended Interchange

Replacing a nozzle of one make with another sometimes presents problems. This is partly due to unique design differences among the various makes, plus the fact that the nozzle manufacturers use different methods for evaluating spray angles, patterns, and spray quality.

- When interchanging a Delavan A, B, or W with another manufacturer's nozzle, it may be necessary to try the next wider spray angle.
- Del-O-Flo™ A and B nozzles will interchange whenever standard A or B nozzles are called for.

TYPE A NOZZLE

TYPE B NOZZLE

Delavan Nozzle Interchange Chart

Delavan	Danfoss	Steinen	Fluidics	Monarch
A	H	S	SF	NS
A	HR	PH	HF	PL
B	S	H	HF	PLP
B		SS	SF	R
*W or *B	ES	Q	KSF	AR
*A	EH		KFH	
SS	SS up to 2GPH			
A or W	SS over 2GPH			
MH		MH		

Applications with Kerosene

WARNING: Improper modification to combustion units may create a fire hazard resulting in possible injury. Contact the original equipment manufacturer before modifying the combustion unit.

Section 2: Flow Rates

Atomizing nozzles are available in a wide range of flow rates, all but eliminating the need for specially calibrated nozzles. Between 1.00 GPH and 2.00 GPH, for example, seven different flow rates are available. Generally, with hot water and warm air heat, the smallest firing rate that will adequately heat the house on the coldest day is the proper size to use and the most economical. Short on-cycles result in low efficiency. Another guideline is to select the flow rate that provides a reasonable stack temperature regardless of the connected load.

Determining Proper Flow Rates

The proper size nozzle for a given burner unit is sometimes stamped on the nameplate of the unit.

The following guidelines may be used for determining the proper flow rates:

1. Flow Rate (capacity)

All the nozzle capacity charts in this catalogue are based on water with a tolerance of ± 5% on rated flows. However, the actual flow rate through the nozzle can be affected by factors such as pressure, specific gravity, and viscosity.

a. Pressure – theoretically, the flow rate is proportional to the square root of the pressure ratio and is expressed as follows:

$$Q_1 = Q_2 \sqrt{\frac{P_1}{P_2}}$$

- Where Q1 is the calculated flow rate at the desired operating pressure P1
- Q2 and P2 are the known flow rate and pressure taken from the charts given for each nozzle type.
- This relationship is generally acceptable for most industrial nozzle applications but is not correct for all nozzle types.

b. Specific Gravity (density) – this is the ratio of the mass of a given volume of liquid to the mass of the same volume of water. For liquids other than water, the flow will vary inversely to the square root of the specific gravity of that liquid. The formula that can be used to determine the flow rate is as follows:

$$\textit{Liquid Flow Rate} = \textit{Water Flow Rate} \times \frac{1}{\sqrt{\textit{Specific Gravity}}}$$

Calculations may vary. Follow manufacturers specifications.

This relationship can be approximated with a conversion factor from the following table.

Specific Gravity	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Conversion Factor	1.2	1.12	1.05	1.0	.95	.91	.88	.85	.82	.79	.77	.75

c. Viscosity – this is probably the most significant of all liquid properties since it can vary over a wide range of values and is somewhat complex in spraying applications. Generally with higher viscosities, there is a reduction in flow through the nozzle. Viscosity also affects the spray pattern and spray quality.

2. Operating Pressure

This is the major factor that affects the flow rate through a nozzle. To determine the operating pressure needed to achieve a specified flow that is not indicated in the capacity charts, the previous formula can be re-written as follows:

$$P_1 = P_2 \left(\frac{Q_1}{Q_2}\right)^2$$

- Where P1 is the calculated pressure for the desired flow rate Q1.
- P2 and Q2 are the known pressure and flow rate.
- Again, this relationship is acceptable for most industrial nozzle applications but is not correct for all nozzle types.

Calculations may vary. Follow manufacturers specifications.

Section 2: Determining the Proper Firing Rate for a House

Two procedures for determining the optimum nozzle size have been developed. One is the standard heat loss calculation method and the other is the K-factor sizing formula.

1. **Standard Heat Loss Calculations Method** If the amount of heat loss is known, the amount of replacement heat (heat load) needed is also known. From this information, the proper size of a boiler or furnace can be determined, thus the correct nozzle size. This method can be used for determining the proper nozzle size in new construction, a new heating system in an existing house, or a new liquid fuel burner installation. This method requires extensive measurements of the house and other construction details.

   Recommended Resource Material:
   "Cooling and Heating Load Calculation Manual," American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. (ASHRAE).

   "Heat Loss Calculation Guide," The Hydronics Institute (IBR), 35 Russo Place, Berkeley Heights, NJ 07922.

2. **The K-Factor Sizing Formula** This is a sizing calculation that meets fuel dealer and heating contractor needs for a quick procedure to determine the proper nozzle size for existing heating systems. The K-factor calculation uses fuel dealer records of degree days (a measure of "coldness") and liquid fuel used, plus other information, but does not require any measurements of the house.

   Recommended Resource Material:
   "Handbook and Product Directory — Fundamentals," American Society of Heating, Air Conditioning and Refrigeration Engineers, Inc. (ASHRAE).

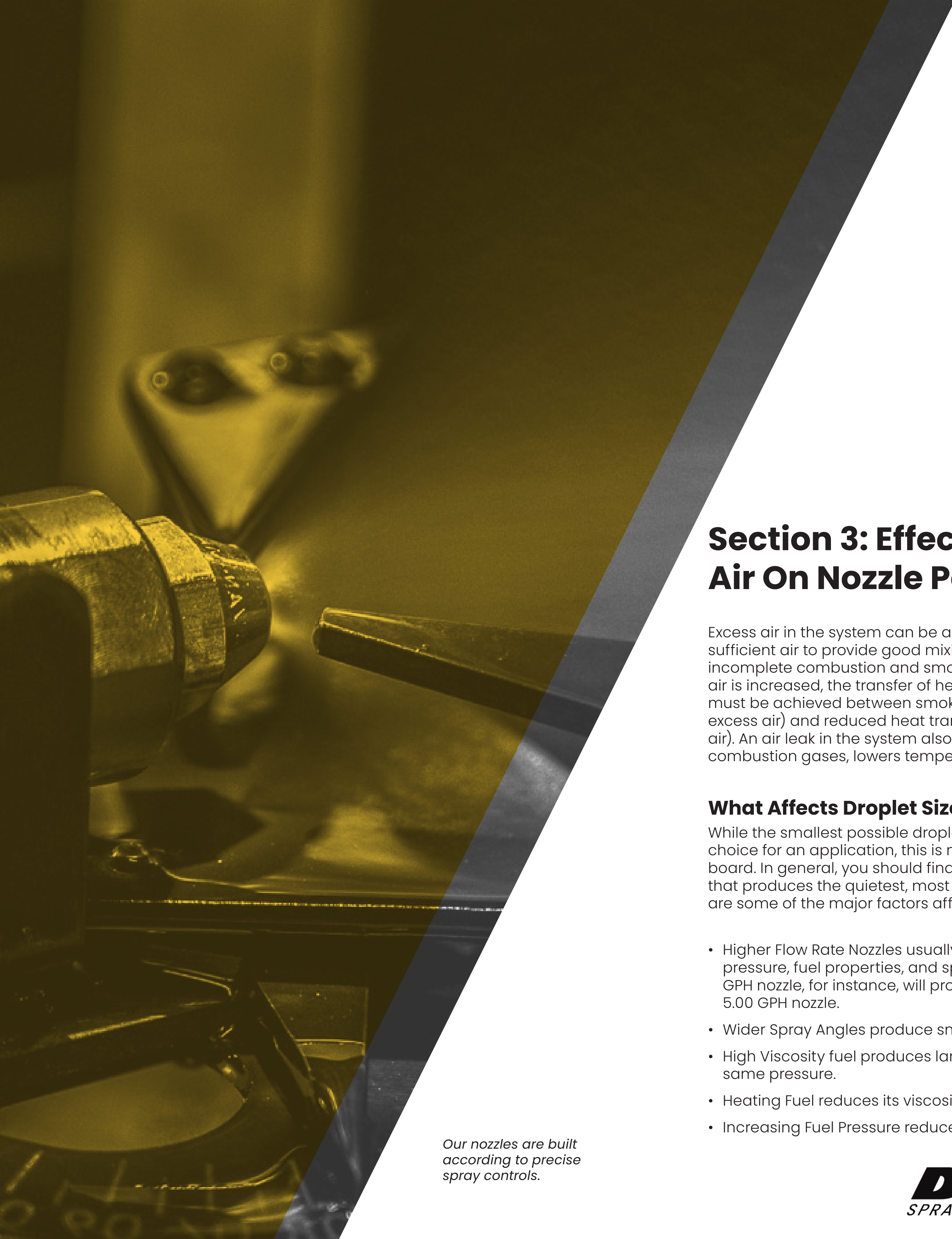
   "The Professional Serviceman's Guide to Oil Heat Savings," R.W. Beckett Corp., 38251 Center Ridge Road, PO. Box D, Elyria, OH 44035.

3. **OFTEC**
   oftec.org/technicians/industry-training/training-courses-assessments

4. **NORA**
   NORA Learning & Resource Center - NORA's Learning & Resource Center (noraweb.org)

   Liquid Heating Fuel - NORA's Learning & Resource Center (noraweb.org)

We specialize in assisting original equipment manufacturers in designing and specifying the best nozzles to fit their applications.



Our nozzles are built according to precise spray controls.

Section 3: Effects of Excess Air On Nozzle Performance

Excess air in the system can be a trouble spot. The burner must have sufficient air to provide good mixing of air and liquid fuel, or you get incomplete combustion and smoke. Unfortunately, as the amount of air is increased, the transfer of heat is reduced. A delicate balance must be achieved between smoke problems (caused by insufficient excess air) and reduced heat transfer (caused by unnecessary excess air). An air leak in the system also causes lost efficiency. It cools down combustion gases, lowers temperature, and raises stack temperature.

What Affects Droplet Size?

While the smallest possible droplet size is sometimes the best choice for an application, this is not always true across the board. In general, you should find the droplet size and distribution that produces the quietest, most efficient combustion. Here are some of the major factors affecting the droplet size.

- Higher Flow Rate Nozzles usually produce larger droplets, assuming pressure, fuel properties, and spray angle remain the same. A 10.00 GPH nozzle, for instance, will produce larger droplets than a 5.00 GPH nozzle.
- Wider Spray Angles produce smaller droplets
- High Viscosity fuel produces larger droplets in the spray at the same pressure.
- Heating Fuel reduces its viscosity and produces smaller droplets.
- Increasing Fuel Pressure reduces droplet size.

Section 3: Effects of Pressure On Nozzle Performance

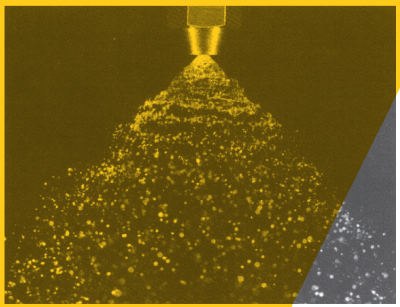


Figure 10:
Spray at 10 psi pressure

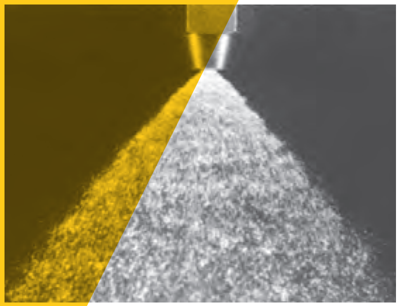


Figure 11:
Spray at 100-psi pressure

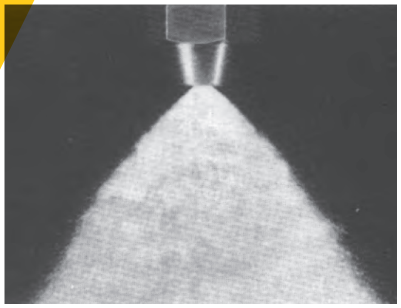


Figure 12:
Spray at 300-psi pressure

* Pressure can be reduced between the pump and the chamber by clogged filters in the line or the nozzle. Check pressure whenever reduced, not just at the pump.

Normally, 100 psi is considered satisfactory for the fixed pressure supplied to the nozzle, and all manufacturers calibrate their nozzles at that pressure.

It is interesting to observe the sprays of a nozzle at various pressures. ***See Figures 10-12***. At the low pressure, the cone-shaped film is long and the droplets breaking off from it are large and irregular. Then, as the pressure increases, the spray angle becomes better defined. Once a stable pattern is formed, any increase in pressure does not affect the basic spray angle, measured directly in front of the orifice.

At higher pressure, however, beyond the area of the basic spray angle, the movement of droplets does make a slight change in direction—inward. That's because at this point, the air pressure outside the spray cone is higher than that on the inside, which deforms the spray inward, as shown in ***Figure 11 and 12***.

Pressure has another predictable effect on nozzle performance. As you would expect, an increase in pressure causes a corresponding increase in the flow rate of a nozzle, assuming all other factors remain equal. This relationship between pressure and flow rate is best shown in the table on **page 29.**

Increasing pressure also reduces droplet size in the spray. For example, an increase from 100 to 300 psi reduces the average droplet diameter about 28%. One last word on the subject: if pressure is too low, you may be under-firing the burner. Efficiencies may also drop sharply because droplet size is larger and the spray pattern changed. If pressure isn't carefully checked,* the marking on the nozzle becomes meaningless. Pressures of more than 100 psi are sometime desirable, but rarely do burners operate at anything less. This is critical in new alternative fuels as viscosity changes with the various products and systems geographically.

Effects of Pressure On Nozzle Flow Rate

Nozzle Rating at 100 PSI	Nozzle Flow Rates in US Gallons per Hour (Approx.)					
	120 PSI	140 PSI	160 PSI	175 PSI	200 PSI	300 PSI
0.40	0.44	0.47	0.51	0.53	0.57	0.69
0.50	0.55	0.59	0.63	0.66	0.71	0.87
0.60	0.66	0.71	0.76	0.79	0.85	1.04
0.65	0.71	0.77	0.82	0.86	0.92	1.13
0.75	0.82	0.89	0.95	0.99	1.06	1.30
0.85	0.93	1.01	1.08	1.12	1.20	1.47
0.90	0.99	1.06	1.14	1.19	1.27	1.56
1.00	1.10	1.18	1.26	1.32	1.41	1.73
1.10	1.20	1.30	1.39	1.46	1.56	1.91
1.20	1.31	1.42	1.52	1.59	1.70	2.08
1.25	1.37	1.48	1.58	1.65	1.77	2.17
1.35	1.48	1.60	1.71	1.79	1.91	2.34
1.50	1.64	1.77	1.90	1.98	2.12	2.60
1.65	1.81	1.95	2.09	2.18	2.33	2.86
1.75	1.92	2.07	2.21	2.32	2.47	3.03
2.00	2.19	2.37	2.53	2.65	2.83	3.46
2.25	2.46	2.66	2.85	2.98	3.18	3.90
2.50	2.74	2.96	3.16	3.31	3.54	4.33
2.75	3.01	3.25	3.48	3.64	3.89	4.76
3.00	3.29	3.55	3.79	3.97	4.24	5.20
3.25	3.56	3.85	4.11	4.30	4.60	5.63
3.50	3.83	4.14	4.43	4.63	4.95	6.06
4.00	4.38	4.73	5.06	5.29	5.66	6.93
4.50	4.93	5.32	5.69	5.95	6.36	7.79
5.00	5.48	5.92	6.32	6.61	7.07	8.66
5.50	6.02	6.51	6.96	7.28	7.78	9.53
6.00	6.57	7.10	7.59	7.94	8.49	10.39
6.50	7.12	7.69	8.22	8.60	9.19	11.26
7.00	7.67	8.28	8.85	9.26	9.90	12.12
7.50	8.22	8.87	9.49	9.92	10.61	12.99
8.00	8.76	9.47	10.12	10.58	11.31	13.86
8.50	9.31	10.06	10.75	11.24	12.02	14.72
9.00	9.86	10.65	11.38	11.91	12.73	15.59
9.50	10.41	11.24	12.02	12.57	13.44	16.45
10.00	10.95	11.83	12.65	13.23	14.14	17.32
11.00	12.05	13.02	13.91	14.55	15.56	19.05
12.00	13.15	14.20	15.18	15.87	16.97	20.78
13.00	14.24	15.38	16.44	17.20	18.38	22.52
14.00	15.34	16.57	17.71	18.52	19.80	24.25
15.00	16.43	17.75	18.97	19.84	21.21	25.98

NOTE:

- Information on this chart uses PS-111 US fuel 2.9 Cst for measurement and is to be as a general guide only.
- Information on this page is to be as a general guide only.

WARNING:

- Improper modification to combustion units may create a fire hazard resulting in possible injury.
- Contact the original equipment manufacturer before modifying the combustion unit.

Section 3: Recomended Combustion Chamber Dimensions

Recommended Combustion Chamber Dimensions

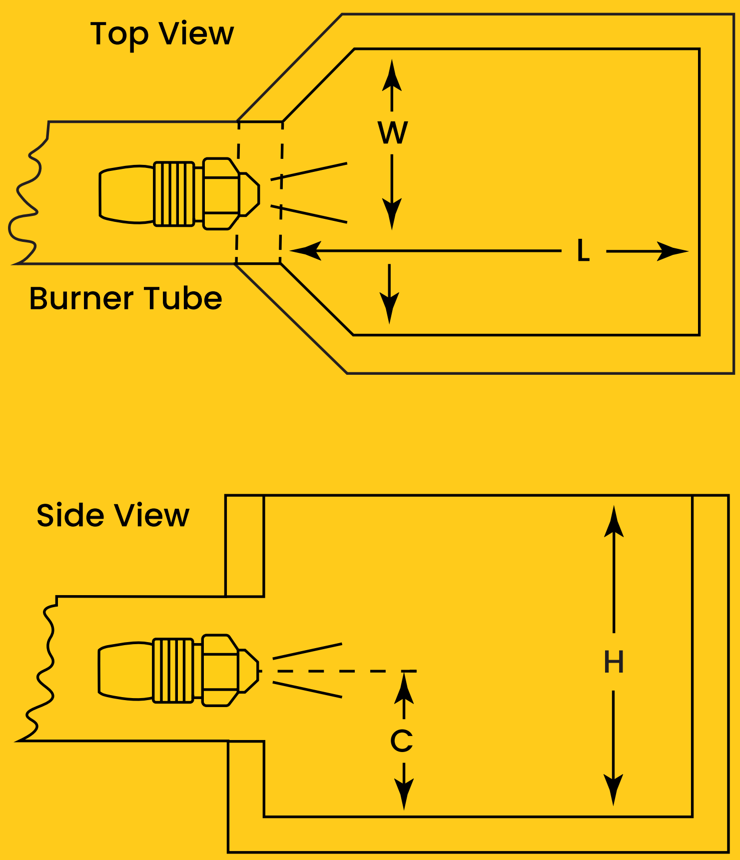


Figure 13

Nozzle Size or Rating (GPH)	Spray Angle	Square or Rectangular Combustion Chamber				Round Chamber (Diameter in Inches)
		L Length (In.)	W Width (In.)	H Height (In.)	C Nozzle Height (In.)	
0.50 – 0.65	80°	8	8	11	4	9
0.75 – 0.85	60° 80°	10 9	8 9	12 13	4 5	* 10
1.00 – 1.10	45° 60° 80°	14 11 10	7 9 10	12 13 14	4 5 6	* * 11
1.25 – 1.35	45° 60° 80°	15 12 11	8 10 11	11 14 15	5 6 7	* * 12
1.50 – 1.65	45° 60° 80°	16 13 12	10 11 12	12 14 15	6 7 7	* * 13
1.75 – 2.00	45° 60° 80°	18 15 14	11 12 13	14 15 16	6 7 8	* * 15
2.25 – 2.50	45° 60° 80°	18 17 15	12 13 14	14 15 16	7 8 8	* * 16
3.0	45° 60° 80°	20 19 18	13 14 16	15 17 18	7 8 9	* * 17

Recommend oblong chamber for narrow sprays.

NOTES: *These dimensions are for average conversion burners. Burners with special firing heads may require special chambers.*

- Higher back wall, flame baffle, or corbelled back wall increase efficiency on many jobs.
- Combustion chamber floor should be insulated on conversion jobs.
- For larger nozzle sizes, use the same approximate proportions and 90-sq. in. of floor area per 1 gph.

Burner Air Patterns

Burner air patterns are much like nozzle spray patterns in that they are classified as either hollow or solid. As you would expect, a burner with a hollow air pattern generally requires a hollow cone fuel nozzle. A burner with a solid air pattern will give highest efficiency with a solid cone nozzle, but the flame will probably be longer.

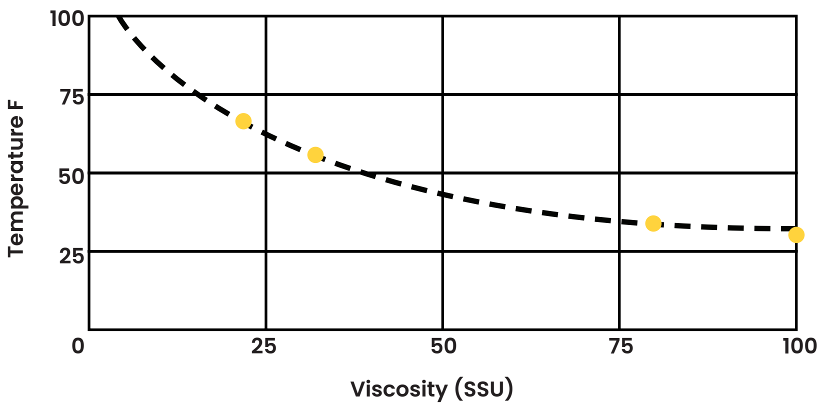
Section 4: Effects of Viscosity On Nozzle Performance

One of the most important factors affecting nozzle performance is viscosity, technically defined as a measure of resistance to flow within a liquid. More commonly, viscosity is thought of in terms of "thickness." For example, a gallon of gasoline can be poured through the spout of a can much faster than a gallon of tar. That's because the tar has a much higher viscosity than gasoline, or greater resistance to flow.

Strangely enough, the opposite is true to nozzle applications. With an increase in viscosity, nozzle flow rate also increases.

Temperature is the main factor in changing fuel viscosities. It works something like a scale ***(Figure 14)***. As the temperature goes down, the viscosity goes up. Take No. 2 fuel oil for example: at a temperature of 100°F, it has a viscosity of 35 SSU (Seconds Saybolt Universal). But when the temperature drops to 20°F, the viscosity increases to 65 SSU.

An outside storage tank may contain cold fuel, and cold fuel can cause problems. Here's what happens: the thick fuel passes into the nozzle, through the slots, and into the swirl chamber. Since it is more viscous, the rotational velocity is slowed down. This causes a thickening of the walls in the cone of fuel as it emerges from the orifice, so the nozzle actually delivers more fuel and larger droplets ***(see Figures 15 and 16)***. As a result, the flame front moves away from the burner head. In severe cases, atomization may be so poor that the fuel cannot be ignited. If it is ignited, it often produces a long, narrow, and noisy flame that burns off the back wall of the combustion burner.



Temperature F: 20, 30, 80, 100
Viscosity (SSU): 35, 37, 52, 65

Figure 14:
How temperature affects viscosity.

Although such situations are not widespread, it is good to know how to diagnose the problem and find a solution for it. While some success has been reported with special nozzles, most service technicians have found that the surest solution is to increase the energy input. Following the appliance manufacture pressure tables, an example of this is done by increasing pump pressure from 100 psi to 120-145 psi. Since increased pressure means increased flow rate, it may be desirable to use the next size smaller nozzle. As the burner ignites, it acts as a fuel pre-heater and the viscosity problem will disappear in 10 to 15 minutes. The burner can be left at this increased pressure without harm to the pump. In extreme cases of high viscosity due to cold fuel it may be necessary to preheat the fuel to get ignition.

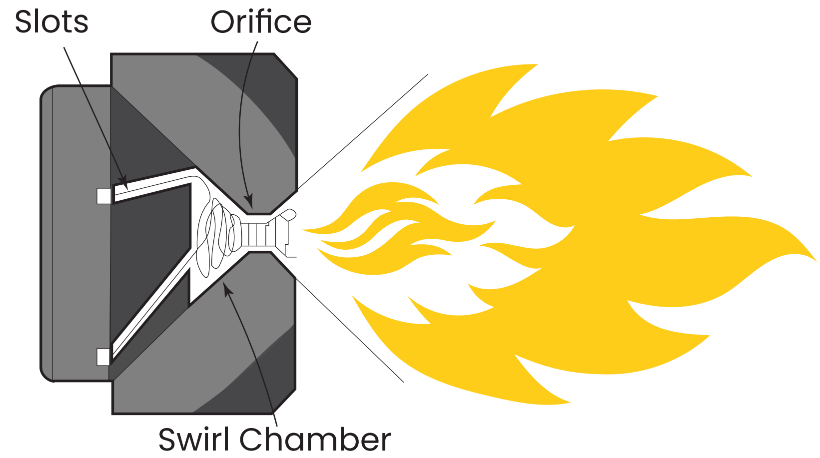


Figure 15:
Cold Fuel

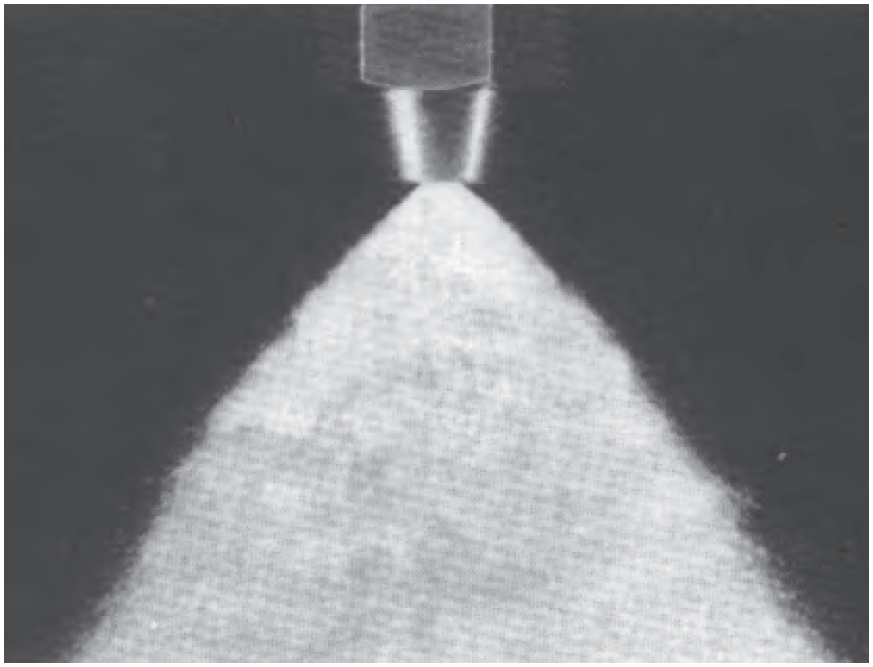


Figure 16:
High Viscosity Spray

Section 4: Examples of Proper Nozzle Selection

The following recommendations are solidly based on many years of field experience and laboratory testing. But, like most recommendations, they are subject to exceptional cases or conditions.

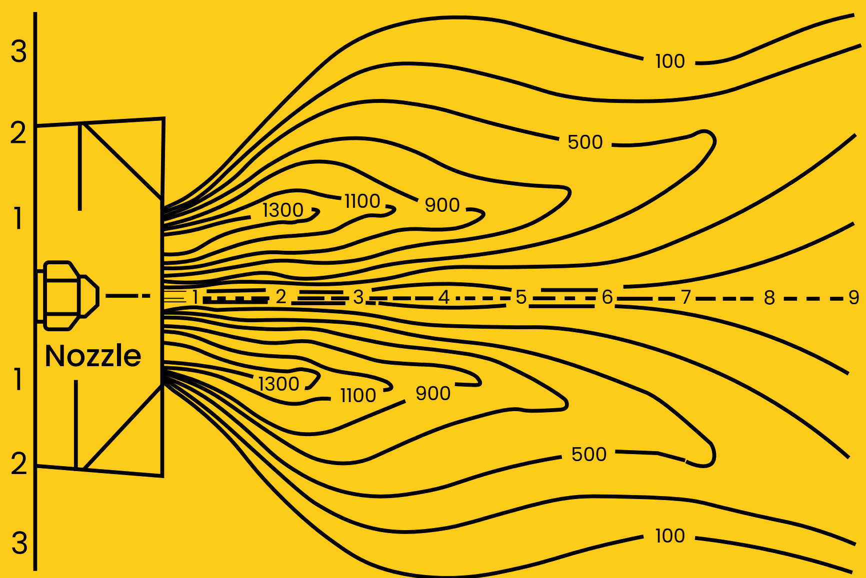


Figure 17:
Hollow Air Pattern

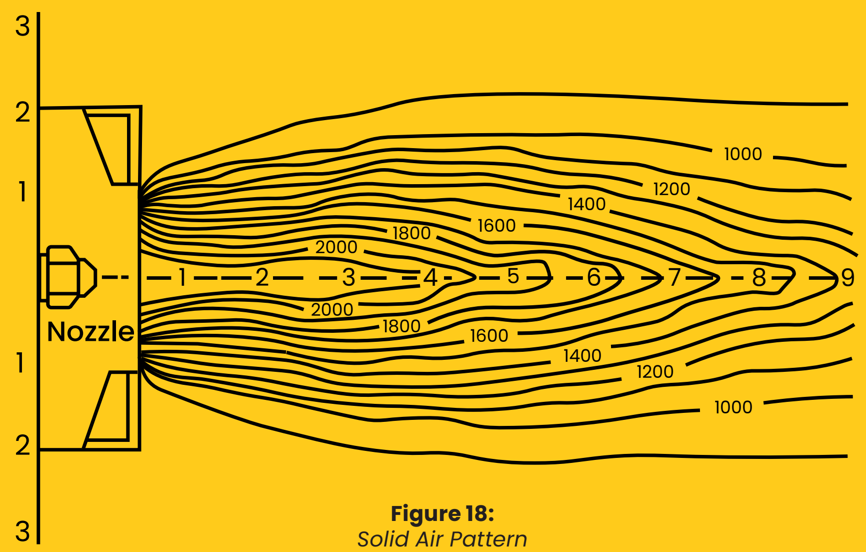


Figure 18:
Solid Air Pattern

Burners with Hollow Air Patterns

The burner air pattern shown in ***Figure 17*** produces a very definite hollow "air spray," with no measurable air velocity at the center of the pattern. The angle of this particular air spray shows it will require a 70° to 80° hollow cone nozzle for good matching. A solid cone nozzle, or one with a narrow angle, would produce a poor match and probably create smoke in the center of the flame, which couldn't be cleaned up by any adjustment of air.

Burners with Solid Air Patterns

The burner air pattern shown in ***Figure 18*** produces a moderate form of solid "air spray." In actual tests this burner would show a slightly better CO_2 reading with a solid cone nozzle. This would become even more pronounced in burners showing higher air velocities at the center of the pattern.

Burners with Flame Retention Heads

This type of firing is standard on all new equipment and most upgraded conversions. As the name implies, the flame front is retained, or locked in close to the burner head. This is accomplished by means of a specially designed disc with slots or edges over which the air flows, creating a recirculating airflow.

Properly designed and located, a flame retention head produces an efficient, compact, bushy flame that is free from smoke or excessive noise. Nozzle selection for a specific burner should be in accordance with the manufacturer's instructions for angle and pattern.

Burners with Flow Rates up to 2.00 GPH

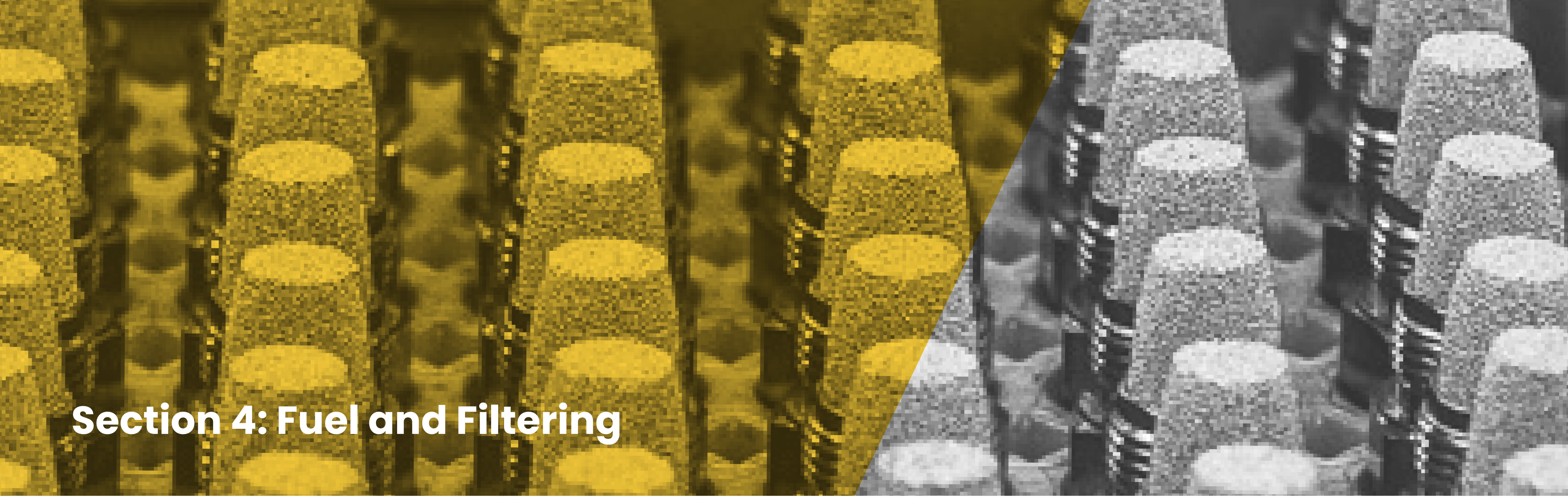
Hollow cone nozzles can be used successfully for most applications, even on burners with the highest air velocity in the center of the pattern Generally, conventional or Shell Head burners can utilize hollow cone nozzles. In cases where more fuel is needed near the center, it may be advisable to select a nozzle with a narrower spray angle or a solid cone type. Hollow cone nozzles in the smaller burners assure the quietest possible operation. That's why they are sometimes used even if it means sacrificing CO_2. Type A and B Del-O-Flo™ can be used in place of standard A and B nozzles. A Type W nozzle can also be used with success.

Burners with Flow Rates Between 2.00 and 3.00 GPH

Hollow or solid nozzles may be selected, depending upon burner air pattern. This range is not as critical and therefore not subject to some of the problems found either above or below this range.

Burners with Flow Rates above 3.00 GPH

Here it's advisable to start with solid cone nozzles which produce smoother ignition in most burners at these higher flow rates. Burners with hollow air patterns are the exception. In this flow range, pulsation is not as prevalent as in the smaller sizes.



Section 4: Fuel and Filtering

Combustion Nozzles for a wide range of fuels.

Preheaters

Preheaters can overcome the effects of cold fuel but at the same time they can also affect nozzle performance. According to Delavan tests, flow rate, pattern, and angle can be affected so it's best to test the nozzle performance installed in a burner when a pre-heater is used.

Chemical Additives

Chemical additives play a significant role in the industry. Fuel additives serve good purposes, such as making liquid fuel cleaner, easier flowing, and easier to ignite, but they can sometimes have a negative effect on nozzle performance. Use care in selecting and using chemical additives.

Residential Liquid Fuel Burner Adjustments for Optimum Fuel Utilization

For complete instructions refer to these publications:

"Guidelines for Residential Oil Burner Adjustments,"
U.S. Environmental Protection Agency

"The Professional Serviceman's Guide to Oil Heat Savings,"
R.W. Beckett Corp., 38251 Center Ridge Road, P.O. Box D, Elyria, OH 44035

Adjustments Concerning Nozzles

Following the appliance manufacturer's recommendations, an annual replacement of the nozzle is a good guide. The nozzle size should match the design load. **DO NOT OVER SIZE.** (For determination of over sizing, refer to publications listed on **pages 22-25.**) Short cycles and low percent "on" time result in higher overall pollutant emissions and lower thermal efficiency.

An in-line liquid fuel filter will reduce problems due to nozzle clogging. It should be located as close as possible to the liquid fuel burner. Care should be taken to prevent air leakage into the fuel suction line. Use continuous runs of copper tubing and use minimum number of joints and fittings. **Always use flare fittings.** Select the nozzle and spray pattern, whenever possible, using burner manufacturer's instructions. On burner-boiler or burner-furnace matched assemblies, use the appliance manufacturer's instructions. Bleed air from the pump and nozzle piping to avoid trapped air.

The Value of Quality Filtration

The nozzle is the heart of the liquid fuel heating system, and it is critical to prevent nozzle contamination. Good filters will remove extraneous dirt in the fuel as well as rust and sludge that form in the fuel tank and could plug the nozzle slots or orifice.

Check the line filter between the tank and pump and replace it frequently. After working on the system, flush a pint of fuel through the fuel line to get rid of any stirred-up sediment. Use properly sized filters and strainers on the nozzle. A Delavan® line filter on installations under two gallons-per-hour flow is also recommended.

Section 4: Combustion Nozzles

Delavan ProTek® Nozzle System
The Delavan ProTek® Nozzle System combines a Delavan nozzle and the unique Delavan ProTek® Valve Component, a patented nozzle filter with a built-in control valve. This unique system has been designed to improve nozzle performance at start up and prevent poor shut off and after drip. It provides the following distinct benefits:

- Reduction of combustion pollutants for cleaner air
- Reduction of soot and carbon build-up for cleaner furnace operation and faster, easier service clean-ups
- Elimination of costly fuel afterburn and drizzling
- Immediate and efficient firing at start-up
- Dramatic reduction of hydrocarbons at start-up and shut down

ProTek® Nozzle System/ ProTek® Valve

Available as a complete system (nozzle and valve assembly) or the valve can be purchased separately to replace the standard filters on Delavan nozzles 2.00 GPH or less. Two versions of the valve are available (See Operating Pressures Chart).

Reduces soot and carbon formation with cleaner starts, and prevents poor shut down and after drip.

Operating Pressures

Minimum Operating Pressures						
Valve Part #	Supply Pump		Valve Open		Valve Close	
	PSI	(BAR)	PSI	(BAR)	PSI	(BAR)
60030-001	135.0	(9,3)	125.0	(8,6)	65.0	(4,5)
60030-002	100.0	(7,0)	85.0	(5,9)	45.0	(3,1)

** Delavan ProTek® Nozzle System*

Sintered Filter

Mesh Strainer

Sintered & Mesh Strainers

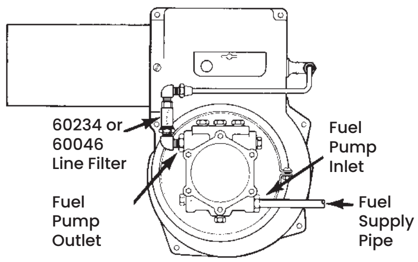
Sintered filters are for lower gph nozzlesand are made of thousands of tiny bronze pellets fused together into an effective filtering medium of uniform thickness and density. Delavan mesh strainers are constructed of brass bodies and stainless steel screens.
Nozzle filters and strainers cannot be expected to handle the complete filtering job. A line filter between the tank and burner is strongly recommended.

Line Filters

- Use Delavan's line filter for extra filtration in burner applications of 2.00 GPH or less.
- These offer four times the filtering area of a standard nozzle strainer and twice the protection.
- A plugged line filter can cause a pressure drop. Check the pressure on the outlet side of the filter while the unit is flowing to see that it is the same as the pump pressure. If less, replace filter.

Choices

- #60046 – 1/8" MNPT inlet and outlet threads
- #62034 – MSAE 45° Flare inlet and outlet threads



***NOTE**: Replace the line filter during the annual service check for an economical way to maintain clear lines.*

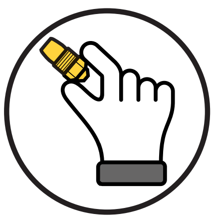
Furnished as Standard on these sizes	Part Number	Filter or Strainer Description	Media or Mesh Size
.40	45560-004	Sintered	Super Fine
.50 - 2.00	45560-001	Sintered	Fine
2.25 - 15.00	46046-002	Mesh	120M
16.00 & Up	-	None	-

Section 5: Nozzle Care & Service Tips

A liquid fuel burner nozzle is an intricate piece of hardware, designed to do an accurate job of atomizing and metering fuel in the spray pattern best suited to a given burner. You can help ensure top performance of this vital component by following these important guidelines.

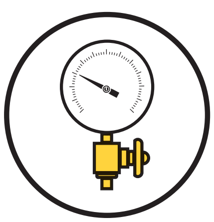
Until installation, Keep Nozzles in Their Original Containers

preferably in a suitable box or rack. They should not be permitted to roll around in a drawer or toolbox or be carried loose in pockets. On service calls, they should be kept in a clean nozzle box.



1. **Handle the Nozzle Carefully**

   after removing it from its container. Pick it up by the hex flats, avoiding contact with the filter or strainer to prevent contamination. This is especially important for nozzles with lower flow rates, as their smaller slots are more easily clogged.

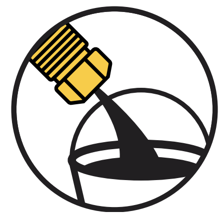


2. **Nozzles Should Always be Handled with Clean Tools Again to Reduce the Possibility of Contamination.**

   To properly service a nozzle and check its performance, it's recommended that you use a pressure gauge, vacuum gauge, and a complete combustion analyzer including a hand held smoke pump tester.

3. **Be Sure the Strainer or Filter is in Place**

   on the nozzle before installation. Do not disassemble the nozzle before installing it because great care has been taken to make sure the nozzle is absolutely clean on delivery.



4. **Before Installing a New Nozzle, it is Very Important to Flush the Nozzle Line and Adapter**

   with at least a pint of fuel pumped through it to remove sludge and dirt, or you can blow out the line with compressed air if it's available. Failure to do this has been the reason for numerous callbacks for plugged nozzles.

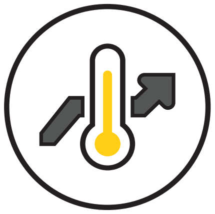
5. **The Nozzle Orifice is Polished to a Glasslike Finish.**

   Don't ruin it with a wire or pin, or by bumping it with a wrench. This can cause streaks in the spray.

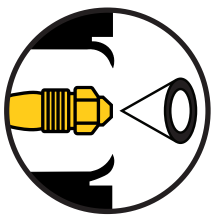
6. **Don't Blow Into the Nozzle.**

   While this may seem to be the handiest and quickest way to "clean" a nozzle, you run the risk of contaminating it instead.

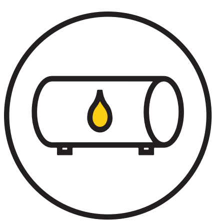
Section 5: Nozzle Care & Service Tips



7. A Nozzle Can Become Overheated Due to Back Pressure in the Combustion Chamber.
This results in coke and sludge formation both inside and outside of the nozzle. Follow furnace or boiler manufacturer's specifications.



8. On a Conventional Installation, be Sure the End of the Burner Tube is Fush or Slightly Set Back
with a soft fiber combustion chamber to prevent the nozzle from becoming overheated. Follow manufacturer's specifications when available.

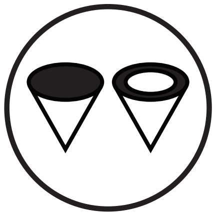


9. Make Sure the Fuel Tank is Clean.
Water and sludge in the tank can clog lines, filter, or nozzles.

10. Be Sure the Supply Line Filter (between tank and burner) is Adequate for the Size of Nozzle Used.
It will remove many of the small particles which may be present in the fuel or formed in the tank. Filtration is particularly recommended for burners using small nozzles. The filtering element should be replaced at each summer cleanup and the line flushed out with fuel. The Delavan line filter should also be replaced annually.

11. Nozzle Cleaning
A quality nozzle should last through a normal heating season provided that an excellent to superior grade filtration system is used. A Delavan nozzle is a fixed precision metering device with no moving parts. When not overheated, there have been cases where a nozzle has worked several heating seasons trouble-free. However, most service organizations have shown the best, most economical results can be obtained by replacing nozzles annually. To clean a nozzle properly is a painstaking, time-consuming job. In the lower flow rates, it's practically impossible to see whether the orifice and distributor slots are thoroughly clean without the aid of a microscope. Also, disassembly of or tampering with the nozzle will void the manufacturer's warranty. In the long run, you will save your time and the customer's money by a program of nozzle replacement.

Section 6: General Troubleshooting Guide



Determining Burner Pattern

Following the appliance manufacturer's specification, to establish the correct spray pattern, try a hollow cone nozzle with an 80° spray angle (a popular angle in the industry). If the pattern is not satisfactory, change to a solid cone nozzle. Reducing nozzle angle in 10 increments from 80° is a good way to find proper angle. (Mobile home units usually require 90° spray angles.)

Noisy Flames

Pulsation and thumping or rumbling can be objectionable to a homeowner. It's possible in some cases to correct the situation by proper nozzle selection.

- Check to make sure the pump pressure is properly set.
- Check the nozzle spray to be sure it is satisfactory. If the nozzle is clogged, it may be impossible to ignite the resulting spray.
- Check the spray pattern. Following the manufacturer'spressure chart, some burners give delayed ignition with the hollow cone sprays, in which case a solid cone nozzle may be the answer.
- Sometimes the next size smaller nozzle will help. Also, the smaller droplets will burn cleaner, decreasing the amount of soot and dirt.
- Installing a delayed opening solenoid valve on the nozzle line can usually help pulsation during start-up or shutdown.

Cold Fuel

Outside storage tanks can be a source of burner problems because liquid fuel becomes more viscous as the temperature drops. This, in turn, can result in slow ignition, collapsing sprays, and noisy flames. There have been some cases where the liquid fuel was so cold, it would not flow through the pipe.

Although some success with special nozzles has been reported, the surest cure for this problem is to increase the pump pressure following the specifications, as an example, to 120-145 psi, utilizing the chart. The extra energy from the pump will atomize the heavier fuel, resulting in better ignition and a more stable flame.

Delayed Ignition

Check the following items:

- Check for proper electrode setting.
- Check the insulators for cracks or for a conducting coat of soot or fuel. Cracks sometimes occur under the electrode bracket, causing a short circuit.
- Check to see that the combustion air openings aren't too wide open.

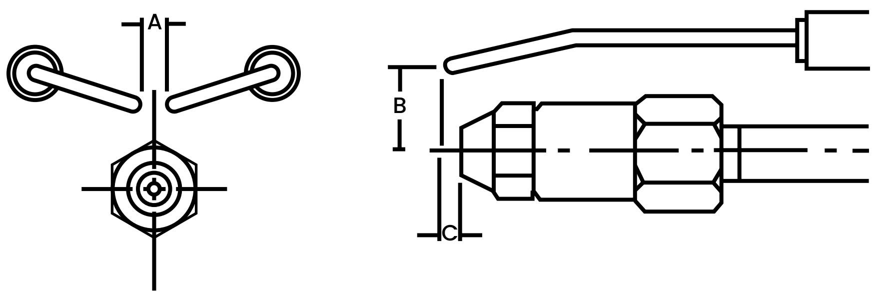


Figure 19:
Follow burner manufacturer recommended Electrode Settings.

Furnace Room Odors

In the case of furnace room odor, check these items:

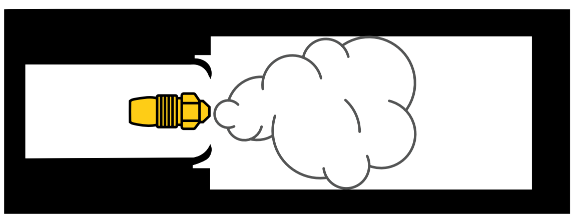
- Check the draft over the flame and make sure it runs with positive pressure over the flame. If it's lower than that, check for obstructions in the flues, or for poor chimney draft.
- Check to be sure that the unit is not being over fired.
- Check to see that there is not too much air through the burner.
- Delayed ignition also can be a cause of odors.

Section 6: General Troubleshooting Guide

Smoky Flames

Since there are a number of possible causes, there are several things to check:

- Check the air handling parts of the burner.
- Check the combustion chamber or the burner tube for damage. In the case of a stainless steel chamber, it might be burned through in one or more places. In the case of a brick chamber, some of the bricks might have become dislodged, leaving openings. Sometimes a burner retention head will be burned off or warped.
- Check the nozzle for contamination. If clogged, it could produce an off-center flame, resulting in smoke.
- Going to a size smaller nozzle might eliminate smoke.



Spray Impingement

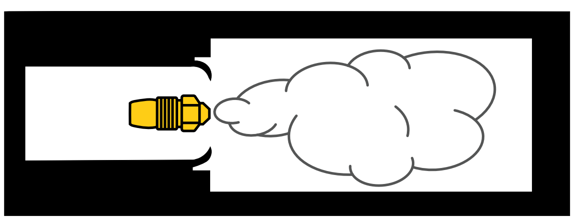
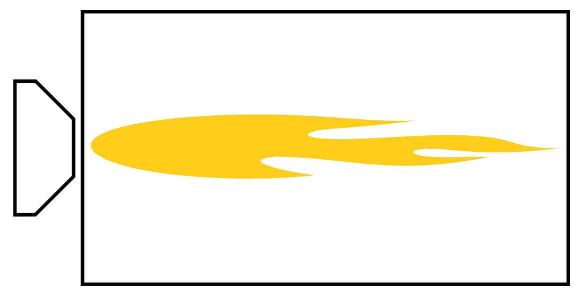


Figure 20:
Spray Impingement corrected by using a narrower spray angle

- Check to see if nozzle spray angle is too wide for the burner air pattern. In this case, smoke may form at the side of the flame. The solution is to select the next narrower spray angle.
- A solid cone spray pattern in a burner with a hollow air pattern will produce a smoky center in the flame. This can be corrected by changing to a hollow cone nozzle of the proper spray angle.
- Check for spray impingement on the walls or floor of the combustion chamber, or at the end of the burner tube. This is a cause of carbon build-up and smoky flames. It's usually corrected by the proper choice of spray angle or by going to a solid cone spray pattern. If it's at the end of the burner tube, you may have to relocate the nozzle.

Off Center Flames

- These may be caused by off center location of the nozzle in the burner tube. The nozzle tube or bracket may be bent or improperly located.
- If the heavy flame always appears on the same side in a particular burner, this is due to a peculiarity of the air pattern in that burner and can't be corrected by changing nozzles.
- A nozzle contaminated by sludge or other foreign matter will usually produce an off center flame.



Long Flames

A narrow spray angle always produces a long flame. High viscosity fuel can also be a cause since the spray angle tends to collapse. As mentioned before, this can sometimes be solved by increasing pump pressure and going to the next size smaller nozzle. Solid cone nozzles also produce a longer flame.

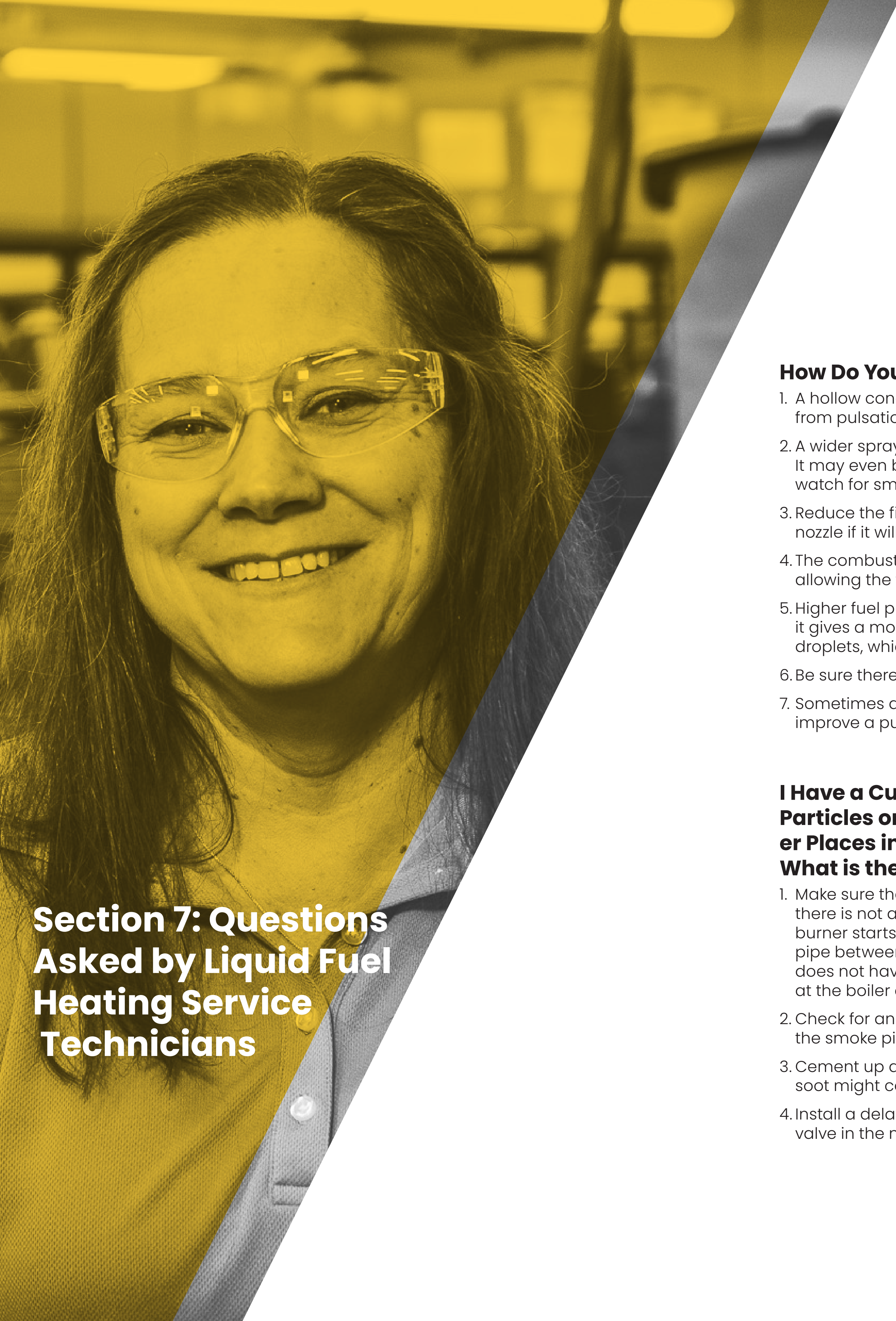
Section 7: Questions Asked by Liquid Fuel Heating Service Technicians

What should I do on a job where it is difficult to clean up the flame?

1. Check the flame to see whether it is off center **(see discussion of off center flames on page 47).**
2. Check the fan blades and if they are covered with lint and dirt, clean them.
3. If this is a conventional liquid fuel burner, check for a burned-off retention head.
4. Check the liquid fuel pressure to be sure that it is at least 100 psi.
5. Check for a plugged line filter or pump strainer.
6. If the smoke is at the outside edges of the flame, try a narrow angle nozzle.
7. If the smoke occurs at the end of the flame, try a wider spray angle.
8. The burner may have insufficient air capacity for this firing rate.
9. The burner may have too high air capacity for this firing rate. This would mean that the burner head couldn't handle a low firing rate.
10. It might just be a very inefficient burner, which cannot be made to burn clean.
11. The nozzle may be partially plugged, resulting in poor atomization.
12. The liquid fuel may have a high viscosity or it might be cold, resulting in a collapsing spray.
13. Get sufficient air into the boiler room. If necessary, put in an air intake pipe with a screen and storm cover.

The flame in a burner is always off center and heavy on the right side. How can I find a nozzle that will straighten the flame?

1. If the flame is always heavy on one side, the nozzle does not cause it. It would be impossible to make a nozzle spray that is heavy on one side and always have it come up on the same side of the burner.
2. Check the position of the nozzle in the burner head. The chances are it is off to one side or the other.
3. With a short burner tube, the air stream may be stronger on one side than the other. That will give the appearance of an off center flame.
4. If the burner is installed to one side of the combustion chamber, the flame may also give the appearance of being heavy on one side.
5. If the nozzle spray pattern is off center due to contamination or any other reason, it may make a flame which is heavy on one side, but it could be in any direction.



Section 7: Questions Asked by Liquid Fuel Heating Service Technicians

How Do You Cure Pulsation?

1. A hollow cone nozzle generally gives greater freedom from pulsation than a solid cone nozzle.
2. A wider spray angle sometimes helps a pulsating condition. It may even be necessary to use a 90° nozzle. In this case, watch for smoke at the outer edges of the flame.
3. Reduce the firing rate to the next smaller nozzle if it will carry the heating load.
4. The combustion chamber may be too large, allowing the flame to leave the burner.
5. Higher fuel pressure sometimes helps because it gives a more stable spray pattern and smaller droplets, which burn closer to the burner.
6. Be sure there is air intake into the boiler room.
7. Sometimes a flame retention burner will cure or improve a pulsating or rumbling condition.

I Have a Customer Who Complains of Soot Particles on the Floor Around the Boiler and Other Places in the Basement. The Flame is Clean. What is the Reason for This?

1. Make sure that you have adequate chimney draft so that there is not a back-pressure in the smoke pipe when the burner starts. This type of complaint occurs with a long smoke pipe between the boiler and the chimney. If the smoke pipe does not have enough pitch, there may be a backpressure at the boiler connection even with sufficient chimney draft.
2. Check for an obstruction at the point where the smoke pipe enters the chimney.
3. Cement up all leaks in the boiler setting where soot might come out on the start.
4. Install a delayed opening solenoid valve or ProTek® valve in the nozzle line to make smoother starts.

Section 7: Questions Asked by Liquid Fuel Heating Service Technicians

If the Burner Sometimes Fails to Ignite Smoothly and Starts with a Puff, What Can be Done to Improve it?

1. Check the manufacturer's electrode specifications for spray angle.
2. Clean carbon and dirt from the points and from the insulators.
3. The transformer may be weak and not delivering full voltage or current. If you don't have another transformer immediately available, file the electrodes to a sharp point. This will give a better spark.
4. Check for cracked insulators. Sometimes an insulator may be cracked under the electrode bracket and it is difficult to find. This could cause a high voltage leak, thus reducing the voltage at the points.
5. A partially plugged nozzle causing off-center spray can cause delayed ignition.
6. Above about 2.50 gph, a hollow cone spray may sometimes cause delayed ignition. Check with the appliance manufacturer.
7. The air setting on the burner may be wide open, thus tending to blow the flame out before it is established. Adjust the air correctly.

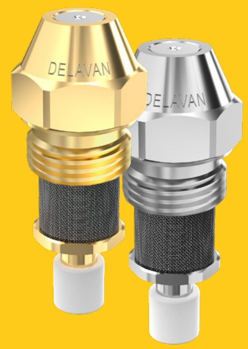
I Have Tried Firing Fractional Gallonage Nozzles and They Only Work Two or Three Weeks and Plug Up. Does Everyone Have that Same Problem?

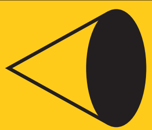
1. First of all, do not remove a nozzle from its vial before you are ready to install it in the burner. That may contaminate it.
2. Be sure an adequate supply line filter is installed. This size of nozzle should have a filter capable of removing particles over 50 microns. The problem is knowing which filter will do that. Generally speaking, the paper filters are finer than the felt or woven filters that are available.
3. Install a Delavan line filter for extra nozzle protection. Make sure all trapped air is removed and follow installation instructions.
4. The Delavan Del-O-Flo™ nozzle may help. It was designed especially to minimize the usual plugging problems associated with low flow rates.
5. Flush or blow out the nozzle line and adapter before installing the nozzle.
6. If the nozzle runs exceptionally hot, find out why and remove the cause.

Section 8: Other Delavan Nozzles Available

Liquid Fuel Burner Nozzles for Industrial Applications

VARIFLO™





Bypassing nozzle with variable flow rate

Spray Angles: 30°–90°

- *Permits variable burner outputs based on bypass pressure*
- *Wider spray angles at lower flow rates*
- *Less subject to clogging*

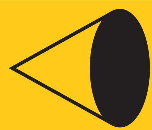
Flow Rate @100 PSI #2 0.75–50.00 GPH

Thread Size: 9/16-24 UNEF

Hex Size: 5/8"

Material: Brass and 416 Stainless

SNA™



Air Atomizing nozzle for extremely fine spray particle size at low air pressures

Spray Angles: varies with air pressure type 70–90°

- *Produces a solid cone spray with extremely fine particle size at low air pressures and low CFM*
- *Flow rates, spray angles, and droplet sizes can be modified, with limitations, by variations in air, lift, etc*
- *Clog-free operation of low volume due to large inside passages*

Fuel Flow Rate: .20–1.00 GPH at 3-5 PSI air pressure using lift height of 1-7"

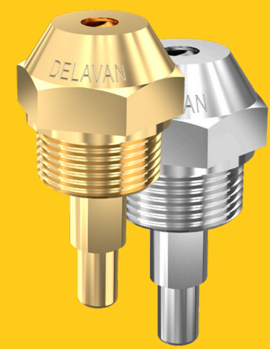
Air Volume: .36-102 CFM

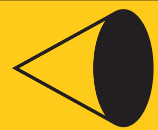
Thread: 9/16-24 UNEF

Hex: 5/8"

Material: Brass and 416 Stainless

AIRO™





Air Atomizing Nozzle with a uniform solid cone, spray angle varies with air pressure

Spray Angles: varies with air pressure type 60–90°

- *For good atomization of both light and heavy oils at higher flow rates*

Flow Rate: 10.0 to 200 GPH

Thread Size: 3/4"-20 UNEF & 15/16"-20 UNEF

Hex Size: 7/8" and 1 1/4"

Adapter Air Inlet: 1/4-1/2 NPT

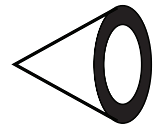
Adapter Liquid Inlet: 1/8-1/4 NPT

Air Pressure: 20-150 PSI

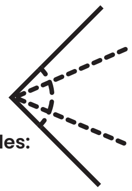
Material: Brass, Stainless Steel, Inconel, and Hastelloy

Humidification Nozzles for Liquid Fuel Burner Applications

WDA TYPE NOZZLE



Hollow Cone Fine Atomization with no Central Distribution



Spray Angles: 30°–90°

Small Hollow Cone Nozzle. Consists of five parts: body, orifice disc, distributor, retainer, and strainer.

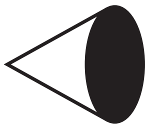
Flow Rate: 0.40-65 GPH

Nozzle Size: 9/16-24 UNEF

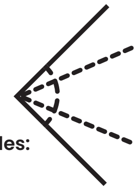
Adapter Treads: Male Female 1/8-1/4" NPT

Material: Brass and 416 Stainless

WDB TYPE NOZZLE



Soild Cone Producing uniform distribution across a wide pressure range



Spray Angles: 30°–90°

Solid Cone Nozzle Consists of five parts: body, orifice disc, distributor, retainer, and strainer.

Flow Rate: 0.40-65 GPH

Nozzle Size: 9/16-24 UNEF

Adapter Treads: Male Female 1/8-1/4" NPT

Material: Brass and 416 Stainless

See Liquid Fuel Burner Nozzle Catalog #1709 for ordering and technical information, or visit www.delavan.com.

Delavan, part of R.W. Beckett, is a world leader in the design and manufacture of high quality spray nozzles and fluid handling systems. Since 1935, we have grown to be one of the leading spray nozzle manufacturers. Operating from dedicated manufacturing facilities, Delavan now supplies more than 30,000 different components to thousands of customers in virtually every manufacturing and processing industry. Our success has been driven by our outstanding service, our manufacturing flexibility, and our technical application expertise to ensure our customers obtain the maximum benefit from the solutions they choose.

Precision Tested.
People Trusted.

DELAVAN®
SPRAY TECHNOLOGIES

For more information on our products and help connecting with a distributor near you, visit ***delavan.com*** or contact us at:

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US Toll Free Number: ***+1-800-902-6943***
Fax: ***+1-803-245-4146***
General Inquiries: ***sales@delavan.com***

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