Beckett Online Training

Series 1: The Basics of Oil Burners

Module 1: Combustion Basics

April 30, 2020

Overview

This series will focus on the combustion cycle and set up of Beckett AF/AFG burners. Upon completion of this series you should be able to:

- List the components of a combustion cycle
- Apply and adjust a fuel unit / fuel pump
- Show how input rating changes directly with a change to pump pressure
- State the differences between an AF and AFG burner
- Set the electrodes and head positions using the Beckett T-501 and Z-2000 gauges
- Set the Z dimensions for:
  - F heads
  - M air tubes
- Benefits of solid-state igniters
- Understand operation and sizing of draft regulators
- Understand nozzle types
- Learn impact of oil temperature on operation
- Commission a burner using the 4-step combustion efficiency test

Components of Combustion

- Air, Fuel and Heat
- Drummed into us since we began in the trade
- Combustion is possible when all 3 are balanced
- Combustion is defined as “rapid oxidation”
- The “balance” effects quality of combustion

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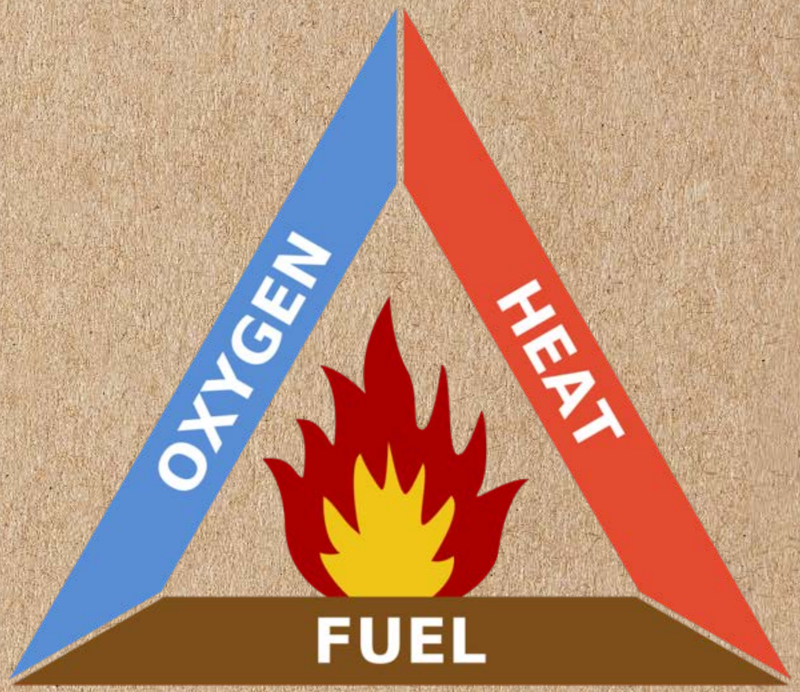
Combustion

- Combustion is defined as the rapid oxidation of a fuel
- Oxidation occurs when an oxidizer reacts with the fuel, in our case heating oil
- The oxidizer comes from combustion air
- For our purposes air contains 21% Oxygen and 79% Nitrogen*



*** The composition of excess air is predominantly Nitrogen, with various other inert gases**

3 T's of Combustion

TIME

- Normally, combustion reactions are so rapid that the time to complete them seems instantaneous.
- A good example is the combustion of gasoline in an internal combustion engine.
- However, natural gas or a droplet of oil will travel several feet in the furnace and require a finite period of time between the start of ignition and the completion of burning.

https://www.myodesie.com/wiki/index/returnEntry/id/3054

3 T's of Combustion

TEMPERATURE

- If a mixture of air and fuel is heated gradually, a temperature will be reached at which outside heat is no longer required and rapid combustion occurs.
- This temperature is referred to as the ignition temperature and is defined as the temperature at which more heat is generated by the combustion process than is lost to the surrounding atmosphere.
- At this point, combustion becomes self-sustaining.
- Below this point, the fuel/air mixture will not burn freely and continuously unless external heat is supplied.

https://www.myodesie.com/wiki/index/returnEntry/id/3054

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3 T's of Combustion

TURBULENCE

- If the fuel and air are mixed in swirling paths, instead of each flowing in streamlined paths, combustion will be greatly improved because the mixing of fuel and air is more complete.
- The proper amount of air for a given amount of fuel means nothing if the two are not mixed.

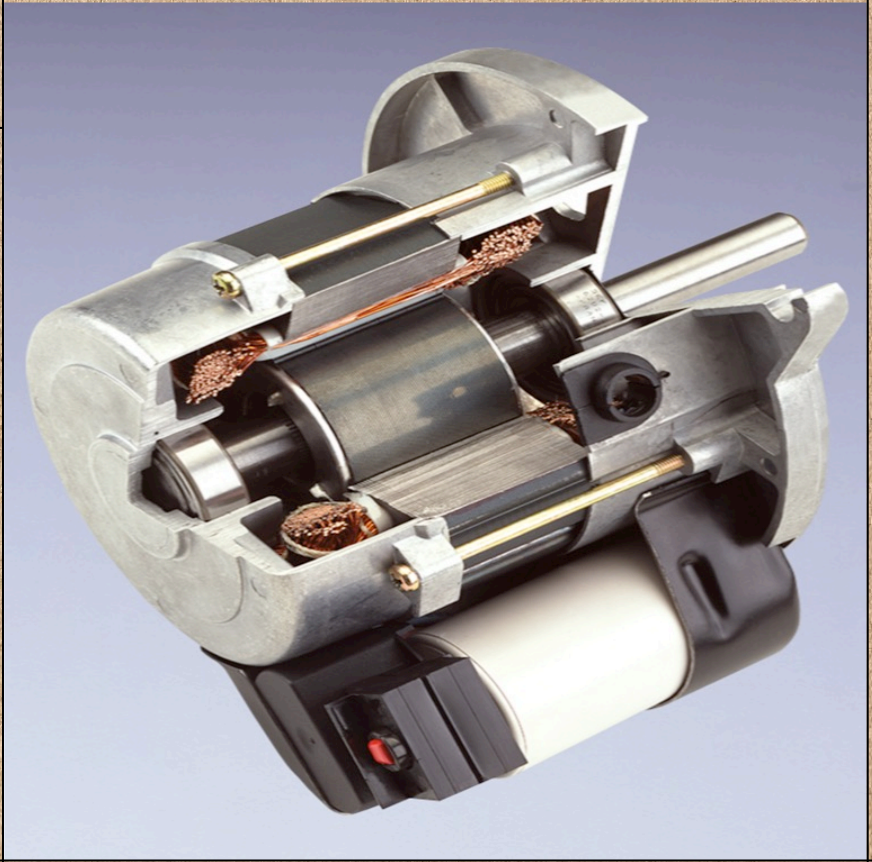
https://www.myodesie.com/wiki/index/returnEntry/id/3054

Combustion Air

- Combustion air is delivered to the atomized fuel by the motor and fan
- There are 2 fans used by Beckett for most residential burners
  - One is for the AF
  - The other for the AFG and NX burners

Combustion Air

- Fans are driven by an electric motor
- Modern Beckett residential burners use a 3450 rpm PSC motor
- Fan is held to the rotor shaft with a set screw
- Motor comes up to speed rapidly and drives the fuel unit through a pump coupling



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Combustion Air

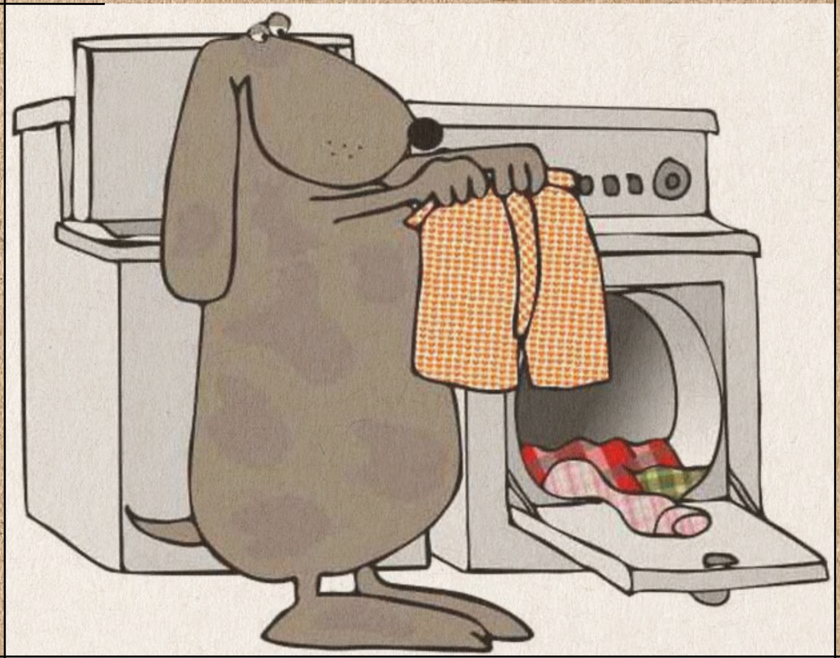
- NFPA 31 and IMC require $50ft^3$ / 1,000 BTU/hr input when combustion air is provided by the space
- Based on:
  - 0.5 Air Changes per Hour
  - 1 draft regulator or draft hood

Example

- Installation: 3 section pin boiler, .75gph nozzle
  - .75 X 140,000 = 109,000
  - 109,000 / 1000 = 109
  - 109 X 50 = 5,450
- When combustion air is supplied from the boiler area there must be 5,450ft^3 of free air
- To provide proper air the space required must minimally be 720ft^2 at a ceiling height of 8'

Be careful!

- Remember…We have based our calculation on free air space, one draft regulator and an air change of 0.5 / hour
  - To have adequate combustion air there must be enough space to stack 5,450 boxes 1’ X 1’ X 1’
- Is there anything else that vents air from the building?



Draft Control

- Draft controls will maintain proper contact time of combustion air within the firebox
- Breech pressure and overfire pressure measurements assure consistent combustion
- Typical breech pressures are:
  - -0.04 vertical fire tube, warm air furnaces and two pass pin style boilers
  - -0.02 to -0.03 for 3 pass boilers
- Check manufacturer's I&O for contact time

Draft Control

When to Use a Draft Control:

Power Burners

- A power burner is designed so that a fan delivers negative air pressure to the combustion chamber.
- A single-acting draft control for oil maintains that negative pressure.

Draft Control

When to Use a Draft Control:

Power Burners

- A power burner designed to burn natural gas or LP gas operates in the same manner.
- While a draft hood (diverter) is often used on gas units fired with an atmospheric burner, a double-acting barometric draft control should be used for furnaces and boilers fired with power burners

Draft Control

When to Use a Draft Control:

Draft Inducers / Power Venters

- With these devices, draft is increased or created causing fluctuations in air flow through the combustion chamber.
- These fluctuations can be negated by the use of a barometric draft control located between the draft inducer or power venter and the furnace, boiler or water heater it services.

Draft Control

When to Use a Draft Control:

Draft Inducers / Power Venters

- Use a single-acting control for oil and gas-fired equipment with a power vented system.
- Use a single acting control for oil and a double-acting control for gas-fired equipment with a draft induced system

Draft Control

When to Use a Draft Control:

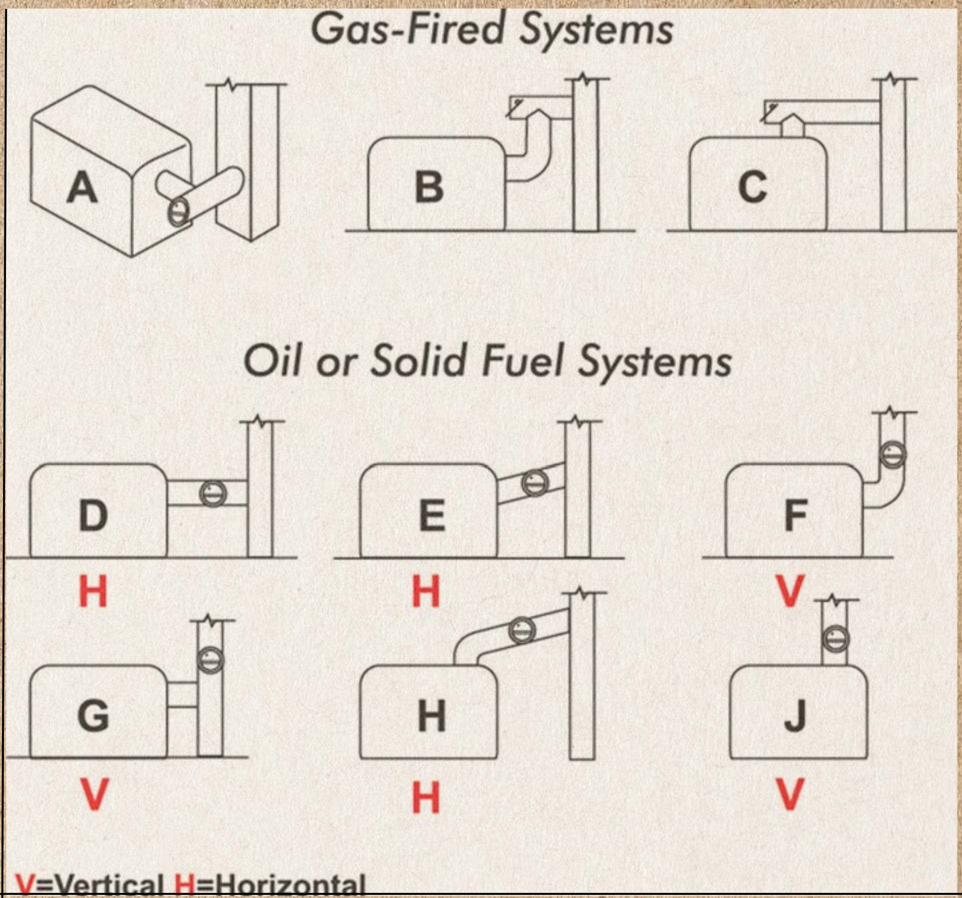
Forced Draft Burners

- Forced draft installed with a stack height in excess of 30’ will probably develop excessive natural draft, reducing the amount of pressure within the furnace or boiler.
- A barometric draft control will help eliminate this undesirable stack action and permit the unit to be pressurized.

Draft Control

- Install the regulator properly!
- The Regulator can be installed in a bullheaded tee for atmospheric gas fired systems
- Install the regulator in the branch for power burners, fan assist or solid fuel applications

Atmospheric



Fuel Units

- Fuel units are available in different configurations
- There are two basic models:
  - Single stage
  - Two stage
- Many are specified with a valve to control oil delivery timing

Fuel Units

- Each design can be applied as single pipe or two pipe, depending on the installation
- Single pipe is used when vac. lift is below 6-8"hg
- Use two pipe when vacuum lift exceeds 8"hg
- Use two stage when vac. lift exceeds 12"hg
- Use a lift pump if the vac lift exceeds 15"hg.

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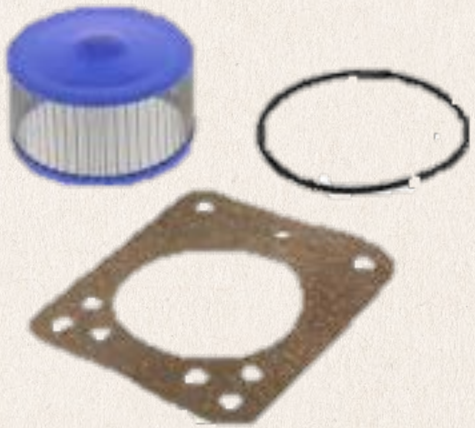
Fuel Units

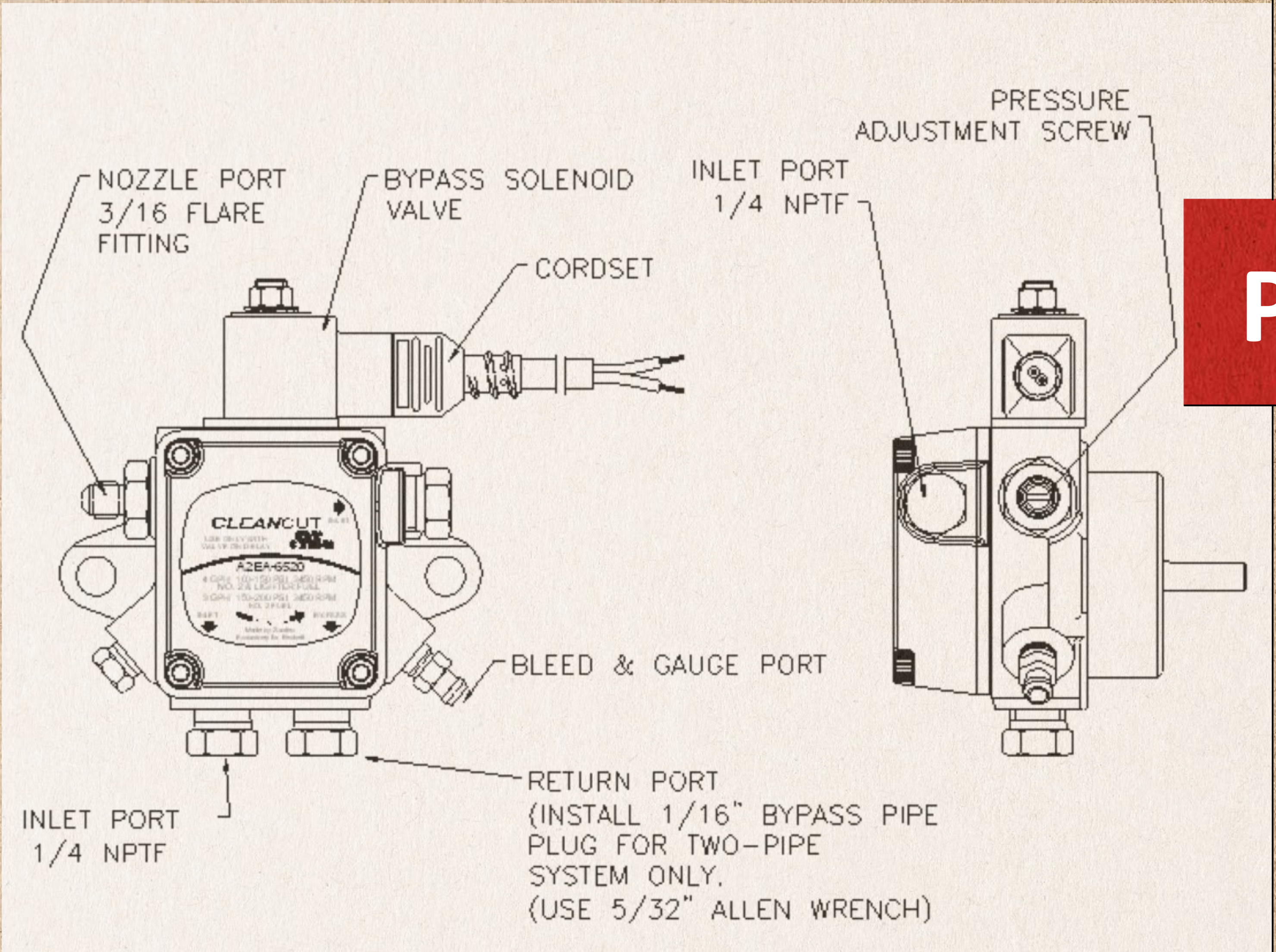
PF103x3

PF103x2

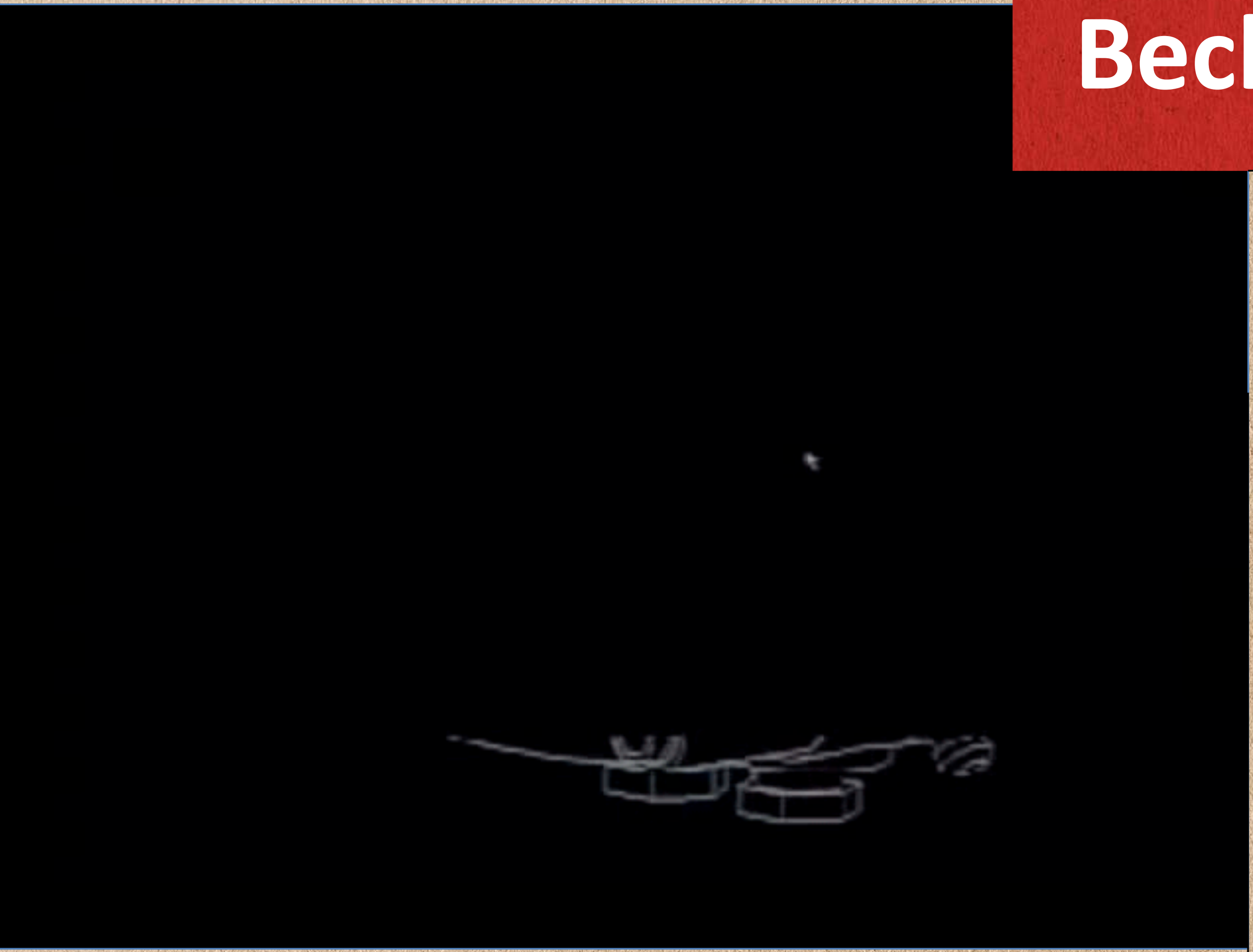
PF104x2



Pumps


NOZZLE PORT
3/16 FLARE
FITTING
BYPASS SOLENOID
VALVE
CORDSET
INLET PORT
1/4 NPTF
PRESSURE
ADJUSTMENT SCREW
CLEANCUT
A2EA-6520
BLEED & GAUGE PORT
INLET PORT
1/4 NPTF
RETURN PORT
(INSTALL 1/16" BYPASS PIPE
PLUG FOR TWO-PIPE
SYSTEM ONLY.
(USE 5/32" ALLEN WRENCH)

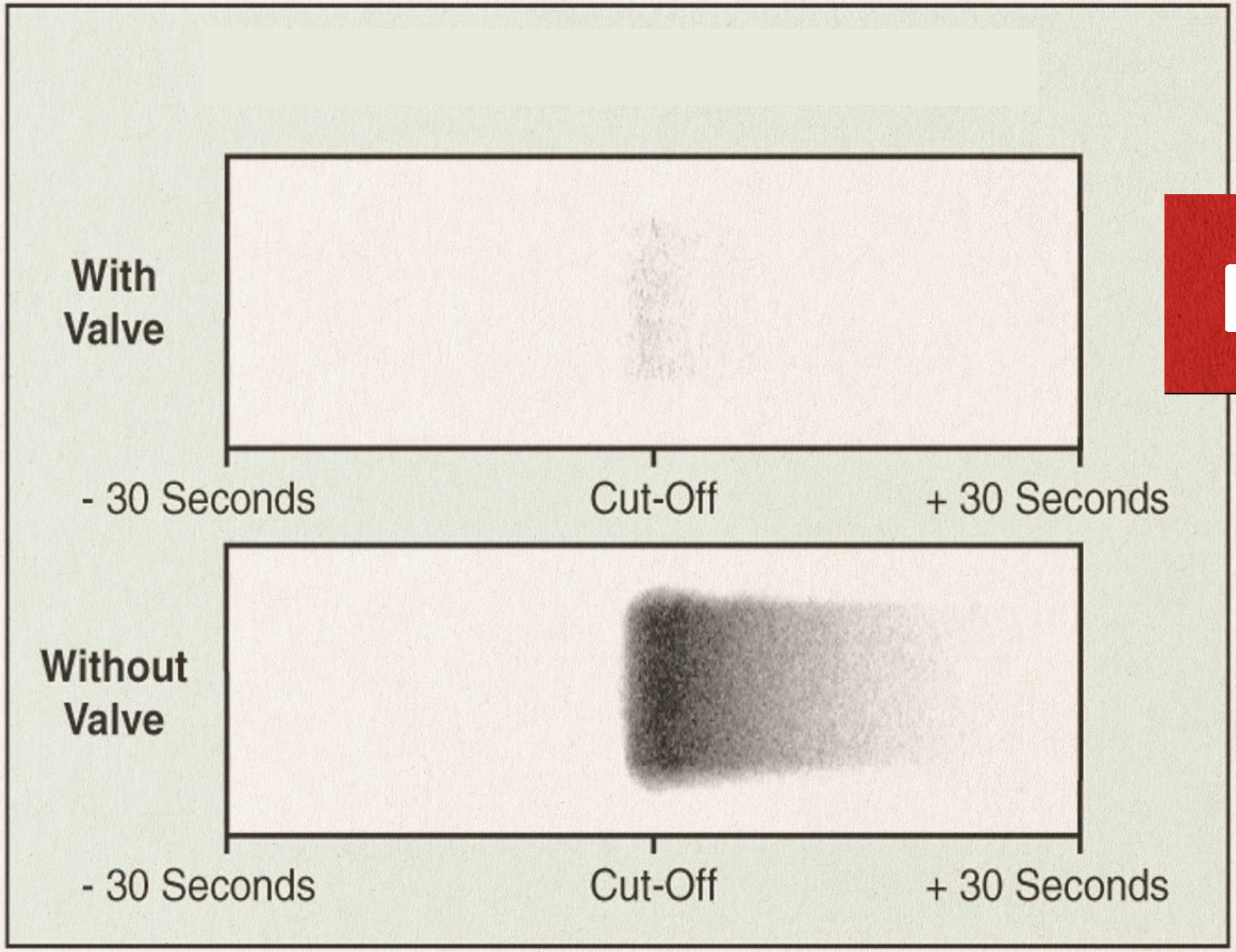
Beckett CleanCut Pump



CLICK HERE TO WATCH VIDEO ON BECKETTCORP.COM

Click the button above to access to go to BeckettCorp.com to watch the video shown on this slide

Pumps


With Valve
- 30 Seconds
Cut-Off
+ 30 Seconds
Without Valve
- 30 Seconds
Cut-Off
+ 30 Seconds

Vacuum

- Vacuum expresses the absence of pressure
- Physics states that high pressure travels towards a point of lower pressure
- The gear set within a fuel unit performs two functions:
  - Create a point of lower pressure at the entrance of the gear set
  - Pressurize the oil at the exit of the gear set

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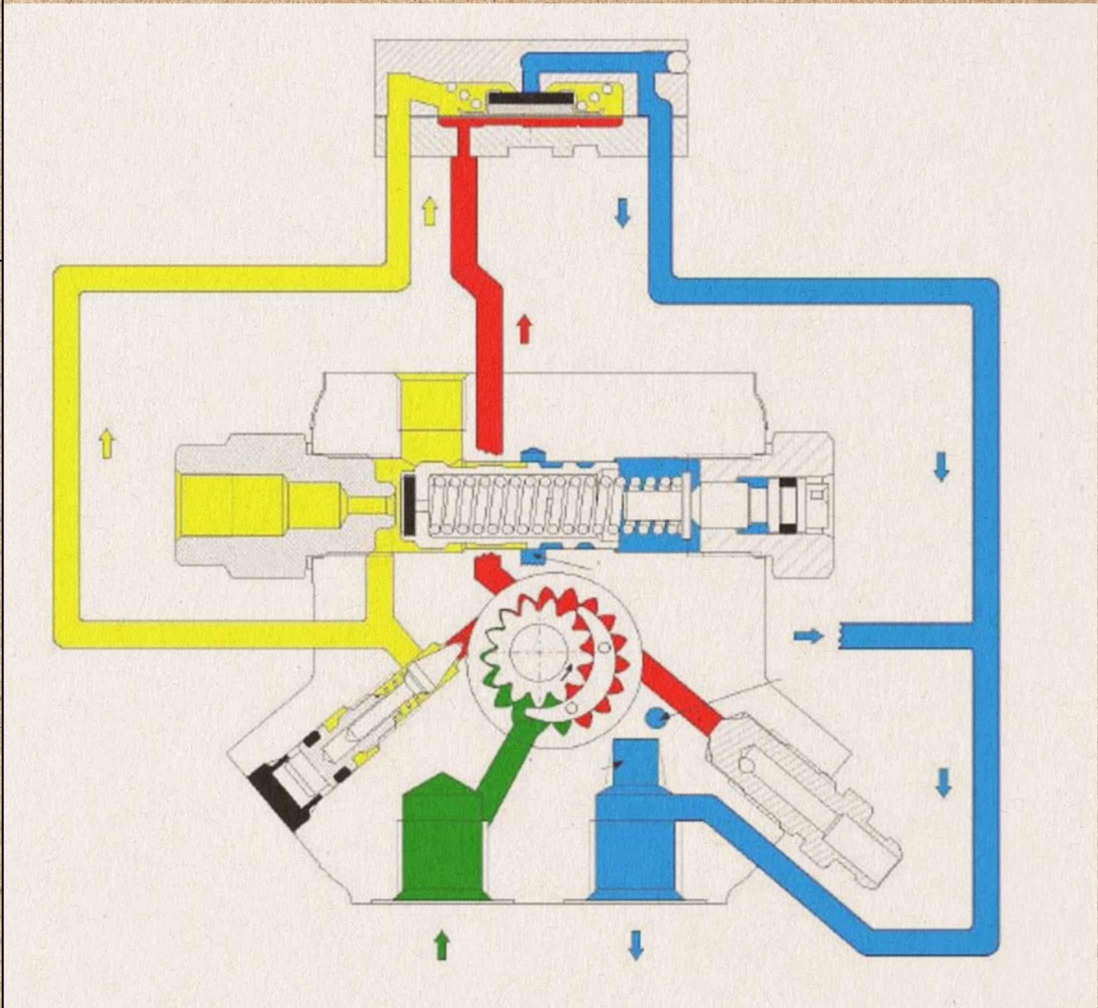
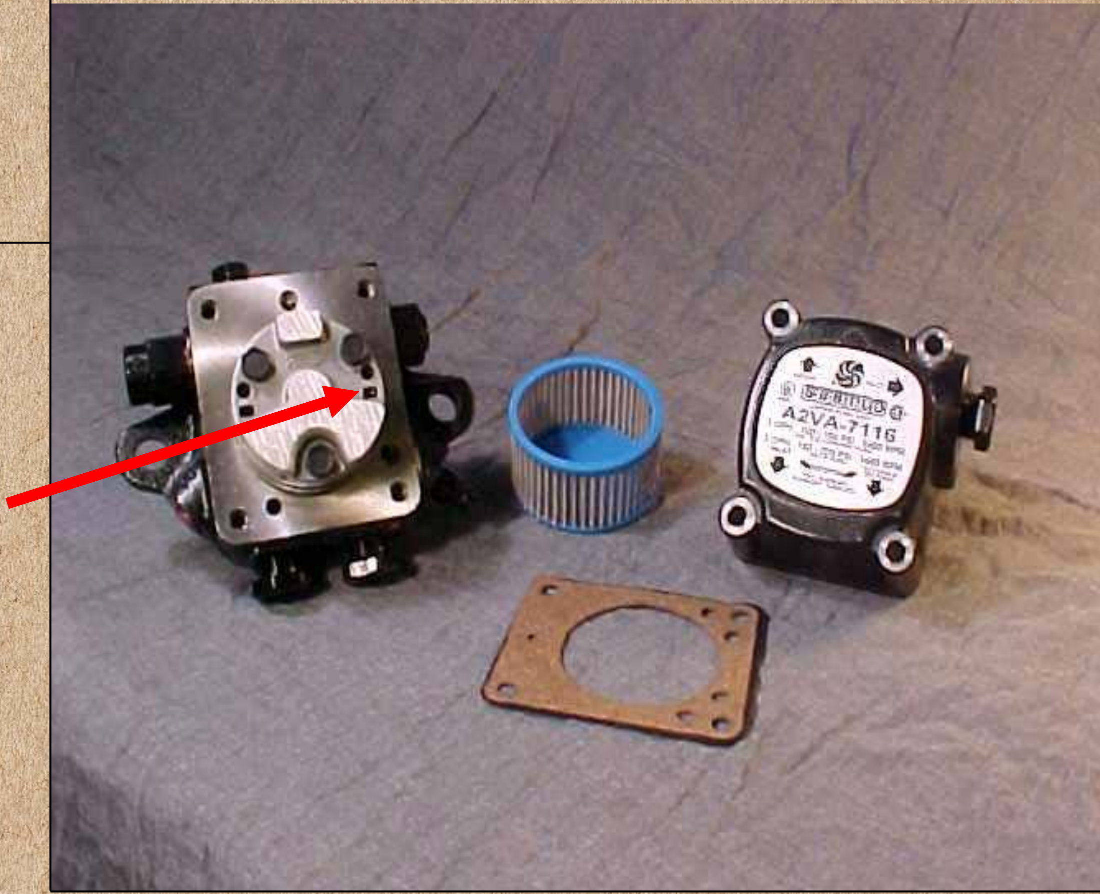
Fuel Units and Vacuum

- The gearset turns within the fuel unit
- Rotation draws product in by creating a vacuum
- Product is pressurized as it leaves the gearset
- At cutoff speed piston will move back towards pressure spring, fuel will exit nozzle port
- Pressure to nozzle reaches set pressure at full motor speed



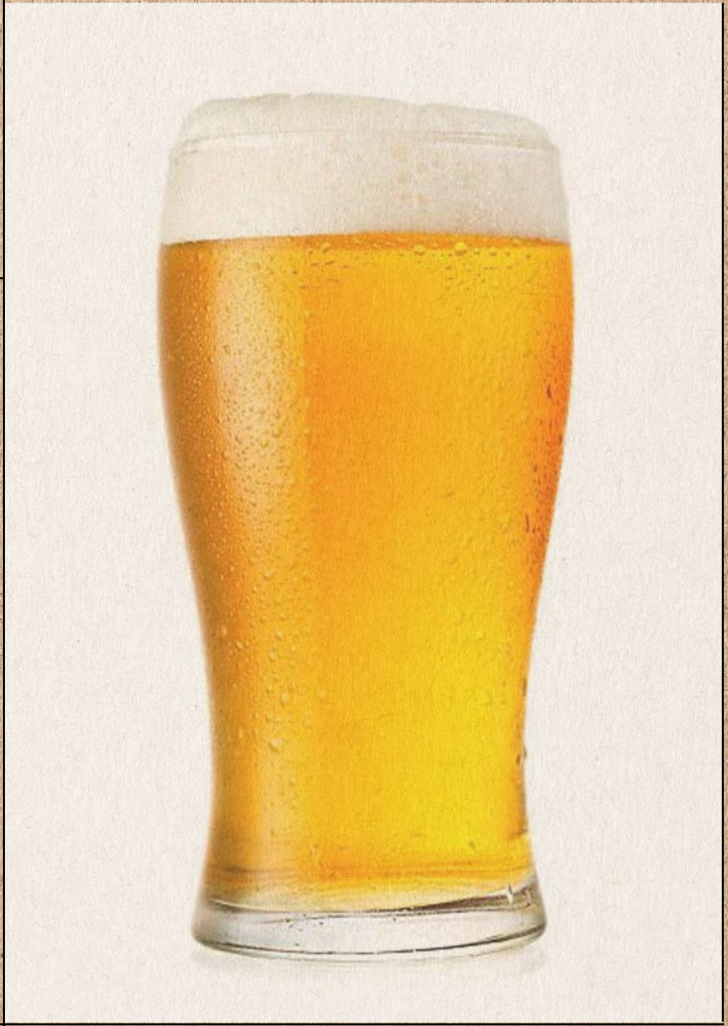
Entrance to gearset

- Product enters strainer cover and is drawn through strainer media
- Entrance to gearset chamber is just below midline of unit
- When product level drops below entrance unit will act as if there is no product, (out of oil)



Effect of Vacuum

- As vacuum increases, pressure decreases
- Pressure holds matter together
- Fuel oil will start to degas, creating microbubbles
- Microbubbles will collect, causing foam that is similar to the head on a glass of beer



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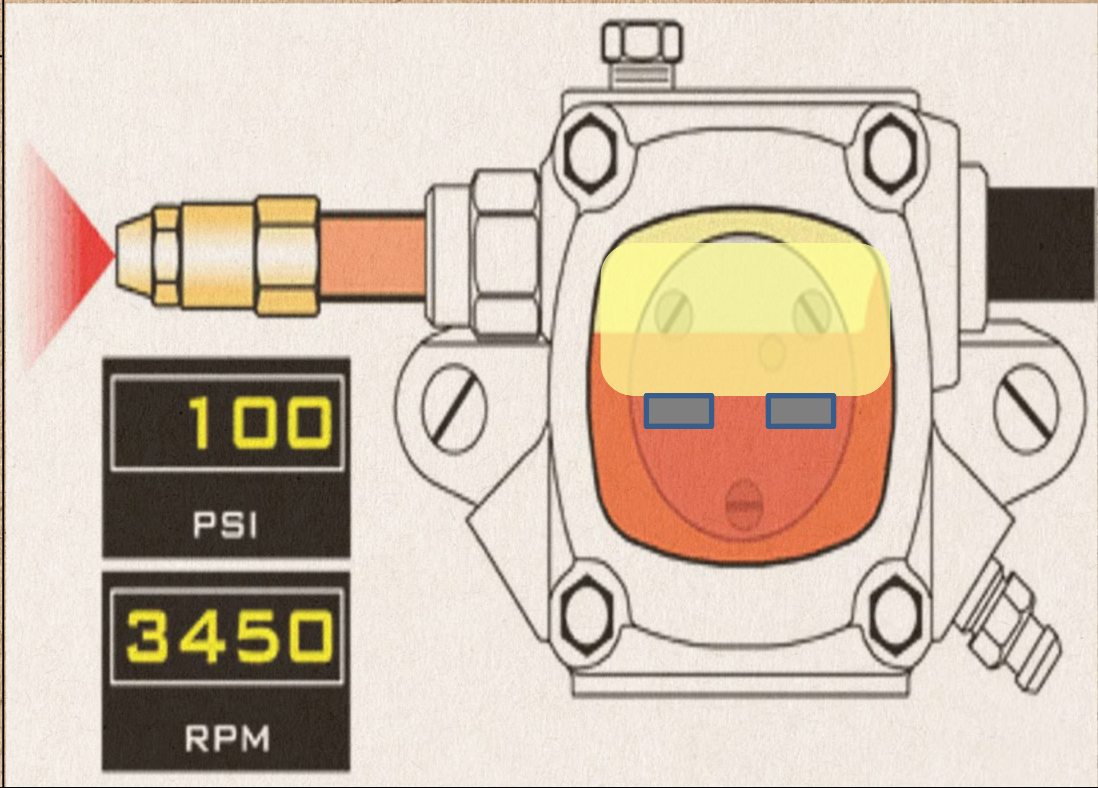
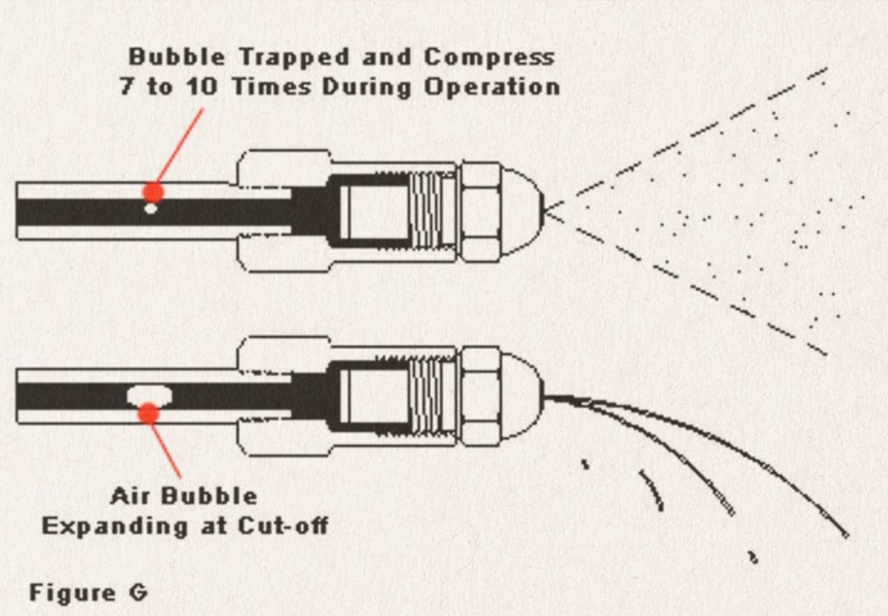
Effect of Vacuum

- As vacuum rises the foam will fill the strainer cover area, finally reaching the gearset ports.
- The microbubbles appear around 6” of vacuum. Typically they are very visible between 8-10”.
- At the end of cycle the foam will dissipate, like that head on a beer.
- There’s the no heat that stumps you.
- Hit the reset, then it comes back later.



Effect of Vacuum or Air Leaks



- Oil supply must be free of air leaks
- Additionally the supply must not create excessive vacuum
- Air leaks will introduce air bubbles into the supply
- High vacuum will create foaming within the fuel unit
- Microbubbles will cause an after drip when they expand at rest

Pump Pressure Cut-off Test

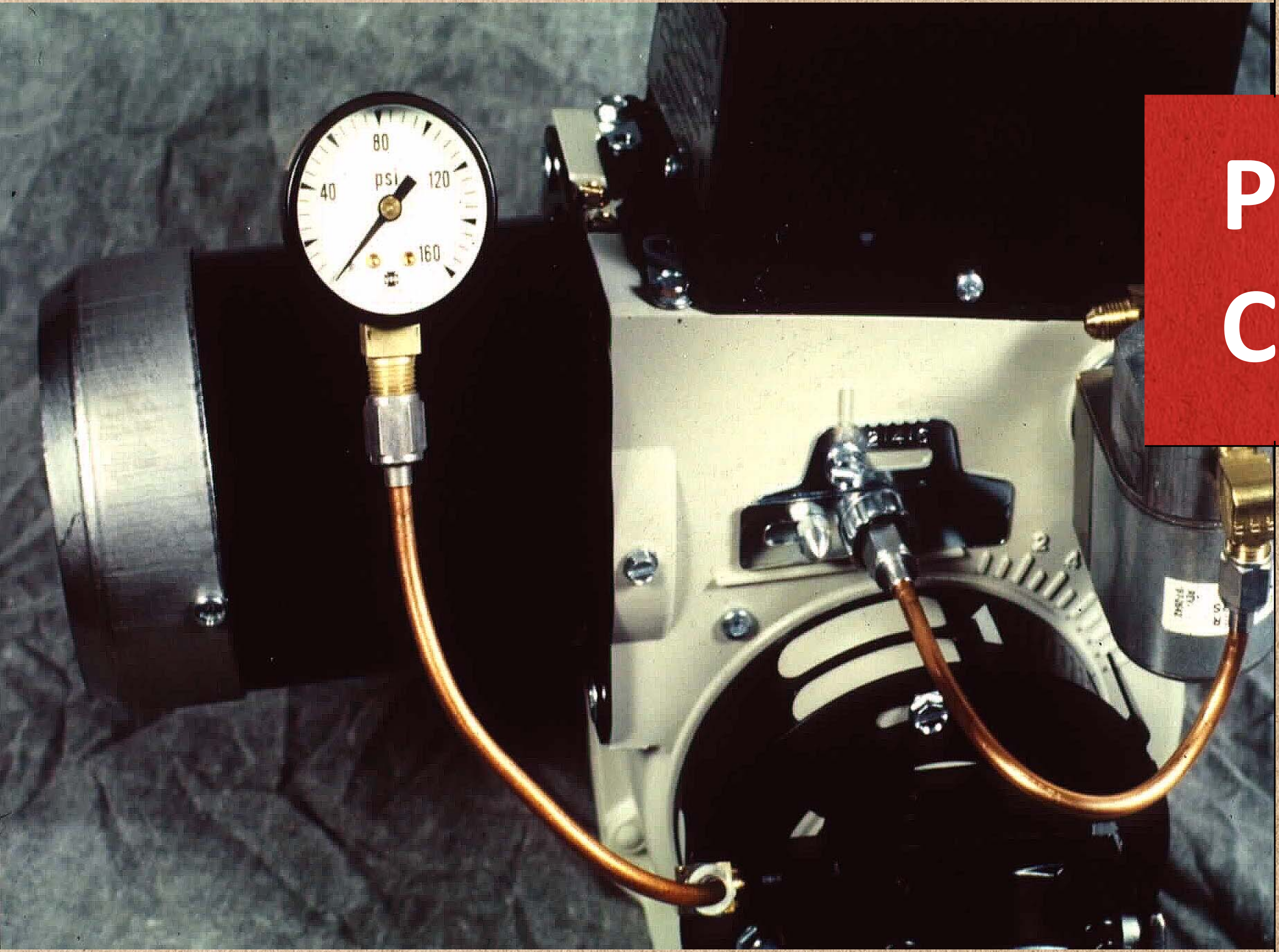
Pump Pressure Cut-off Test

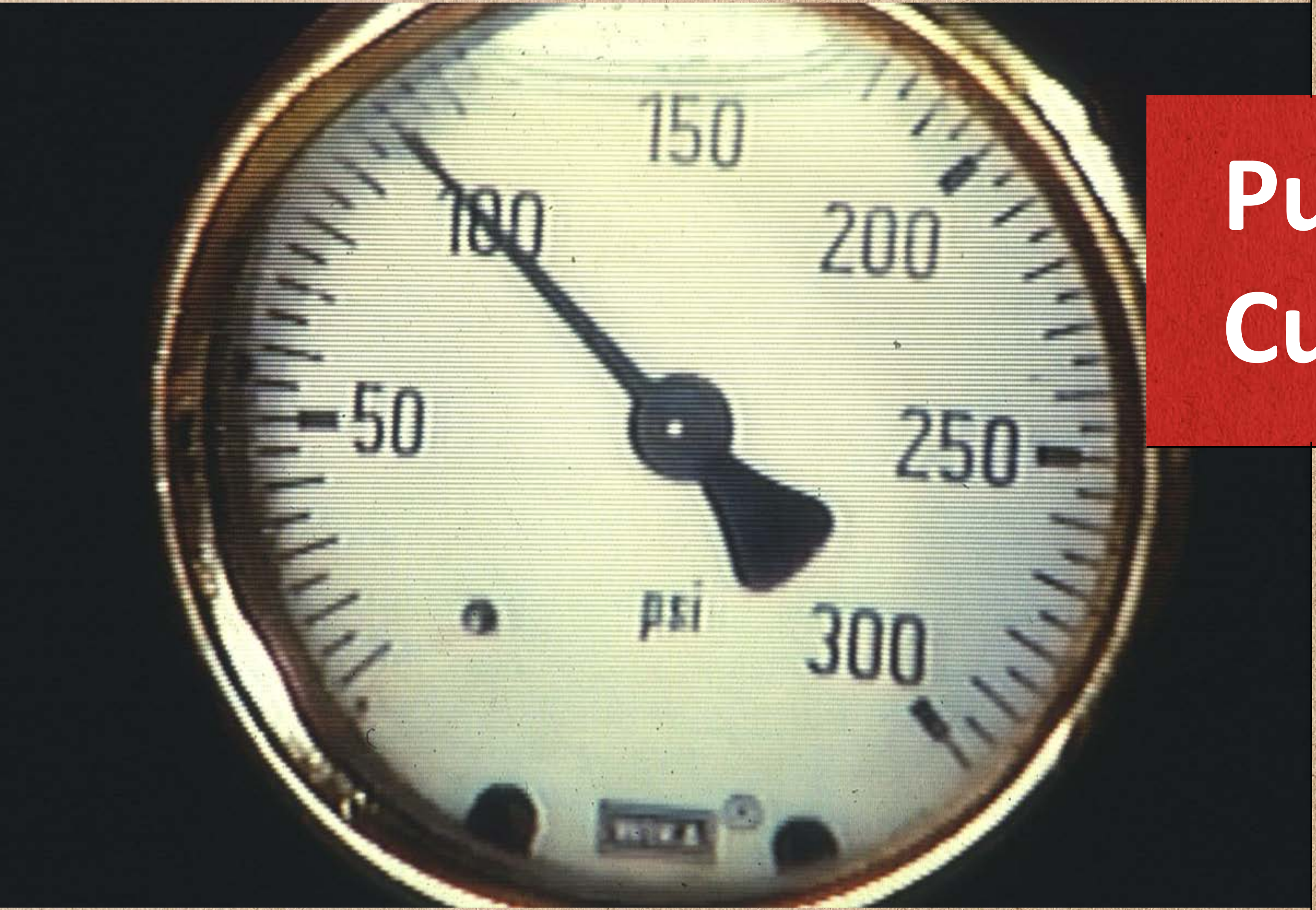
- A pressure and cut off test can be conducted using a properly installed pressure gauge
- Pressure should hold steady to the manufacturer's setting
- Pump cut off tests are conducted to ensure the pump cut-off is sealing at the end of cycle

Pump Pressure Cut-off Test

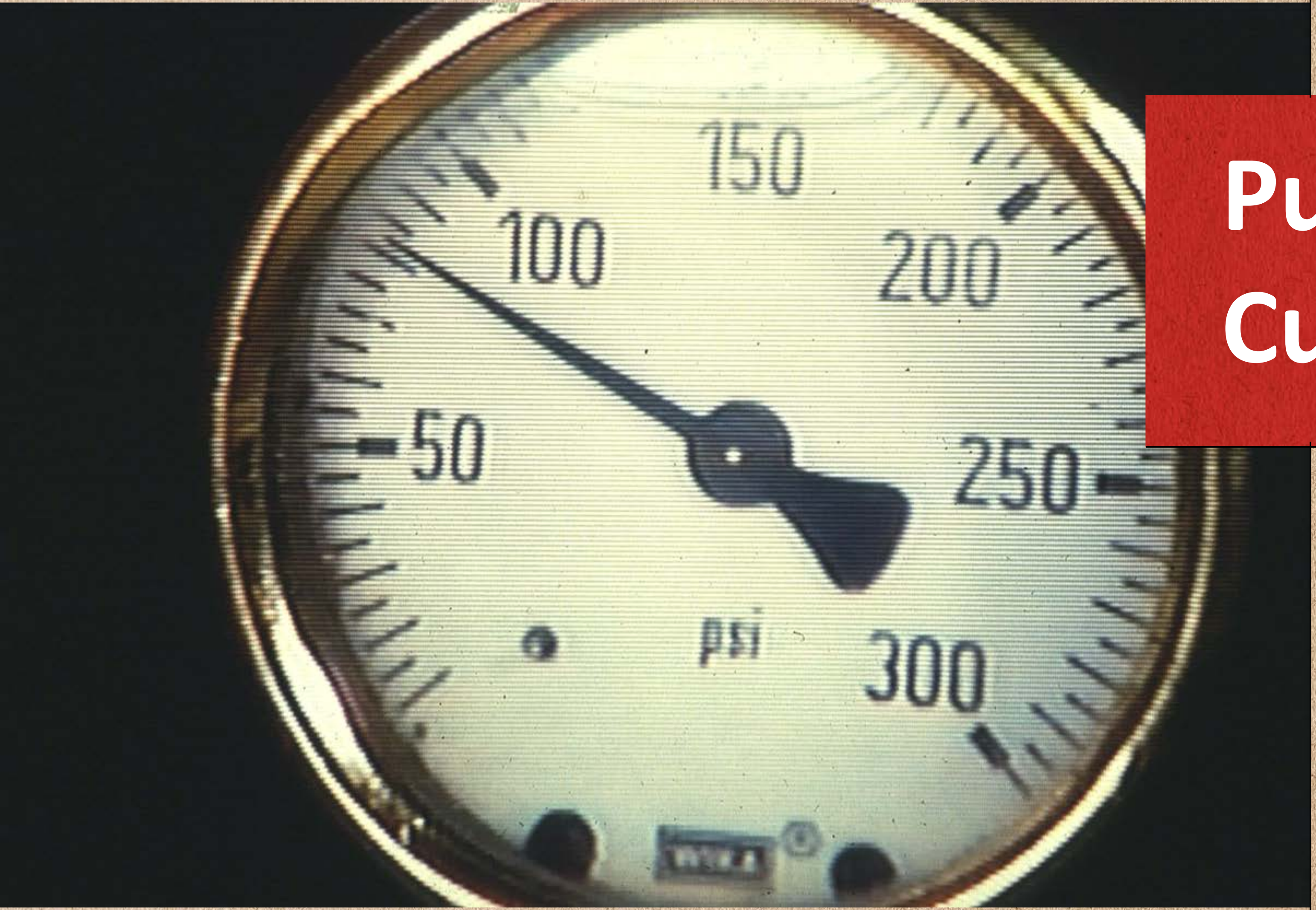
- A leaking pump cut off can cause
  - Odors
  - Soot
  - Noise on start
  - Loss of prime
  - After drip / accumulation of oil in the combustion area

Pump Pressure Cut-off Test

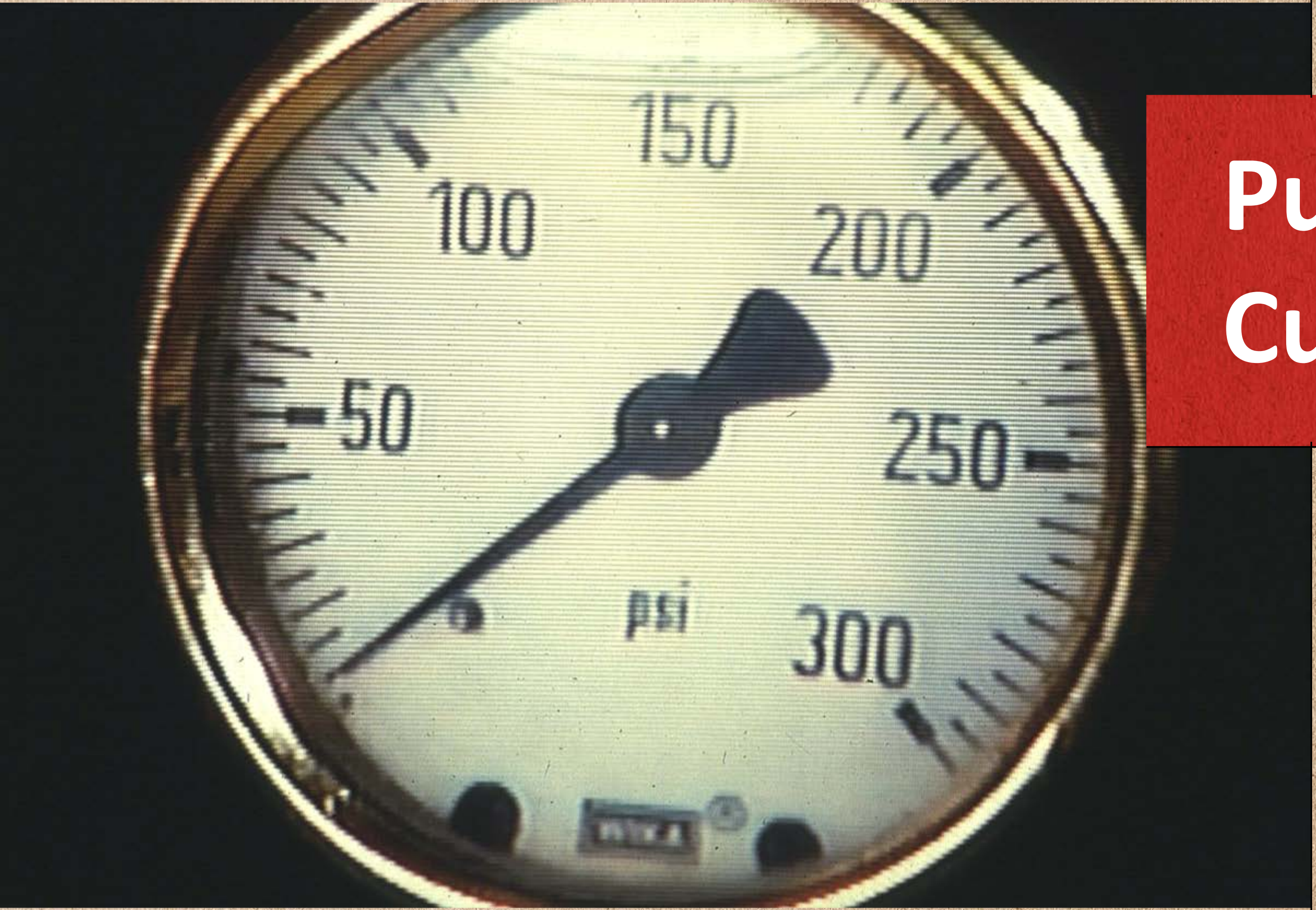




Pump Pressure Cut-off Test

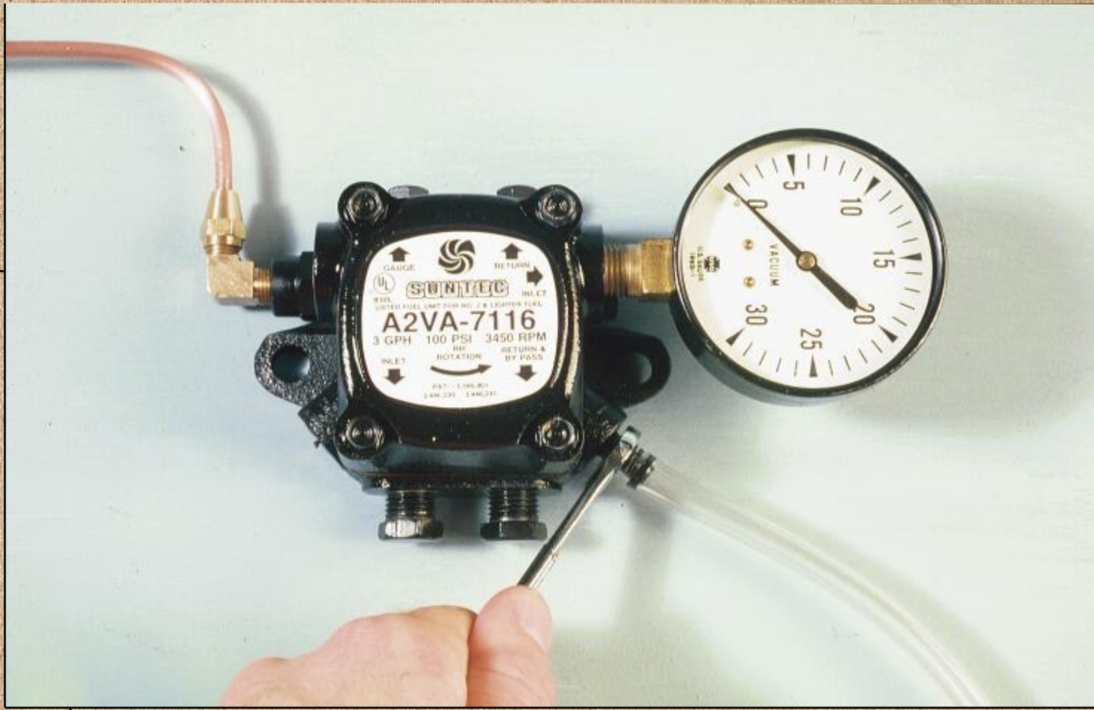


Pump Pressure Cut-off Test



Pump Pressure Cut-off Test

Priming the pump

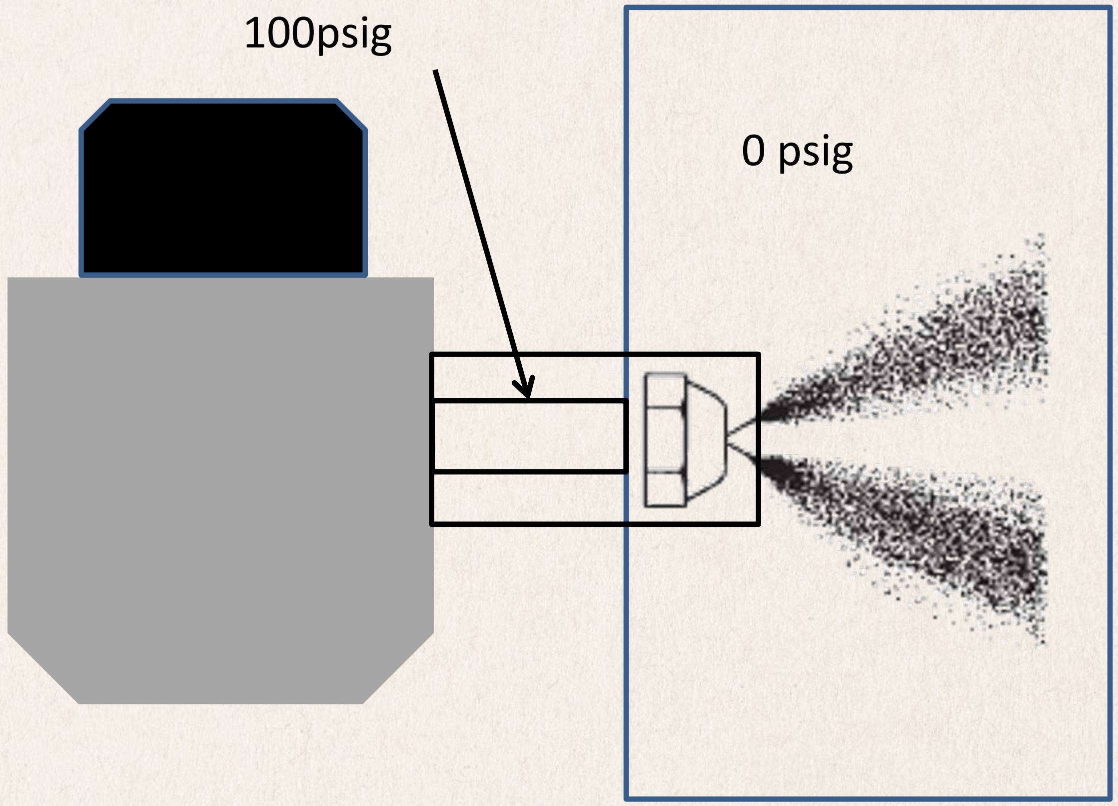


- Ready yourself for priming:
  - Install a clear plastic tube over the bleeder
  - Run the tube to a container with oil
  - Initiate a call for heat
  - Open the bleeder with a 3/8” open end wrench
  - Bleed until the oil runs clear, free of foam or bubbles
  - Close bleeder and check for leaks

No Teflon Tape / Compression Fittings

Use Good Flare Joints!

Atomization



- Fuel leaves nozzle at 100 PSIG
- Firebox area is 0 PSIG
- Fuel atomizes after liquid sheet due to pressure drop

NOZZLE CAPACITIES					
U.S. Gallons per Hour No. 2 Fuel Oil					
Rate GPH @ 100 psi	OPERATING PRESSURE: pounds per square inch				
	125 psi	140 psi	150 psi	175 psi	200 psi
0.40	0.45	0.47	0.49	0.53	0.56
0.50	0.56	0.59	0.61	0.66	0.71
0.60	0.67	0.71	0.74	0.79	0.85
0.65	0.73	0.77	0.80	0.86	0.92
0.75	0.84	0.89	0.92	0.99	1.06
0.85	0.95	1.01	1.04	1.13	1.20
0.90	1.01	1.07	1.10	1.19	1.27
1.00	1.12	1.18	1.23	1.32	1.41
1.10	1.23	1.30	1.35	1.46	1.56
1.20	1.34	1.42	1.47	1.59	1.70
1.25	1.39	1.48	1.53	1.65	1.77
1.35	1.51	1.60	1.65	1.79	1.91
1.50	1.68	1.77	1.84	1.98	2.12
1.65	1.84	1.95	2.02	2.18	2.33
1.75	1.96	2.07	2.14	2.32	2.48
2.00	2.24	2.37	2.45	2.65	2.83
2.25	2.52	2.66	2.76	2.98	3.18

Remember pump pressure

- Nozzles are rated at 100 psi.
- If you change the pressure the input rating changes
- Do not exceed the appliance rating!
- Consult a pressure chart when changing pressure

Using the Chart

NOZZLE CAPACITIES					
U.S. Gallons per Hour No. 2 Fuel Oil					
Rate GPH @ 100 psi	OPERATING PRESSURE: pounds per square inch				
	125 psi	140 psi	150 psi	175 psi	200 psi
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0.50	0.56	0.59	0.61	0.66	0.71
0.60	0.67	0.71	0.74	0.79	0.85
0.65	0.73	0.77	0.80	0.86	0.92
0.75	0.84	0.89	0.92	0.99	1.06
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2.00	2.24	2.37	2.45	2.65	2.83
2.25	2.52	2.66	2.76	2.98	3.18

- The appliance is rated for 1.00 GPH input. Presently the burner has a 0.85 nozzle at 140 psi.
- Cold oil is affecting light off. You want to increase pump pressure for better atomization.
- Check rating of pump. Is it rated to 200 psi for this input?
- Continue if so.

Using the Chart

NOZZLE CAPACITIES					
U.S. Gallons per Hour No. 2 Fuel Oil					
Rate GPH @ 100 psi	OPERATING PRESSURE: pounds per square inch				
	125 psi	140 psi	150 psi	175 psi	200 psi
0.40	0.45	0.47	0.49	0.53	0.56
0.50	0.56	0.59	0.61	0.66	0.71
0.60	0.67	0.71	0.74	0.79	0.85
0.65	0.73	0.77	0.80	0.86	0.92
0.75	0.84	0.89	0.92	0.99	1.06
0.85	0.95	1.01	1.04	1.13	1.20
0.90	1.01	1.07	1.10	1.19	1.27
1.00	1.12	1.18	1.23	1.32	1.41
1.10	1.23	1.30	1.35	1.46	1.56
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1.65	1.84	1.95	2.02	2.18	2.33
1.75	1.96	2.07	2.14	2.32	2.48
2.00	2.24	2.37	2.45	2.65	2.83
2.25	2.52	2.66	2.76	2.98	3.18

- Presently the burner has a 0.85 nozzle at 140 psi.
- Pick a pressure, let's say 175 psi for this example.
- Go to the 175 psi column. Find an input that is close to 1.00 GPH.
- Follow the row to the left column.
- That is the size nozzle at that pump pressure.
- Use the same pattern and angle.
- What happens when it warms up?
- The burner lights easier and may sound quieter.

It’s your turn.

What other questions do you have?

CLICK HERE TO ASK THE EXPERTS

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