Heating Basics – Gas Valve Systems

UNI-LINE® PRODUCT KNOWLEDGE
Subjects We Will Cover In This Session

- Choosing the Right Gas Valve
- Fuel and Pressure Characteristics
- NFPA 54 National Fuel Gas Code
- Gas Valve Applications
- Gas Valve Actuator Types
- Gas Valve Characteristics
- Gas Valve Manufacturers
- Ignition Control System
- Ignition Manufacturers
- Flame Rectification
- Pilot Basics
- Thermocouple and Thermopile Basics
- Installation and Troubleshooting Tips
- Website Tools
- When You Have Questions
- Q&A
Choosing the Right Gas Valve

• **Trusted Brand** – Dependable and reliable with a history of innovative products.

• **Universal Products** – The right product for the job. Simplifies inventory. Assured compatibility.

• **Availability** – Where you need it, when you need it.

• **Quality** – Works right the first time.

• **Contractor Friendly** – Simple set-up and installation. Saves time & money. Eliminates second guessing.

• **Support** – Sales and technical support for all your needs.

• **Innovative** – Leading technology for maximum performance.

Simply the Right Choice™
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTU</td>
<td>British Thermal Units</td>
</tr>
<tr>
<td>LC</td>
<td>Low Capacity</td>
</tr>
<tr>
<td>LP</td>
<td>Liquid Propane</td>
</tr>
<tr>
<td>MV</td>
<td>Main Valve</td>
</tr>
<tr>
<td>NAT</td>
<td>Natural Gas</td>
</tr>
<tr>
<td>PD</td>
<td>Pressure Drop</td>
</tr>
<tr>
<td>PV</td>
<td>Pilot Valve</td>
</tr>
<tr>
<td>SLC</td>
<td>Snap-action Low Capacity</td>
</tr>
<tr>
<td>mV</td>
<td>milliVolts</td>
</tr>
<tr>
<td>WC</td>
<td>Water Column</td>
</tr>
</tbody>
</table>
## Fuel Characteristics

<table>
<thead>
<tr>
<th>Natural Gas</th>
<th>Characteristics</th>
<th>Liquid Propane (LP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.64</td>
<td>Specific Gravity</td>
<td>1.53</td>
</tr>
<tr>
<td>1000</td>
<td>BTUs / Cubic Feet</td>
<td>2500</td>
</tr>
<tr>
<td>7”WC – 10.5”WC</td>
<td>Service Pressure Range</td>
<td>11”WC – 14”WC</td>
</tr>
<tr>
<td>1200º F</td>
<td>Ignition Temperature</td>
<td>950º F</td>
</tr>
<tr>
<td>10/1</td>
<td>Combustion Air/Gas Ratio</td>
<td>24/1</td>
</tr>
</tbody>
</table>

- Natural gas is lighter than air and rises
- L.P. gas is heavier and *puddles* in the lowest area it can find
Fuel Characteristics of British Thermal Units

- Definition of BTU: The quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit
- Many gas appliances are rated depending on BTU output
- The more heat needed, the higher the BTU rating
- Residential gas water heaters (regardless of fuel) are rated between 15,000 and 75,000 BTU
- Over 75,000 BTU is considered Commercial Water Heater
- Commercial Water Heaters rated between 75,000 and 750,000 BTU
Pressure Characteristics

<table>
<thead>
<tr>
<th>Pressure Side</th>
<th>Natural Gas</th>
<th>Liquid Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet Pressure</td>
<td>7” – 10” WC</td>
<td>14” – 17” WC</td>
</tr>
<tr>
<td>Outlet Pressure</td>
<td>3” – 4” WC @ 1” PD</td>
<td>10” – 11” WC @ 1” PD</td>
</tr>
</tbody>
</table>

- Excessive inlet pressure will not necessarily cause the gas valve to lock up
  - However, the valve will not regulate pressure correctly
- Gas line pressure from utilities vary seasonally with demand
  - During peak usage, inlet pressure can drop below the 7” WC Natural gas shown above
- High rise buildings may experience low pressure on upper floors
  - Especially during cold weather, many times a 2 psig system is used to compensate
- In some instances OEMs will specify higher outlet pressures
  - To obtain BTU rates beyond the capabilities of the gas valve at 1” pressure drop
NFPA 54 National Fuel Gas Code

- Issued initially in 1974, reviewed June 2008 version
- Gas code based on requirements from:
  - American Gas Association
  - American National Standard Installation of Gas Appliances and Gas Piping
    - (ANSI Z21.30)
  - Installation of Gas Piping and Gas Equipment on Industrial Premises
    - (ANSI Z83.1)
  - Fuel Gas Piping
    - (ASME B31.2)
- More information can be obtained from www.nfpa.org
Table 5.4.2.1 Approximate Gas Input for Typical Appliances

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Input Btu/hr (Approx)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Space Heating Units</strong></td>
<td></td>
</tr>
<tr>
<td>Warm air furnace</td>
<td></td>
</tr>
<tr>
<td>Single family</td>
<td>100,000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>60,000</td>
</tr>
<tr>
<td>Hydronic boiler</td>
<td></td>
</tr>
<tr>
<td>Single family</td>
<td>100,000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>60,000</td>
</tr>
<tr>
<td><strong>Space and Water Heating Units</strong></td>
<td></td>
</tr>
<tr>
<td>Hydronic boiler</td>
<td></td>
</tr>
<tr>
<td>Single family</td>
<td>120,000</td>
</tr>
<tr>
<td>Multifamily, per unit</td>
<td>75,000</td>
</tr>
<tr>
<td><strong>Water Heating Appliances</strong></td>
<td></td>
</tr>
<tr>
<td>Water heater, automatic storage</td>
<td></td>
</tr>
<tr>
<td>50 gal to 40 gal tank</td>
<td>35,000</td>
</tr>
<tr>
<td>Water heater, automatic storage</td>
<td></td>
</tr>
<tr>
<td>50 gal tank</td>
<td>50,000</td>
</tr>
<tr>
<td>Water heater, automatic</td>
<td></td>
</tr>
<tr>
<td>instantaneous</td>
<td></td>
</tr>
<tr>
<td>Capacity at 2 gal/min</td>
<td>142,800</td>
</tr>
<tr>
<td>Capacity at 4 gal/min</td>
<td>285,000</td>
</tr>
<tr>
<td>Capacity at 6 gal/min</td>
<td>428,400</td>
</tr>
<tr>
<td>Water heater, domestic,</td>
<td></td>
</tr>
<tr>
<td>circulating or side-arm</td>
<td>35,000</td>
</tr>
<tr>
<td><strong>Cooking Appliances</strong></td>
<td></td>
</tr>
<tr>
<td>Range, freestanding, domestic</td>
<td>65,000</td>
</tr>
<tr>
<td>Built-in oven or broiler unit,</td>
<td></td>
</tr>
<tr>
<td>domestic</td>
<td>25,000</td>
</tr>
<tr>
<td>Built-in top unit, domestic</td>
<td>40,000</td>
</tr>
<tr>
<td><strong>Other Appliances</strong></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>3,000</td>
</tr>
<tr>
<td>Clothes dryer, Type 1 (domestic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>35,000</td>
</tr>
<tr>
<td>Gas fireplace direct vent</td>
<td>40,000</td>
</tr>
<tr>
<td>Gas log</td>
<td>80,000</td>
</tr>
<tr>
<td>Barbecue</td>
<td>40,000</td>
</tr>
<tr>
<td>Gas light</td>
<td>2,500</td>
</tr>
</tbody>
</table>

For SI units, 1000 Btu/hr = 0.293 W.
# Central Heating Applications

<table>
<thead>
<tr>
<th>Factory Model (Uni-Line® Part)</th>
<th>BTU @ 1” PD</th>
<th>Min - Max BTU Capacity</th>
<th>Standing</th>
<th>Intermittent</th>
<th>Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7000 STD</strong> (Uni-Line 700)</td>
<td>Nat 300,000</td>
<td>10,000 – 720,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>LP 485,000</td>
<td>10,000 – 900,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>7000 HC</strong> (Uni-Line 700)</td>
<td>Nat 600,000</td>
<td>200,000 – 800,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>LP 972,000</td>
<td>300,000–1,150,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>7200</strong> (Uni-Line 720)</td>
<td>Nat 150,000</td>
<td>15,000 – 200,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>LP 240,000</td>
<td>15,000 – 320,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
### Space Heating And Hearth Applications

<table>
<thead>
<tr>
<th>Factory Model</th>
<th>BTU @ 1&quot; PD</th>
<th>Min - Max BTU Capacity</th>
<th>Standing</th>
<th>Intermittent</th>
<th>Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7000 STD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Uni-Line 700)</td>
<td>Nat 300,000</td>
<td>10,000 – 720,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>LP 485,000</td>
<td>10,000 – 900,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>7200</strong></td>
<td>Nat 150,000</td>
<td>15,000 – 200,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Uni-Line 720)</td>
<td>LP 240,000</td>
<td>15,000 – 320,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>2000</strong></td>
<td>Nat 125,000</td>
<td>25,000 – 170,000</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Uni-Line 722)</td>
<td>LP 200,000</td>
<td>25,000 – 272,000</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>7500</strong></td>
<td>Nat 100,000</td>
<td>6,700 – 160,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>(Uni-Line 722)</td>
<td>LP 162,000</td>
<td>6,700 – 226,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td><strong>7000 LC</strong></td>
<td>Nat 40,000</td>
<td>5,000 – 70,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>(Uni-Line 710)</td>
<td>LP 65,000</td>
<td>5,000 – 100,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td><strong>7000 ST</strong></td>
<td>Nat 100,000</td>
<td>10,000 – 160,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>(Uni-Line 700)</td>
<td>LP 162,000</td>
<td>10,000 – 225,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
</tr>
</tbody>
</table>
# Commercial Water Heating Applications

<table>
<thead>
<tr>
<th>Factory Model</th>
<th>BTU @ 1” PD</th>
<th>Min - Max BTU Capacity</th>
<th>Standing</th>
<th>Intermittent</th>
<th>Direct</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7000 STD</strong></td>
<td>Nat 300,000</td>
<td>10,000 – 720,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Uni-Line 700)</td>
<td>LP 485,000</td>
<td>10,000 – 900,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>7200</strong></td>
<td>Nat 150,000</td>
<td>15,000 – 200,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Uni-Line 720)</td>
<td>LP 240,000</td>
<td>15,000 – 320,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>7000 HC</strong></td>
<td>Nat 125,000</td>
<td>25,000 – 170,000</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Uni-Line 722)</td>
<td>LP 200,000</td>
<td>25,000 – 272,000</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>7000 HC</strong></td>
<td>Nat 600,000</td>
<td>200,000 – 800,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>(Uni-Line 700)</td>
<td>LP 972,000</td>
<td>300,000 – 1,150,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
# Commercial Cooking Applications

<table>
<thead>
<tr>
<th>Factory Model</th>
<th>BTU @ 1&quot; PD</th>
<th>Min - Max BTU Capacity</th>
<th>Standing</th>
<th>Intermittent</th>
<th>Direct</th>
<th>Temp Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>7000 STD</td>
<td>Nat 300,000</td>
<td>10,000 – 720,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-40 to 175°F</td>
</tr>
<tr>
<td>(Uni-Line 700)</td>
<td>LP 485,000</td>
<td>10,000 – 900,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>7200</td>
<td>Nat 150,000</td>
<td>15,000 – 200,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-40 to 175°F</td>
</tr>
<tr>
<td>(Uni-Line 720)</td>
<td>LP 240,000</td>
<td>15,000 – 320,000</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>Nat 125,000</td>
<td>25,000 – 170,000</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>-40 to 175°F</td>
</tr>
<tr>
<td>(Uni-Line 722)</td>
<td>LP 200,000</td>
<td>25,000 – 272,000</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>7500</td>
<td>Nat 100,000</td>
<td>6,700 – 160,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>0 to 185°F</td>
</tr>
<tr>
<td>(Uni-Line 722)</td>
<td>LP 162,000</td>
<td>12,000 – 226,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>7000 LC</td>
<td>Nat 40,000</td>
<td>5,000 – 70,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>-40 to 225°F</td>
</tr>
<tr>
<td>(Uni-Line 710)</td>
<td>LP 65,000</td>
<td>5,000 – 100,000</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>TS11 J &amp; K</td>
<td>Nat 210,000</td>
<td>NA</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>32 to 300°F</td>
</tr>
<tr>
<td>(Uni-Line 700)</td>
<td>LP 340,000</td>
<td>NA</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
</tbody>
</table>
## Residential Water Heating Applications

<table>
<thead>
<tr>
<th>Factory Model</th>
<th>BTU @ 1” PD</th>
<th>Min - Max BTU Capacity</th>
<th>Standing</th>
<th>Intermittent</th>
<th>Direct</th>
<th>Temp Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>2200K (Uni-Line 110)</td>
<td>Nat 86,000</td>
<td>10,700 – 107,000</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td>32 to 175ºF</td>
</tr>
<tr>
<td></td>
<td>LP 100,000</td>
<td>7,000 – 140,000</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>R103RV (Uni-Line 110)</td>
<td>Nat NA</td>
<td>NA</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td>32 to 175ºF</td>
</tr>
<tr>
<td></td>
<td>LP &gt; 35,000</td>
<td>3,500 – 35,000</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>2000 (Uni-Line 722)</td>
<td>Nat 125,000</td>
<td>25,000 – 170,000</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
<td>-40 to 175ºF</td>
</tr>
<tr>
<td></td>
<td>LP 200,000</td>
<td>25,000 – 272,000</td>
<td>✗</td>
<td>✔️</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>R110R (Uni-Line 110)</td>
<td>Nat 86,000</td>
<td>10,700 – 107,000</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td>32 to 175ºF</td>
</tr>
<tr>
<td></td>
<td>LP 100,000</td>
<td>7,000 – 140,000</td>
<td>✔️</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
</tbody>
</table>
Gas Valve Actuator Types

- **Manual** – Standing pilot valve manually turned ON and OFF for each heating cycle.

- **Millivolt** – Wall thermostat actuated with manual gas cock, automatic pilot safety valve and a Millivolt operator. The automatic pilot safety is separate from gas cock and provides shutoff in case of pilot outage. Millivolt gas valves do not require external power source.

- **24 Volt, 120 Volt, and 240 Volt** – Combines a manual main and pilot gas valve, a separate automatic safety pilot valve, pilot filtration, and automatic electric valve.

- **Hydraulic** – Temperature is sensed by a capillary bulb. The bulb in the return air stream is actuated open and close by the hydraulic system.
Millivolt Actuated Gas Valve

Wall Thermostat

ECO (Limit)

Pilot and Thermopile

Gas Cock

Safety

Operator

Pilot Line ⇒

Operator

Pilot Line ⇒

Gas Cock

Safety
Robertshaw® 700 & 710 Millivolt Wiring

1950 Series Two-Lead Thermopile

1951 Series Coaxial Thermopile

Safety Magnet
24 Volt Actuated – Standing Pilot System

Most popular Uni-Line® part is 710-402, Factory Part 7000-ERLC
Hydraulic Actuated – Standing Pilot System

- Gas Cock
- Pilot and Thermocouple
- ECO (Limit)
- Safety
- Temperature Control Knob
- Sensing Bulb

Temperature Setting:
- 56°F LO 1 2 3 4 5 6 7 8 HI 90°F
Additional Gas Valve Characteristics

- Combination Gas Valves
- Open Valve Options
  - Standard Opening
  - Slow Opening
  - Step Opening
  - Two-stage Models
- Close Valve Options
  - Snap Action
  - Snap Throttle
Combination Gas Valves

Combination valves include three components

- Regulation
- Safety valve
- Main valve actuated by thermostat or bulb
Additional Gas Valve Characteristics

Robertshaw® Gas Valve Opening Characteristics

**OPENING CHARACTERISTICS**

**STANDARD OPEN**
- instant full flow

**SLOW OPEN**
- S7A = 0 - 5 sec. to full flow
- S7B = 5 - 10 sec. to full flow
- S7C = 10 - 30 sec. to full flow

**STEP OPEN**
- SO1 = 30% of full flow
- SO2 = 40% of full flow
- SO3 = 50% of full flow
- SO4 = 60% of full flow
- SO5 = 70% of full flow
Additional Characteristics for Two-Stage

- Robertshaw® two-stage gas valves use a two-stage, two-pressure regulator which responds to a two-stage controller (thermostat)
- Available in capacities from 29,000 to 960,000 BTU/Hr
- Piping sizes from 3/8 to 1 inch
- Can be used with either natural gas or liquid propane
- Two-stage has ability to vary gas pressure delivered to main burner(s) through use of solenoid operated two-pressure regulator
- First stage actuator of the gas valve is energized
- When heat demand increases, second stage regulator is energized
- First stage setting is determined as a percentage of the full output of the valve and is factory set
- Second stage pressure regulator setting is nominal 3.5” WC for natural gas and 11” for LP
Snap-Action And Snap-Throttle Hydraulic Valves

HYDRAULIC 700-202

HYDRAULIC WITH REMOTE DIAL 700-208

HYDRAULIC 710-205
## Gas Valve Manufacturers

<table>
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<tr>
<th>Attributes</th>
<th>Robertshaw®</th>
<th>Honeywell</th>
<th>White-Rodgers</th>
<th>Dexen</th>
<th>SIT</th>
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<td>US Based Engineering</td>
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<td>US Based Technical Services</td>
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<td>Hearth Products</td>
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<tr>
<td>Pilot, Thermocouple and Ignition Controls</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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Ignition Control Systems

- Standing Pilot
- Intermittent Pilot Ignition (IPI)
- Direct Spark Ignition (DSI)
- Hot Surface Ignition (HSI)
Ignition Systems

Three Types of Ignition Systems

• Standing pilot – Pilot is manually ignited and stays on constantly. When the thermostat calls for heat, and the pilot flame is making good contact with the thermocouple, the gas valve allows gas to flow to main burner until the call for heat is satisfied. **Least expensive, least efficient.**

• Intermittent pilot (also known as “spark to pilot”) – Pilot is ignited by a spark generated by an ignition module and electrode. When enough heat is generated in the thermocouple, the gas valve allows gas to the main burner and is ignited by the pilot until the call for heat is satisfied. **More expensive, more efficient.**

• Direct spark and Hot Surface Ignition (HSI) – When the thermostat calls for heat, the main burner is ignited by a direct spark or ceramic (glow bar) igniter. Eliminates the pilot, but requires flame sensor and more expensive ignition module. **Most expensive, most efficient.**
Feature List for Ignition Controls

• Approvals
  – CSA
  – UL

• Ease of Use
  – Local vs. Remote Sensing
  • Some use Jumper
  – Diagnostic LEDs

• Application Timings
  – Trial Attempts (1, 3, infinite)
  – Ignition Timing (seconds)
  – Pre/post/inter-purge settings

• Physical
  – 24V AC @ 50 / 60 Hz
  – Surface Mount Technology (SMT)
  – Conformal coating
  – Installable in NEMA-3R boxes
  – Quick connects or plugs

• Safety
  – Hard Lockout
  – Auto-Restart Lockout
  • Eliminates service calls
Acronyms

GRD = Ground
IGN = Ignition
LP = Liquid Propane
MV = Main Valve
NO = Normally Open
NC = Normally Closed
PV = Pilot Valve
V AC = Voltage Alternating Current
V DC = Voltage Direct Current
Definitions

- **Sensors** - Senses the variable change in temperature and sends a signal to the controller.
- **Transmitters** - Interprets signal from sensor to display condition of temperature variable.
- **Transformer** - An electromagnetic device that either raises or lowers the voltage of an alternating current electrical system.
- **Voltage** - The electrical potential pressure behind the flow of electricity, measured in terms of Volts.
- **Current** - The movement of an electrical charge through a circuit, measured in terms of Amps.
- **Hertz** - A unit of measurement for frequency in cycles per second of a waveform.
- **Relay** - An electromechanical device that opens or closes contacts when a current is passed through a coil.
Gases Used In Applications

- Liquid Propane tends to hover at ground level
- Natural Gas rises, goes up the flue
- Manometer measures gas pressure
  - Inches of Water Column
1. Thermostat calls for heat
2. Ignition controller requests a spark to the electrode which ignites the gas
3. Control uses flame rectification or sensor to identify if flame is present
4. Ignition controller sends signal to open gas valve
5. When thermostat is satisfied, gas valve closes to shut off main burner gas
Pilot Ignition System

Valve Operator Terminals
M C P

Transformer
24 VAC
120 VAC

Fan Control NO

High Limit NC

Ignition Control Module

Pilot Line ⇒

Pilot and Electrode / Sensor

Fan Motor
Intermittent Pilot Checkout Procedure

- Turn on main gas supply
- Turn on manual gas valve
- Turn on electrical power
- Set thermostat to call for heat, spark begins
- Air purged from gas line
- Pilot Ignition - main burner ignition
- Turn manual gas valve off - burner & pilot go out
- Sparking begins - turn manual valve on
- Pilot ignites - main burner ignites
Intermittent Pilot Sequence of Operation

- Thermostat calls for heat
- Primary Valve (PV) opens
- Pilot gas flows
- Sparking begins at burner
- Pilot gas ignites
- Pilot flame impinges on electrode / sensor
- Main gas valve (MV) opens
- Main burner ignites
- Once thermostat satisfied, switch contacts open
- Main burner and pilot off
Hot Surface Ignition System

Gas Valve

Ignition Control

Hot Surface Ignitor
Hot Surface Terminology

- **Pre-Purge Cycle** - Allows draft blower to purge the combustion chamber prior to start of equipment.

- **Ignition Attempts** - Number of times the system will attempt to light the ignition if a flame is not detected. After last try, unit goes into lockout.

- **Valve Trial Time or Lockout Timing** - Number of seconds the main valve is left open for ignition. If flame is not detected in a specified time:
  1. The unit goes into lockout if it is a single try for ignition control or
  2. The unit sequences to next ignition attempt cycle if it is a multi-try.

- **Sensor Type** - The presence of a flame can be detected two ways:
  1. Local Sense, using a Hot Surface Ignitor to ignite the gas and detect the presence of a flame.
  2. Remote Sense, using a sense rod that impinges into the main burner flame.

- **Ignitor Warm-Up Time** - Time required for hot surface ignitor to come up to operating temperature. An induced draft blower may also come on during this time period to purge the combustion chamber prior to the main valve opening.
Hot Surface Control Nomenclature

HOT SURFACE IGNITION

HS-780 - 34 - P - L/3 - 08 - A - X - X
R = REMOTE LOCKOUT CONNECTOR
M = MANUAL RESET
A = 120VAC MODULE SUPPLY VOLTAGE
B = 208/240VAC MODULE SUPPLY VOLTAGE
C = 277VAC MODULE SUPPLY VOLTAGE
A = 24VOLT MODULE SUPPLY VOLTAGE
04 = 4 SECOND VALVE TRIAL TIME
06 = 6 SECOND VALVE TRIAL TIME
08 = 8 SECOND VALVE TRIAL TIME
12 = 12 SECOND VALVE TRIAL TIME
1 = SINGLE IGNITION ATTEMPT, THEN LOCKOUT
2 = 2 SINGLE ATTEMPTS, THEN LOCKOUT
3 = 3 IGNITION ATTEMPTS, THEN LOCKOUT
L = LOCAL FLAME SENSE USING IGNITOR
R = REMOTE FLAME SENSE USING SEPARATE SENSING ROD
N = NON PRE-PURGE (IMMEDIATE IGNITION CYCLE)
P = PRE-PURGE CYCLE PRIOR TO IGNITION CYCLE
17 = 17 SECOND PRE-PURGE/IGNITOR WARM-UP TIME
34 = 34 SECOND PRE-PURGE/IGNITOR WARM-UP TIME
HS-780 = BASIC SIMICON HOT SURFACE IGNITION CONTROL
Hot Surface Sequence of Operation

- Thermostat calls for heat, 24 Volts to ignition module
- Combustion blower & other relays are energized
- Non-purge modules - Ignition is powered in 1 second
- Pre-purge modules - Ignition powered in 17 or 34 seconds
- Ignitor heats to approximately 2500 degrees Fahrenheit
- After heat up, valve is activated allowing gas to flow to burner
- Ignitor shuts off at end of trial time and becomes the sensor
- If flame not sensed during trial time, the system shuts down
- If flame is sensed, system runs to satisfy thermostat demand
Manufacturers

- Johnson Controls®
- White-Rodgers®
- Honeywell®
- RAM
- Fenwal®
- Robertshaw®
Flame Rectification

Used On:
- IPI Intermittent Pilot Ignition
- DSI Direct Spark Ignition
- HSI Hot Surface Ignition

How it Works:
- Rectifies AC Current into DC
- Requires flame to ground
- Proves pilot or burner ignition
Flame Rectification Pilot Ignitions

UNI-LINE 712 SERIES FLAME RECTIFICATION PILOT IGNITION SYSTEMS

ELECTRODE  SENSOR
Hot Surface Igniters

- Hot Surface Igniter Types
  - Silicon Nitride
  - Silicon Carbide (fragile)

- Robertshaw® 41-400 Series
  - Silicon Carbide
  - Uni-Line® Catalog Page 121

- Robertshaw® 41-400N Series
  - Silicon Nitride

- Robertshaw universal 41-800 Series
  - Comes as kit with brackets and screws
Ignitor Position

**POSITIONING OF IGNITOR**

NO

YES

NO

IGNITOR SHOULD EXTEND INTO FLAME AS SHOWN IN CENTER EXAMPLE.

With an ohmmeter, check resistance of the ignitor. It should be approximately 60-70 ohms at room temperature. (Resistance readings will lower if the ignitor is warm. High resistance readings indicate possible damage of the ignitor.)
Pilot Basics

TYPICAL PILOT ASSEMBLY

- Hood
- Thermocouple
- Mixing Tube
- Orifice
- Lock Fitting
- Nut
- Mounting Bracket
Pilot Parts

- Robertshaw® 1820 Series with *Left* or *Right* flame pattern type
- Pilot Uni-Kits® are *with* or *without thermopile* pre-mounted
Thermocouple Basics

Copper-Nickel Alloy

Insulated Copper Wire

Contact Button

Load (Safety Magnet)

“Hot” Junction

Copper-Iron Alloy

“Cold” Junction

Copper Sheath

Fitting Nut

Contact Button
Thermocouple Parts

- The **1980** series offers easy installation into most pilot burners
- Uses Snap-Fit® technology
- End of part number refers to various lengths:
  - 1980-012 is 12 inches
  - 1980-072 is 72 inches
Thermocouple Test

Open circuit 25 to 30 Millivolts

HOT JUNCTION

COLD JUNCTION

CONTACT BUTTON

MILLIVOLT METER

30 MV
Thermopile Basics

- **Hot Junctions**
- **Cold Junctions**

- **1950 Series Twin Lead Connector**

- **Load (Safety Magnet)**
- **Load (Gas Valve)**
Thermopile Family Applications

- The **1950** series thermopiles have two lead wire connections and are primarily used in HVAC
- The **1951** coaxial series used on Commercial Cooking
Gas Valve Installation Tips

Determine:

- Natural Gas or Liquid Propane
- Inlet and Outlet Size
- BTU Requirement
- Ignition Method to be Used
- Outlet Pressure Setting Requirement
- Ambient Temperature
- Orientation of Gas Valve
  - Valves should not to be mounted upside down
- Actuator Type: 24 Volts, Millivolt, Hydraulic, Line Voltage
- Opening Speed of Gas Valve
# Troubleshooting Tips for Gas Systems

<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible Cause</th>
<th>Possible Cure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flame Too Large</td>
<td>1. Outlet pressure too high</td>
<td>1. Outlet pressure too high</td>
</tr>
<tr>
<td></td>
<td>2. Defective regulator</td>
<td>2. Defective regulator</td>
</tr>
<tr>
<td></td>
<td>3. Orifice too large</td>
<td>3. Orifice too large</td>
</tr>
<tr>
<td>Noisy Flame</td>
<td>1. Excessive primary air</td>
<td>1. Adjust air shutter</td>
</tr>
<tr>
<td></td>
<td>2. Noisy Pilot</td>
<td>2. See Pilot Troubleshooting slide</td>
</tr>
<tr>
<td></td>
<td>3. Burr in orifice</td>
<td>3. Remove burr or replace orifice</td>
</tr>
<tr>
<td>Yellow Tip Flame</td>
<td>1. Too little primary air</td>
<td>1. Adjust air shutter</td>
</tr>
<tr>
<td></td>
<td>2. Clogged burner ports</td>
<td>2. Clean burner ports</td>
</tr>
<tr>
<td></td>
<td>3. Misaligned orifice</td>
<td>3. Realign orifice and burner</td>
</tr>
<tr>
<td>Floating Flame</td>
<td>1. Blocked venting</td>
<td>1. Inspect vent and clean</td>
</tr>
<tr>
<td></td>
<td>2. Insufficient primary air</td>
<td>2. Adjust air shutter</td>
</tr>
</tbody>
</table>
## Troubleshooting Tips for Gas Systems

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<thead>
<tr>
<th>Condition</th>
<th>Possible Cause</th>
<th>Possible Cure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delayed Ignition</strong></td>
<td>1. Improper ignition location</td>
<td>1. Reposition ignition source</td>
</tr>
<tr>
<td></td>
<td>2. Pilot flame too small</td>
<td>2. Check orifice and clean</td>
</tr>
<tr>
<td></td>
<td>4. Low outlet pressure</td>
<td>4. Adjust pressure regulator</td>
</tr>
<tr>
<td><strong>Failure to Ignite</strong></td>
<td>1. Main gas “Off”</td>
<td>1. Open manual valve</td>
</tr>
<tr>
<td></td>
<td>2. Poor electrical connections</td>
<td>2. Check, clean, &amp; tighten</td>
</tr>
<tr>
<td></td>
<td>3. Defective gas valve</td>
<td>3. Replace with new</td>
</tr>
<tr>
<td></td>
<td>4. Defective thermostat</td>
<td>4. Replace with new</td>
</tr>
<tr>
<td><strong>Burner won’t turn “Off”</strong></td>
<td>1. Poor thermostat location</td>
<td>1. Relocate thermostat</td>
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<tr>
<td></td>
<td>2. Defective gas valve</td>
<td>2. Replace with new</td>
</tr>
<tr>
<td></td>
<td>3. Defective thermostat</td>
<td>3. Replace with new</td>
</tr>
<tr>
<td><strong>Rapid Burn Cycles</strong></td>
<td>1. Clogged furnace filters</td>
<td>1. Clean or replace</td>
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<td>2. Excess t-stat anticipation</td>
<td>2. Adjust t-stat anticipator</td>
</tr>
<tr>
<td></td>
<td>3. Poor thermostat location</td>
<td>3. Relocate thermostat</td>
</tr>
</tbody>
</table>

- When all else fails...
- Check to make sure gas supply is in the “ON” position
Questions To Ask When Selecting Ignition Control Modules

1. What are you heating? What is OEM Factory Number?
2. What is the supply voltage?
3. What is the control voltage?
4. Do you want to clear gas before, during, and/or after heating cycle?
5. How many trials for ignition would you like?
6. How many seconds between trials?
7. What style of heating (direct spark, hot surface, or intermittent pilot)?
8. Do you want remote or local sensing of flame (dual rod or single rod)?
9. How do you want to handle lockout? How long?
10. Do you want board enclosed or open?
11. What type of connectors do you want?
12. Do you need to change voltage levels, switch machines on or off, detect air pressure, replace parts, or need a kit?
Troubleshooting Tips

**Problem # 1: Hot Surface Igniter Does Not Glow Red**

**Possible Causes:**
- No main power
- Faulty Transformer
- Faulty Thermostat- check call for heat
- Faulty Limit Switch
- Faulty blower interlock switch
- Faulty hot surface igniter
- Faulty ignition control
- Remember to wait for purge time, 17 or 34 seconds

**Troubleshooting:**
- With power on and thermostat at its highest position, check voltage between “TH” and “TR” on HS780 module.
  - If 24 Volts is not present, check transformer output
  - If no 24 Volts present on secondary side, change transformer
- Check for 120 Volts at the igniter across “IGN” and “GND”
  - If voltage present, change igniter.
  - If no voltage present, change module.
Troubleshooting Tips

Problem # 2: Igniter Glows Red but Main Burner Will Not Light

Possible Causes:

- Improper Igniter or Sensor Alignment
- Faulty Ignition Control
- Faulty Gas Valve
- High Inlet Gas Pressures
- Polarity Reversed
- No Earth Ground

Troubleshooting:

- Check availability of gas at gas valve. Make sure valve upstream is in the Full On position. Check pressure ok.
- Check “GRD” and “PV/MV” by reversing wires
  - If reversed the gas valve will not open.
- Check proper ignition position and properly grounded
- Check for 24 Volts at gas valve terminals
  - “1” and “2” on a 7200 series, “TH” and “TR” on a 7000 series
  - If Yes, check wire resistance or change gas valve
  - If no, change the 780 series module
Troubleshooting Tips

Problem # 3: Main Burner Shuts Off before the Thermostat is Satisfied

Possible Causes:

- Improper Igniter or Sensor Alignment
- Faulty Ignition Control
- Contaminated Igniter and/or sensor
- Bad burner ground

Troubleshooting:

- Check polarity
- Check for proper igniter position
- Check for proper ignition control grounding
- Visually inspect igniter and remote sensor for any contamination.
  - Clean and replace
- Check main burner ground
- If above steps are ok, replace igniter
Troubleshooting Tips

Problem # 4: Main Burner Does Not Shut Off When Thermostat is Satisfied

Possible Causes:

• Faulty Gas Valve
• Faulty Ignition Control

Troubleshooting:

• Check thermostat to make sure contacts are open, check for 24 Volts between “TH” and “TR”.
  – Should be Zero, if gas valve is stuck open, replace valve
• Check for 24 Volts between “PV/MV” and “GND”.
  – If 24 Volts present, replace ignition control
  – If 24 Volts not present, replace gas valve
## Proper Pilot Flame

<table>
<thead>
<tr>
<th>Correct Flame</th>
<th>Wavy Blue Flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Tip of Thermocouple or Thermopile is 3/8&quot; to 1/2&quot; into pilot flame.</td>
<td>✓ Draft Condition at Pilot</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Noisy, Lifting, Blowing Flame</th>
<th>Hard Sharp Flame</th>
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</thead>
<tbody>
<tr>
<td>✓ High Gas Pressure</td>
<td>✓ High Gas Pressure</td>
</tr>
<tr>
<td>✓ Wrong Pilot Orifice</td>
<td>✓ Pilot Orifice Too Small</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Lazy Yellow Flame</th>
<th>Small Blue Flame</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Clogged Primary Air Opening</td>
<td>✓ Wrong Pilot Orifice Size</td>
</tr>
<tr>
<td>✓ Low Gas Pressure</td>
<td>✓ Low Gas Pressure</td>
</tr>
<tr>
<td>✓ Clogged Pilot Orifice</td>
<td>✓ Clogged Pilot Tube</td>
</tr>
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Access to Uni-Line® product data is easier than ever. Now you can quickly search for the information you need on HVAC, commercial refrigeration, appliance and thermostat products. Linked with literature, cross reference guides and FAQ Knowledge Database, you'll see the Uni-Line difference with just a few clicks.

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Cross reference

Enter part numbers

Click here for more information

See The Difference

Don't lose your cool!
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- Technical Service Fax 1-630-260-7294
- Customer Service 1-800-304-6563
- Customer Service Fax 1-800-426-0804

**Website:**
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- General Information Websites for:
  - Robertshaw®, Paragon®, Eliwell™, Ranco®, and Publication Zone®
  - [www.InvensysControls.com](http://www.InvensysControls.com)
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