Precision Temp PT-56 Gas-Fired Booster Heater Performance Tests

Application of ASTM Standard
Test Method F 2022-00

FSTC Report 5011.03.28

Food Service Technology Center
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Specific appreciation is extended Precision Temp Inc., for supplying the Food Service Technology Center with a gas-fired booster heater for controlled testing in the appliance laboratory.

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Executive Summary

Precision Temp's PT-56 booster heater is a gas-fired alternative to the traditional electric booster heater that supplies the sanitizing rinse to door-type dish machines. Water is heated by eight atmospheric burners with a total input of 55,000 Btu/h in a copper heat exchanger. All components are housed in a stainless steel enclosure. The booster heater is controlled by a microprocessor that regulates a recirculating pump and thermostat. Figure ES-1 illustrates the Precision Temp PT-56 gas-fired booster heater, as tested at the Food Service Technology Center (FSTC).

Figure ES-1. Precision Temp PT-56 gas-fired booster heater.

FSTC engineers tested the booster heater under the tightly controlled conditions of the American Society for Testing and Materials' (ASTM) standard test method.[1] Booster heater performance is characterized by preheat time and energy consumption, idle energy rate, energy efficiency, and flow rate.

Booster heater performance was determined by testing the unit under four conditions (maximum flow capacity with inlet water temperatures of 140°F and 110°F and 50% flow capacity with inlet water temperatures of 140°F and 110°F). The Precision Temp achieved 87% energy efficiency with a maximum flow capacity of 1.84 gal/min.

Energy efficiency is a measure of how much of the energy that a booster heater consumes is actually delivered to the water during the testing process. Booster heater energy efficiency is therefore defined by the following relationship:

$$\text{Energy Efficiency} = \frac{\text{Energy to Water}}{\text{Burner Energy} + \text{Pump/Control Energy}}$$

[1] American Society for Testing and Materials. 2000. *Standard Test Method for the Performance of Booster Heaters.* ASTM Designation F 2022-00, in *Annual Book of ASTM Standards*, Philadelphia.

A summary of the test results is presented in Table ES-1.

Table ES-1. Summary of Booster Heater Performance.

Rated Energy Input Rate (Btu/h)	55,000
Measured Energy Input Rate (Btu/h)	52,333
Tank Capacity (gal)	3.0
140°F Inlet Temperature [a]	
Preheat Time (min)	2.67
Preheat Energy (Btu)	1,891
Flow Rate (gal/h)	110.8 ± 4.7 [b]
Temperature Rise (°F)	45.7
Energy Efficiency (%)	86.5 ± 1.4 [b]
110°F Inlet Water Temperature [a]	
Preheat Time (min)	3.83
Preheat Energy (Btu)	2,902
Flow Rate (gal/h)	70.4 ± 2.2 [b]
Temperature Rise (°F)	74.5
Energy Efficiency (%)	87.6 ± 0.3 [b]
Idle Energy Rate (Btu/h)	1,082
Idle Electric Energy Rate (W)	158.7

[a] Efficiency and flow rate are from the maximum capacity tests.
[b] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

A booster heater's job is to raise the temperature of the water from the primary water heater to a minimum of 180°F to provide the sanitizing rinse for the dish machine. Since most primary building water heaters provide water at 140°F (restaurants) or 110°F (schools and institutions), the ASTM test method evaluates booster heater performance under both conditions. Figures ES-2 and ES-3 display the Precision Temp's ability to maintain a 180°F outlet temperature during the maximum flow capacity tests for both the inlet temperatures.

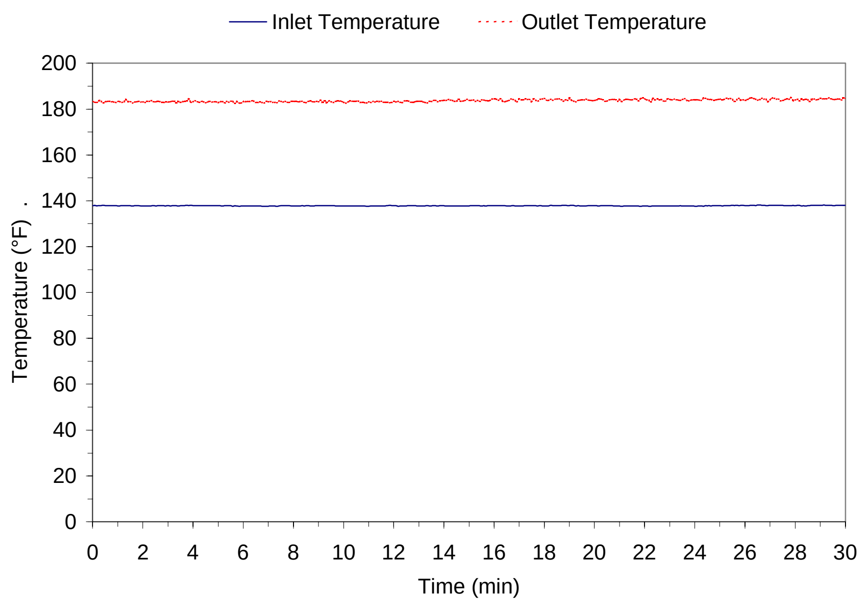

Figure ES-2.
140°F inlet water temperature during Max Capacity Test.

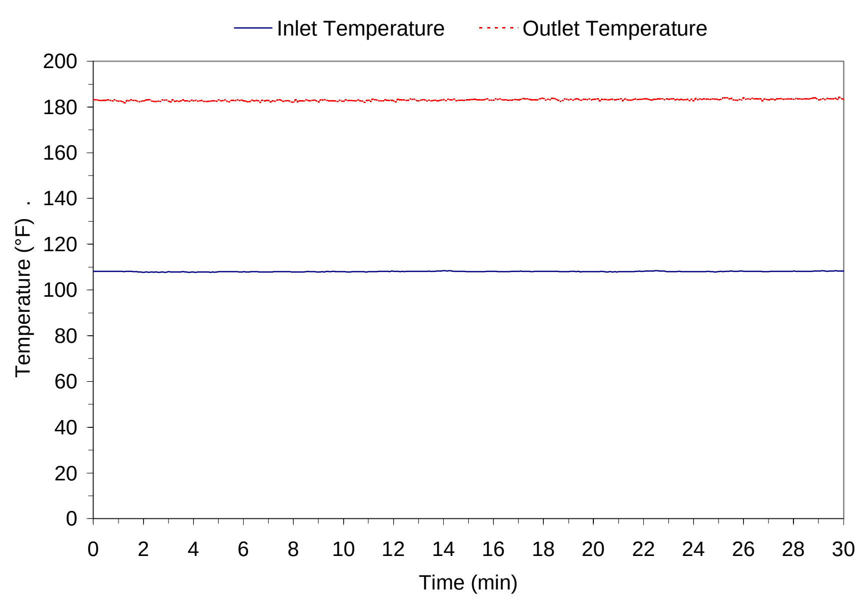

Figure ES-3.
110°F inlet water temperature during Max Capacity Test.

Executive Summary

Precision Temp achieved excellent energy efficiency and flow capacity results during testing at the Food Service Technology Center. With 86.5% energy efficiency and a flow capacity of 110 gal/h, the Precision Temp has established itself as a leader in small gas-fired booster heaters sized for single door-type dish machines. The PT-56 booster heater's high efficiency was complimented by a fairly low idle rate and a short 2.67 minute preheat from 140°F (3.83 minutes to preheat from 110°F). With its high efficiency, low idle rate and speedy preheats, the Precision Temp PT-56 was an excellent all-around performer.

1 Introduction

Background

Dishrooms are one of the most energy-intensive segments of a food service operation, typically representing 18% of a restaurant's total energy bill.[1] The high energy costs associated with operating a large dish machine are further exacerbated by the electric booster heaters cost, which provides the 180°F sanitizing rinse. A new generation of gas-fired booster heaters offers a viable (and economic) alternative to the traditional electric booster heater.

Dedicated to the advancement of the food service industry, the Food Service Technology Center (FSTC) has focused on the development of standard test methods for commercial food service equipment since 1987. The primary component of the FSTC is a 10,000 square-foot appliance laboratory equipped with energy monitoring and data acquisition hardware, 60 linear feet of canopy exhaust hoods integrated with utility distribution systems, appliance setup and storage areas, and a state-of-the-art demonstration and training facility.

The test methods, approved and ratified by the American Society for Testing and Materials (ASTM), allow benchmarking of equipment such that users can make meaningful comparisons among available equipment choices. By collaborating with the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI) through matching funding agreements, the test methods have remained unbiased to fuel choice. End-use customers and commercial appliance manufacturers consider the FSTC to be the national leader in commercial food service equipment testing and standards, sparking alliances with several major chain customers to date.

FSTC engineers previously monitored the energy and water consumption of a dishroom utilizing a low-temperature dishwasher as a part of a whole-building monitoring project.[2,3] These studies reported that the dishroom accounted for 97% of a food service operation's total hot water consumption.

Of that amount, the dish machine consumed nearly half of the dishroom's hot water. The widespread usage of high-temperature dishwashers in the food service industry led the FSTC to develop test methods for quantifying the energy consumption and performance of these systems. These draft test methods were subsequently approved and ratified by ASTM. [4-6]

During the course of developing the test method for booster heaters (ASTM designation F2022-00), FSTC engineers tested several different units. [7] Booster heater performance is characterized by preheat time and energy consumption, idle energy consumption rate, pilot energy consumption rate, and energy efficiency and capacity at two supply temperatures (140°F and 110°F).

The Precision Temp PT-56 gas-fired booster heater features a stainless tank and atmospheric burners beneath a copper fin heat exchanger. A microprocessor controls ignition, flameproofing and thermostat response. The components of the booster heater are housed in a stainless steel case.

This report presents the results of applying the ASTM test method to Precision Temp's PT-56 gas-fired booster heater. The glossary in Appendix A is provided so that the reader has a quick reference to the terms used in this report.

Objectives

The objective of this report is to examine the operation and performance of Precision Temp's gas-fired booster heater under the controlled conditions of the ASTM standard test method. The scope of this testing is as follows:

1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the time and energy required to preheat the appliance from an inlet supply water temperature of 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F to a thermostat setting of 183 ± 3°F.

3. Characterize the idle energy use with the booster heater tank stabilized with an inlet water supply temperature of 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F.
4. Document the flow capacity, energy rate, and energy efficiency with 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F inlet water supply temperature to the booster heater.
5. Document the energy rate and energy efficiency at 50% of flow capacity with 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F inlet water supply temperature to the booster heater.

Appliance Description

Precision Temp's gas-fired booster heater has an input rating of 55,000 Btu/h and is designed to accompany a door-type dishwasher. A microprocessor is used to control ignition, flame proofing, safety systems, and temperature control. A recirculating pump moves water between the heat exchanger and the storage tank, and atmospheric burners fire when water passing through the heat exchanger drops below a set temperature. A removable panel allows for easy access to booster heater internals for maintenance. See Figure 1-1.

Appliance specifications are listed in Table 1-1, and the manufacturer's literature is in Appendix B.

Figure 1-1.
Precision Temp's internal components.

Table 1-1. Appliance Specifications.

Manufacturer	Precision Temp
Model	PT-56
Dimensions	26.4" x 18" x 22.6"
Generic Appliance Type	Atmospheric gas-fired booster heater
Rated Input	55,000 Btu/h
Flue	No flue required
Tank Capacity	3 gallons
Controls	Microprocessor
Construction	Stainless Steel

2 Methods

Setup and Instrumentation

FSTC researchers installed the gas-fired booster heater on a noncombustible floor in a conditioned space. There was at least 6 inches of clearance between the sides of the booster heater and any other appliance. A primary water supply system was installed upstream of the booster heater to provide a constant inlet temperature of 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F. Constant water pressure was maintained by installing a pressure regulator upstream of the booster heater. Water consumption was monitored by installing a calibrated flow meter between the booster heater and the pressure regulator.

A throttling valve and solenoid valve were installed in the outlet pipe, downstream from the outlet connection of the booster heater. To reduce turbulent water flow, a water hammer arrestor was installed immediately upstream of the solenoid valve. All water lines were insulated with standard insulation ($R = 4°F \cdot ft^2 \cdot hr/Btu$) to minimize heat loss. Additionally, large radius turns were used for pipe elbows to reduce frictional losses in the piping system. All test apparatus were installed in accordance with Section 9 of the ASTM test method.[1] A schematic of the test setup is presented in Figure 2-1.

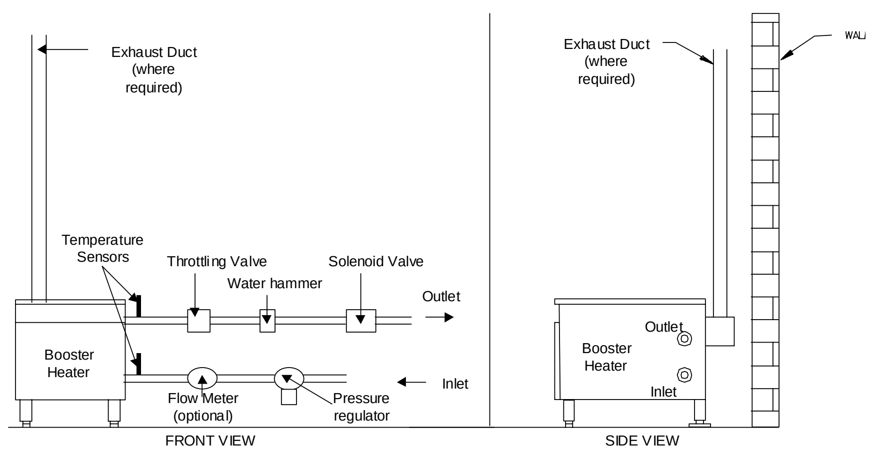

Figure 2-1. Typical equipment configuration.

Thermocouples were positioned in the inlet and outlet lines, 3-inches from the booster heater connections to monitor water temperature. Ambient room temperature was monitored with a temperature sensor placed 24-inches away from the front of the booster heater. The ambient temperature was maintained at 75 ± 5°F throughout the testing. Figure 2-2 illustrates the ambient temperature sensor placement for the booster heater tests.

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft^3. The gas meter and the thermocouples were connected to an automated data acquisition unit that recorded data every 5 seconds. A chemical laboratory used a gas chromatograph to determine the gas heating value on each day of testing. All gas measurements were corrected to standard conditions.

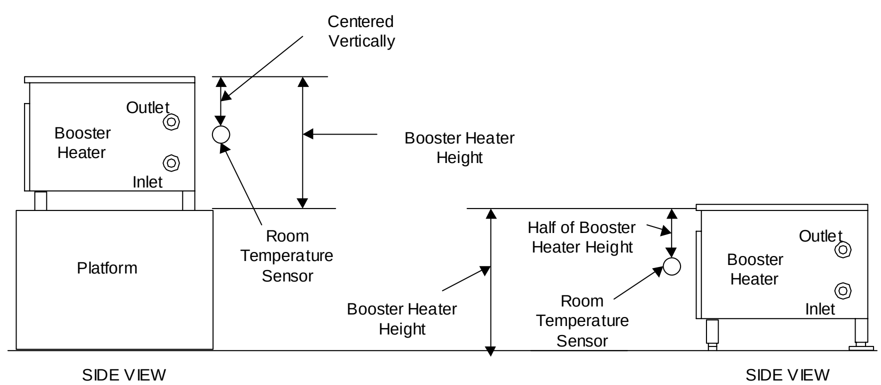

Figure 2-2.
Ambient thermocouple placement for testing.

Measured Energy Input Rate

Rated energy input rate is the maximum or peak rate at which the booster heater consumes energy—as specified on the booster heater's nameplate. Measured energy input rate is the maximum or peak rate of energy consumption, which is recorded during a period when the burners are operating (such as preheat). Researchers compared the measured energy input rate with the nameplate energy input rate to ensure that the booster heater was operating properly.

Efficiency and Flow Capacity Tests

Efficiency and flow capacity tests were run with two different incoming supply temperatures: 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F. For the maximum capacity tests, the booster heater controls were set for continuous burner operation. The throttling valve on the outlet was set so that the outgoing water stabilized at 183 ± 3°F. Time, energy consumption, water flow and water temperatures were monitored and recorded during the 30-minute test period. Control and pump energy (if applicable) were monitored during the testing.

Once the maximum capacity was established for a given supply temperature, the water flow was reduced by 50% and the test was repeated. The half-capacity tests allowed the burners to cycle around the control setpoint. The outlet temperature was maintained at 183 ± 3°F for all efficiency and capacity tests.

Each flow capacity and efficiency test for 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F was repeated a minimum of three times. This procedure ensured that the reported energy efficiency and capacity results had an uncertainty of less than ±10%. The results from each test run were averaged, and the absolute uncertainty was calculated based on the standard deviation of the results.

The ASTM results reporting sheets appear in Appendix C.

3 Results

Energy Input Rate

Prior to testing, the energy input rate was measured and compared with the manufacturer’s nameplate value. This procedure ensured that the booster heater was operating within its specified parameters. The energy input rate was 52,333 Btu/h (a difference of 4.85% from the nameplate rating).

Preheat and Idle Tests

Preheat Energy and Time

The booster heater was turned off overnight and allowed to stabilize at room temperature. With the unit off and the solenoid valve open, 140 $^{+0}/_{-3}$°F water was supplied to the booster heater. Water was run for 5 minutes, to allow the bulk of the booster heater components to equalize in temperature with the inlet supply water. After the 5-minute stabilization period, researchers closed the solenoid valve and set the thermostat's controls to achieve a 183 ±3°F temperature. Energy consumption and elapsed time were recorded as soon as the booster heater was turned on.

Preheat time includes any delay between the time the unit was turned on and the time the burner actually ignited. Preheat was judged complete when the burner cycled off. The preheat tests were conducted at the beginning of a test day for both 140 $^{+0}/_{-3}$°F and 110 $^{+0}/_{-3}$°F inlet water temperatures. Precision Temp's gas-fired booster heater preheated in 2.67 minutes with an inlet supply of 140 $^{+0}/_{-3}$°F water, while consuming 1,891 Btu to reach the thermostat setpoint. With an inlet water temperature of 110 $^{+0}/_{-3}$°F, the unit required 3.83 minutes and 2,902 Btu to raise the water temperature 70°F.

Idle Energy Rate

Once the booster heater storage tank reached a setpoint of 183 ± 3°F, the booster heater was allowed to stabilize for one hour. Time and energy consumption was monitored for an additional six-hour period. The idle energy rate during this period was 1,082 Btu/h, a duty cycle of 2.1%.

Test Results

Input, preheat, and idle test results are summarized in Table 3-1.

Table 3-1. Input, Preheat, and Idle Test Results.

Rated Energy Input Rate (Btu/h)	55,000
Measured Energy Input Rate (Btu/h)	52,333
Percentage Difference	4.85
Preheat 140°F Inlet Temperature:	
Time (min)	2.67
Energy Consumption (Btu)	1,891
Electric Energy (Wh)	7.48
Preheat 110°F Inlet Temperature:	
Time (min)	3.83
Energy Consumption (Btu)	2,902
Electric Energy (Wh)	11.31
Idle Energy Rate (Btu/h)	1,082
Idle Electric Energy Rate (W)	158.7

Efficiency and Flow Capacity Tests

The booster heater was tested under maximum capacity and half-capacity flow rates with both a 140 $^{+0}/_{-3}$°F supply and a 110 $^{+0}/_{-3}$°F supply. Researchers monitored test time, inlet and outlet water temperatures, water flow rate and booster heater energy consumption during these tests.

Results

Maximum Capacity Tests

The maximum capacity tests were designed to reflect a booster heater's peak performance. The booster heater energy consumption and flow rate were monitored while providing as much 180°F water as possible with a fixed supply. These tests simulate a booster heater's performance during a peak period when the dish machine sees continuous use.

The PT-56 booster heater with a inlet water supply of 140°F was 86.5% efficient, while providing 111 gal/h of 180°F rinse water. Additional testing with a 110°F supply showed that the PT-56 produced 70 gal/h of 180°F water and exhibited 88.7% efficiency.

Half-Capacity Tests

The half-capacity tests represent a more typical usage pattern for a smaller, door-type dishwasher. The flow rate was reduced to 50% of the unit's maximum capacity, allowing the heaters to cycle on and off as needed. Researchers ensured that the outlet water did not fall below 180°F during the half-capacity tests.

Test Results

Energy efficiency is a measure of the performance of the entire system, including heat exchanger, pump and controls. The booster heater's energy efficiency is defined as the energy imparted to the water, expressed as a percentage of the amount of energy consumed by the booster heater, including pump motor and controls. A second quantity, thermal efficiency, quantifies the percentage of heat from the burners that was transferred to the water during the testing. A booster heater's thermal efficiency is always higher than its energy efficiency.

Maximum capacity energy efficiency results with a 140°F supply were 86.4%, 87.1%, and 86.0%, yielding an absolute uncertainty of 1.2%. Figures 3-1 and 3-2 show the inlet and outlet water temperatures during the maximum capacity tests. Tables 3-2 and 3-3 summarize the results of the ASTM efficiency and capacity tests. A complete summary of the data from the efficiency tests is presented in Appendix D.

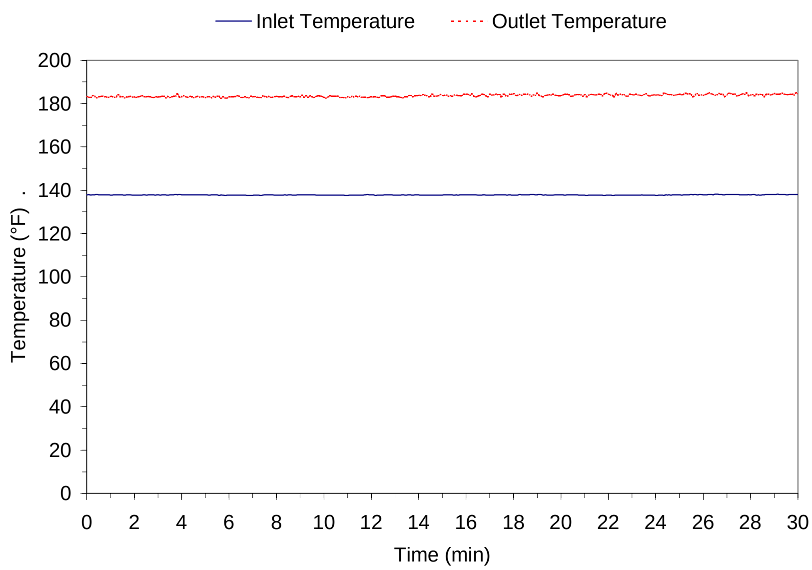

Figure 3-1.
Water temperatures during 140°F max capacity test.

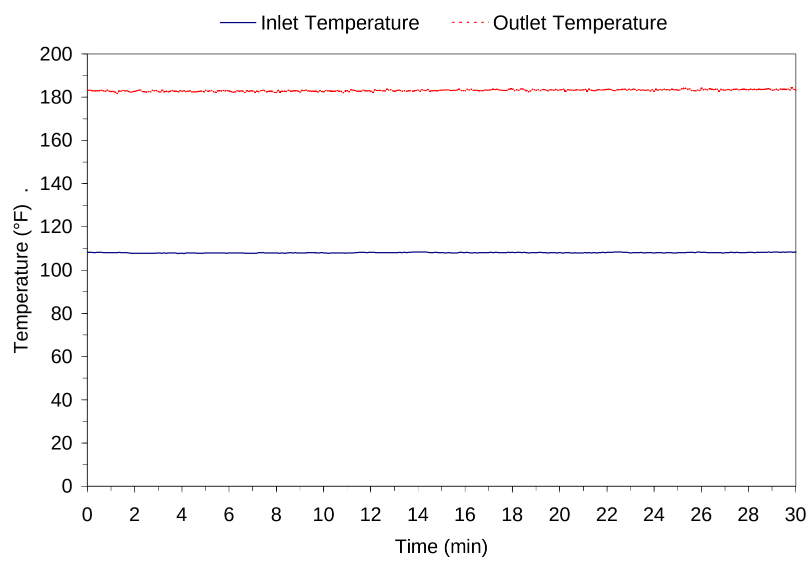

Figure 3-2.
Water temperature during 110°F Max Capacity Test.

Table 3-2. Maximum Capacity Test Results.

	140°F Supply	*110°F Supply*
Flow Rate (gal/h)	110.8 ± 4.7	70.4 ± 2.2
Total Water Consumption (gal)	55.4	35.2
Temperature Rise (°F)	45.7	74.5
Gas Energy Rate (Btu/h)	46,734	47,867
Electric Energy Rate (W)	162.9	163.7
Energy Efficiency (%)	86.5 ± 1.2	87.6 ± 0.3
Thermal Efficiency (%)	87.5	88.7

Half-capacity energy efficiency results with a 140°F supply were 84.0%, 83.9%, and 83.2%, yielding an absolute uncertainty of 1.0%.

Table 3-3. Half-Capacity Test Results.

	140°F Supply	*110°F Supply*
Flow Rate (gal/h)	57.5 ± 0.5	37.9 ± 1.5
Total Water Consumption (gal)	28.8	19.0
Temperature Rise (°F)	52.6	78.9
Gas Energy Rate (Btu/h)	28,624	28,331
Electric Energy Rate (W)	164.5	164.6
Energy Efficiency (%)	83.7 ± 1.0	83.7 ± 1.9
Thermal Efficiency (%)	85.3	85.3

Research has shown the importance of correctly sizing a booster heater to match the dish machine's water consumption and the temperature of the domestic water supply. As inlet water temperature drops, the amount of 180°F water being supplied by the booster heater drops accordingly. Figure 3-3 represents the drop in 180°F sanitizing water relative to the temperature drop of the domestic water supply.

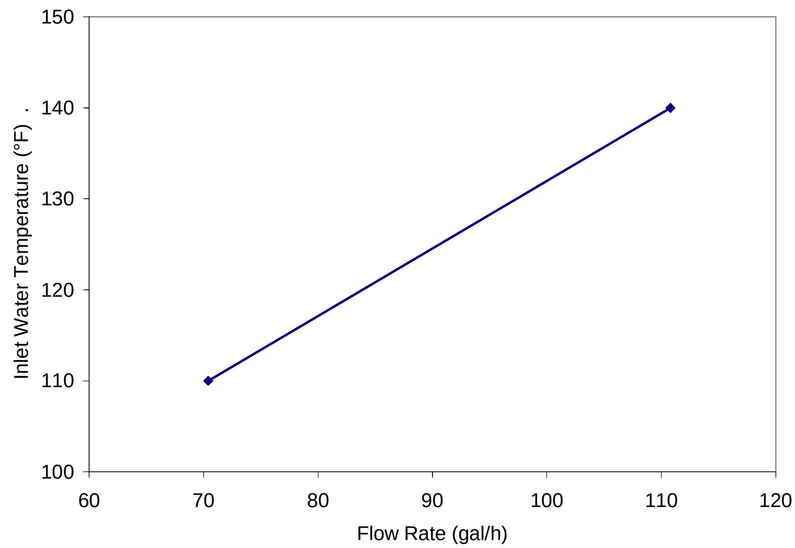

Figure 3-3. Inlet water temperature vs. booster heater flow capacity.

Continual use of a dishwasher with an undersized booster heater can result in a loss of 180°F sanitizing water supply. Oversizing a booster heater can result in unnecessary initial costs.

4 Conclusions

Precision Temp's PT-56 gas-fired booster heater achieved excellent efficiency and flow capacity results during testing at the Food Service Technology Center. Gas-fired booster heaters have seen improvements in design and performance through collaboration between manufacturers and testing facilities such as the FSTC. The ASTM standardized test method for booster heaters can quantify design improvements, which have greatly impacted the acceptance of gas-fired booster heaters within the food service industry.

During maximum flow capacity testing, the PT-56 booster heater posted excellent energy efficiency results of 86.5% and 87.6% with inlet temperatures of 140°F and 110°F respectfully, while showing a low 36% reduction in flow rate between the 140°F and 110°F supply. Notably, Precision Temp's booster heater was able to achieve these results by using atmospheric burners, rather than more costly powered or infrared burners often used for other gas-fired booster heaters.

The unit posted a fast preheat of – 2.68 minutes from a 140°F supply – and a low idle rate of 1,082 Btu/h. With it's part-load efficiency, the 55,00 Btu/h PT-56 booster heater is an excellent all-around performer ideally sized for door-type dish machines.

5 References

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A Glossary

Booster Heater

An appliance that raises water temperature (typically 110°F to 140°F) to 180°F or more to provide high temperature sanitizing rinse water for a dishwasher machine.

Dishwasher Machine

Machine that uniformly washes, rinses, and sanitizes eating and drinking utensils.

Batch Water Flow

Intermittent mode of water delivery at specified flow rate and elapse time. This is the typical style of water delivery of a booster heater supplying final rinse water to a door type dishwasher machine.

Booster Heater Energy Efficiency (%)

Quantity of energy imparted to the water while heating, expressed as a percentage of the total amount of energy consumed by the booster heater (including pump and control energy) during the capacity tests.

Booster Heater Inlet

The point of connection on the booster heater for the water line from the primary supply to the booster heater.

Booster Heater Outlet

The point of connection on the booster heater for the water line from the booster heater to the dishwasher.

Continuous Water Flow.

Uninterrupted water delivery by a booster heater at a specified flow rate. This is a typical mode of water delivery of a booster heater supplying water to a conveyor or rack-less (flight) type dishwasher machine.

Energy Rate (kW or kBtu/h)

Average energy rate of energy consumption during the continuous flow tests.

Flow Capacity (gal/min or gal/h)

Maximum water flow rate at which the booster heater can heat water from a specified inlet temperature to an outlet temperature of 183 ± 3°F during the continuous flow capacity test.

Heating Value (Btu/ft^3)

Heating Content

The quantity of heat (energy) generated by the combustion of fuel. For natural gas, this quantity varies depending on the constituents of the gas.

Idle Energy Rate (kW or Btu/h)

Idle Energy Input Rate
Idle Rate

The rate of appliance energy consumption while holding or maintaining a stabilized operating condition or temperature.

Glossary

Idle Duty Cycle (%)
Idle Energy Factor

The idle energy consumption rate expressed as a percentage of the measured energy input rate.

$$\text{Idle Duty Cycle} = \frac{\text{Idle Energy Rate}}{\text{Measured Energy Input Rate}} \times 100$$

Measured Input Rate (kW or Btu/h)

Measured Energy Input Rate
Measured Peak Energy Input Rate

The maximum or peak rate at which an appliance consumes energy, typically reflected during appliance preheat (i.e., the period of operation when all burners or elements are "on").

Pilot Energy Rate (kW or kBtu/h)

Average rate of energy consumption by a booster heater's continuous pilot (if applicable).

Preheat Energy (kWh or Btu)

Preheat Energy Consumption

The total amount of energy consumed by an appliance during the preheat period.

Preheat Rate (°F/min)

The rate at which the appliance heats during to its operating temperature.

Preheat Time (minute)

Preheat Period

The time required for an appliance to warm from the ambient room temperature (75 ± 5°F) to a specified (and calibrated) operating temperature or thermostat setpoint.

Primary Supply

The service water heater system that supplies water to the booster heater under test.

Rated Energy Input Rate
(kW, W or Btu/h, Btu/h)

Input Rating (ANSI definition)
Nameplate Energy Input Rate
Rated Input

The maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the nameplate.

Test Method

A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

Thermal Efficiency (%)

Quantity of energy imparted to the water, expressed as a percentage of energy consumed by the element(s), gas burner(s), steam coil(s), and/or steam injector(s) during the flow capacity tests. Thermal efficiency data is collected during the continuous flow capacity tests.

Uncertainty

Measure of systematic and precision errors in specified instrumentation or measure of a reported test result.

B Appliance Specifications

Appendix B includes the product literature for the Precision Temp PT-56 booster heater.

Table B-1. Appliance Specifications.

Manufacturer	Precision Temp
Model	PT-56
Dimensions	26.4" x 18" x 22.6"
Generic Appliance Type	Atmospheric gas-fired booster heater
Rated Input	55,000 Btu/h
Flue	No flue required
Tank Capacity	3 gallons
Controls	Microprocessor
Construction	Stainless Steel

Technical Data Sheet

PrecisionTemp Model PT-56 Instantaneous Gas Booster Heater

Type: Gas, instantaneous, tank type, direct vent water heater designed as a dishwasher booster heater for door type machines. Capable of 70°F ΔT. Full gas modulation temperature control system. The Model PT-56 is equivalent to a 12.5 KW electric booster heater.

Dimensions: 26.375" Wide x 18" Deep x 22.625 High. Weight: 105 lbs.

Connections:
Electric: SJO plug is standard
Flue: A flue is not necessary. The Model PT-56 is ventless.
Gas: Brass ½" NPT, bottom accessible.
Water: ¾" NPT, bottom accessible.

Capacity:
55,000 BTU input-44,800 BTU output at a maximum burn at 3.2 WCI manifold pressure.
28,000 BTU input-22,500 BTU output at a low burn at 2 WCI manifold pressure.
10,000 BTU input at ignition.
These manifold pressures are for natural gas.
(70°F at ΔT maximum at 1.2 gallon dump every minute.)

Input Water Temperature:
110°F to 140°F to maintain 180°F rinse temperature.

Installation: 6" NSF legs standard for floor installation under counter or optional wall bracket to mount under dishwasher hood.

Flue: Direct vent. No flue required to outside. Conforms to National Flue Gas Code as unvented appliance when installed per instructions.

Construction:
Modular: Three assemblies for gas, electronics, and water.
Burner: High primary air, 8 element, atmospheric type. Aluminized steel body with stainless steel frame strips.
Heat exchanger: Copper fin tube type with wrap for cooling.
Electronics: Plug in, works-in-a-drawer.
Tank: 316 stainless steel, NSF approved components.
Case: Case and inside mounting assemblies are 304 stainless NSF approved components.

Fuel: Natural gas at 3.5 WCI or propane at 11 WCI.

Power: 115 VAC at 1 Amp with 12 VDC power supply for ignition and controls.

Flue Gas Temperature:
Under 300°F.

Pressure Relief Valve:
Set @ 125 PSI.

Set Temperature:
Factory set at 180ºF. Can be specified or field adjusted for special applications.

Gas Train: **Burner:** Eight element high primary air, atmospheric type with stainless steel flame strips. Steep manifold with brass 1/8" NPT pressure tap.
Modulating Valve: Solid brass conduit with 3/8" NPT ends. Control is non-intrusive into gas cavity, using no seals, pushrods or diaphragms. There is a 5:1 gas flow ration controlled by a magnetic field actuating movement of a poppet in and out of a fixed orifice.
Gas Valve: Redundant solenoid with integral two stage regulator and 1/8" NPT pressure tap.

Water Assembly: **Heat Exchanger:** Solid copper, fin tube type at 7 fins per inch with copper combustion chamber with ½ tube wrap to cool assembly
Pressure Relief Valve: Approved set @ 125 PSI.
Other hardware in contact with water is brass or NSF approved composites.

Controls: **Microprocessor:** Controls ignition, flame proofing, safety systems and electronic gas modulation temperature control. Control boards are mounted in a removable drawer, coated, with plug-in connectors protected by an anti-oxidant compound.
Ignition: Electronic, direct spark type.
Flame Proofing: Rectification, shutting gas valve off in .8 of a second if proofing fails. Ignition and proofing effected by a single stainless probe at the burner.
Temperature Sensors: Two thermistors; one senses water temperature midway through the heat exchanger (mounted in a stainless steel probe with compression fittings on the heat exchanger), and one senses outlet water temperature, (mounted to hot water outlet on the heat exchanger).
Temperature Control: Maintained by microprocessor controlled gas modulation that delivers output water temperature within ± 2ºF by sensing water flow rate and two outputs.

Safety Features: The Model PT-56 is pilotless.
Flame rectification. Gas valve shuts off in .8 of a second if there is a flame outage.
Redundant gas solenoid
Electronic high temperature shut off (two).
ECO high temperature shut off @ 210ºF with manual reset
Pressure relief valve @ 125 PSI

Model PT-56 Operation:

When unit is powered, the microprocessor activated the gas modulation valve and performs component diagnostics. A green LED will flash for normal operation, red will indicate a malfunction signified by different codes. A circulating pump circulates water between the heat exchanger and a three gallon tank. The gas modulating valve will be set to its ignition value. If the temperature of the heat exchanger is below set temperature the spark ignition will be effected and the gas valve will open. Ignition will occur and the flame will be proofed.

The microprocessor now reads the source water temperature, calculates the required gas flow to maintain the set temperature and sets the gas modulation valve to the proper setting. The water temperature is then monitored by the thermistors midway and at the outlet of the heat exchanger to make any minor corrections in gas flow. If there is any change in incoming water temperature, the microprocessor recalculates and makes and required adjustments.

The burner continues to operate until the set temperature is reached and the burner turns off. During this time when the water temperature is within 10°F of set temperature, the burner is modulated down until the set temperature is reached and shuts off the burner. This modulation optimizes efficiency and eliminates rapid burner cycling in high burn.

Approvals: U.S. - ANSI Z21.10.3
Canada – CAN 1-4.3-M85
Sanitation – NSF 5 – 1992

Due to continuous product improvement,
PrecisionTemp reserves the right to change specifications at any time

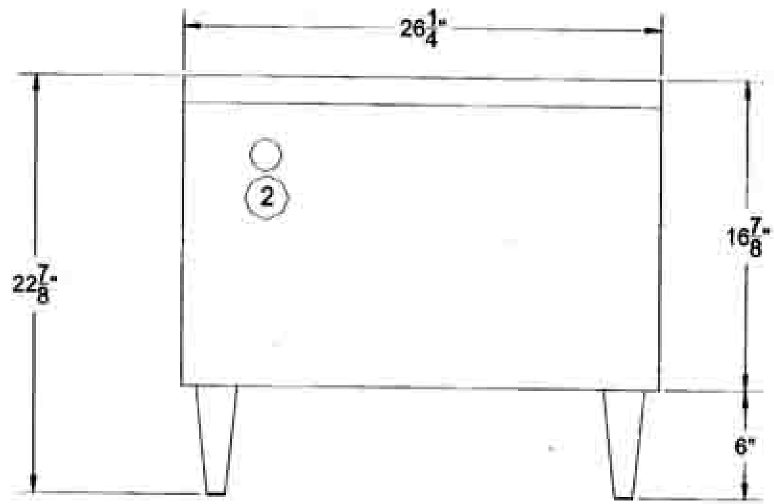
LEGEND

1 TEMPERATURE / PRESSURE RELIEF VALVE

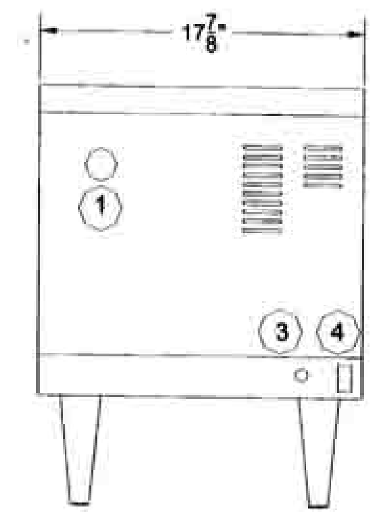
2 ALTERNATE TEMPERATURE / PRESSURE RELIEF VALVE PORT

3 SJO POWER WIRE

4 POWER SWITCH



BACK VIEW



SIDE VIEW

NOTES:
1. CERTIFIED BY ETL FOR VENTLESS OPERATION. CONSULT LOCAL CODES.
2. CLEARANCES: MIN. 6 INCHES FOR ALL SIDES AND FULL ACCESS TO FRONT PANEL.
3. ALL WATER CONNECTIONS ARE 3/4" FEMALE NPT.
4. GAS CONNECTIONS 1/2" FEMALE NPT.

PrecisionTemp Inc. 1006 Kieley Place - Cincinnati, OH 45217 - USA			
PT-56 GAS BOOSTER HEATER			
SIZE	DRAWN BY GLB	DWG NO. PT-56	REV
DATE 1/10/03			

LEGEND

1 *SHOCK ABSORBER / ACCUMULATOR

2 *TEMPERATURE GAUGES

3 *TEMPERATURE / PRESSURE RELIEF VALVE

3a ALTERNATE TEMPERATURE / PRESSURE RELIEF VALVE PORT

4 *DRAIN VALVE

5 *PRESSURE REDUCING VALVE

6 GATE or BALL VALVE 3/4"

7 GAS PIPE INLET 1/2" NPT

8 MANUAL GAS SHUT-OFF

9 *UNION

10 DRIP LEG

11 BOOSTER BYPASS

12 SJO POWER WIRE

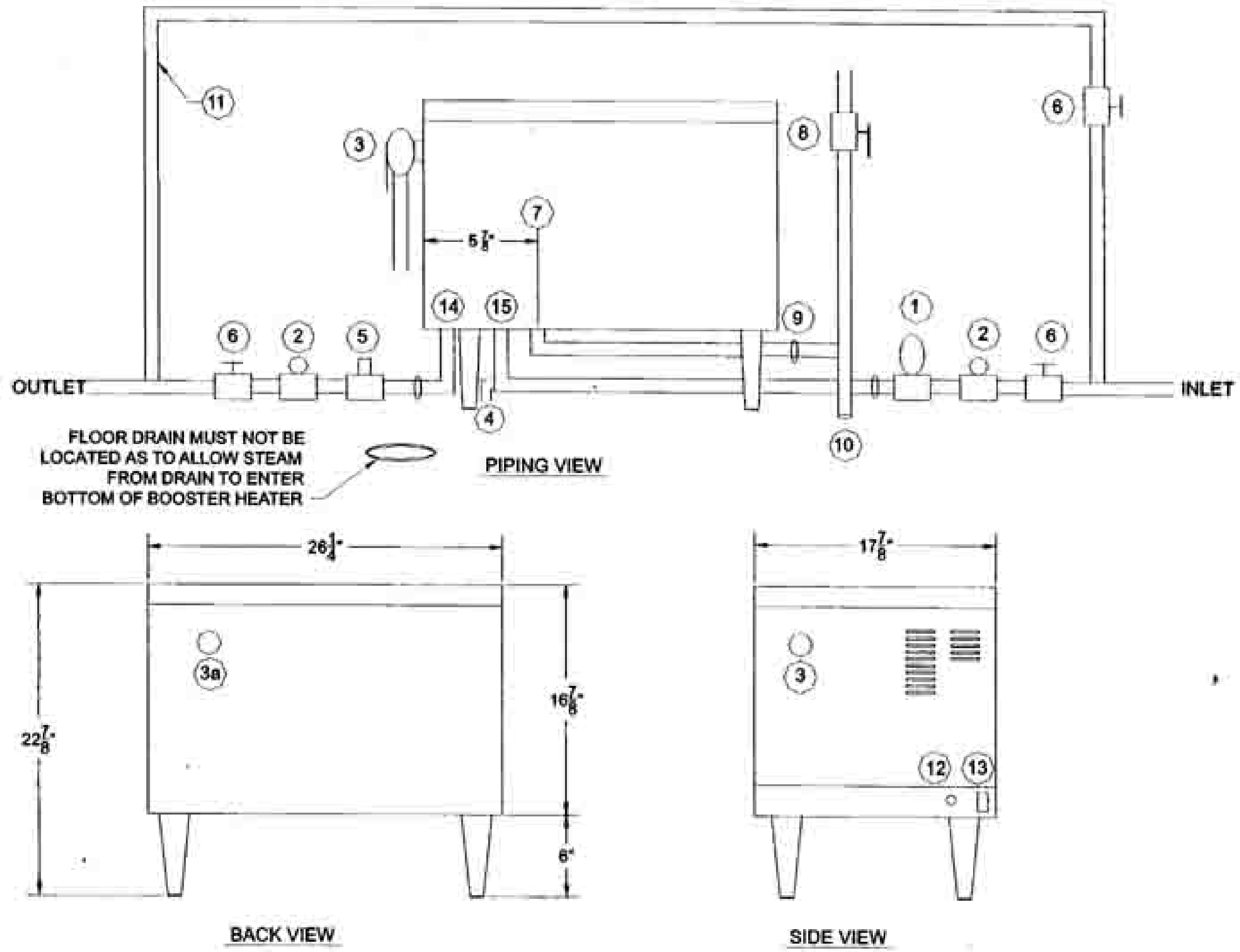
13 POWER SWITCH

14 WATER OUTLET 3/4" NPT

15 WATER INLET 3/4" NPT

CONSULT LOCAL CODES

*INCLUDED IN PT-56 INSTALLATION KIT



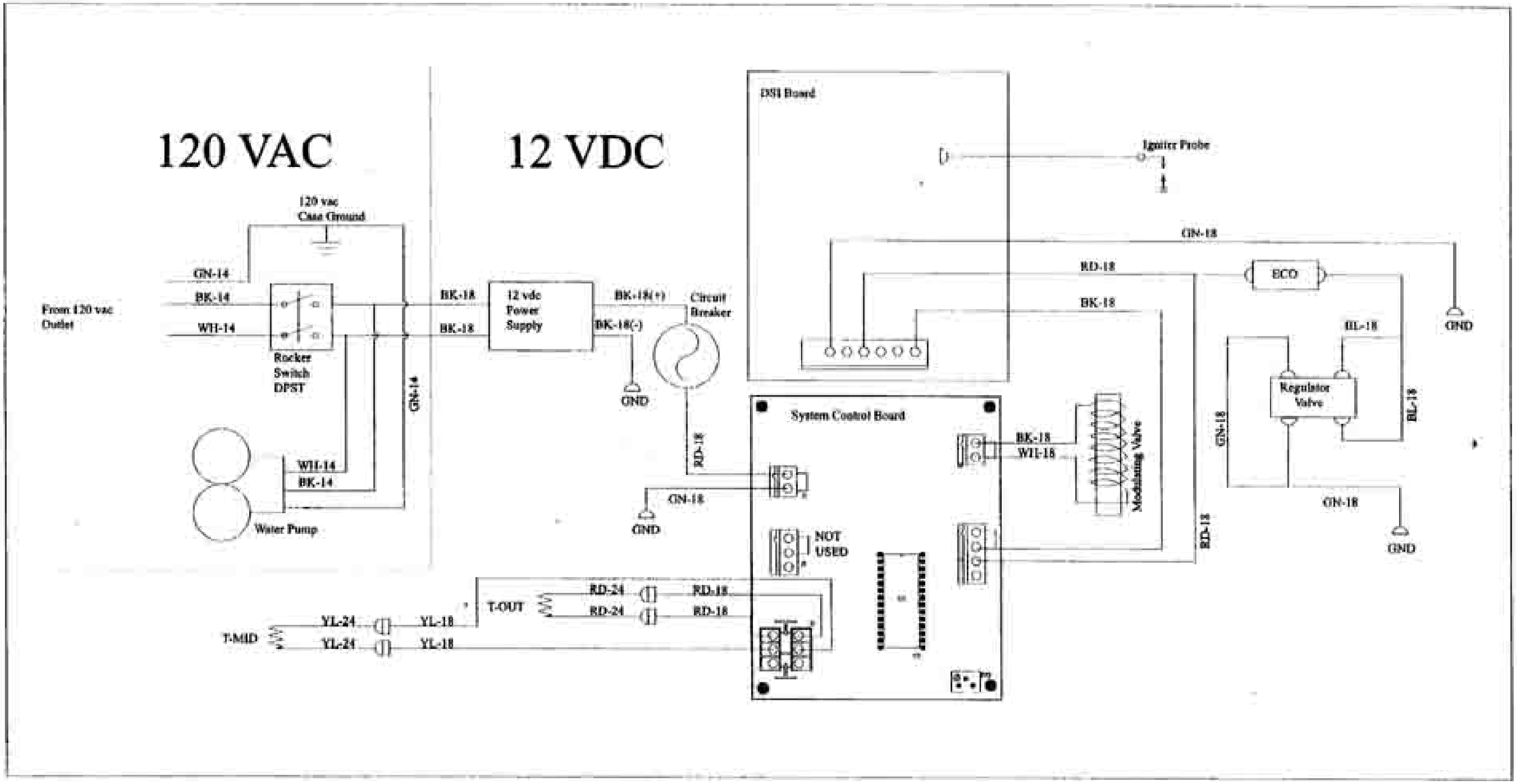
NOTES:
1. CERTIFIED BY ETL FOR VENTLESS OPERATION. CONSULT LOCAL CODES.
2. CLEARANCES: MIN. 6 INCHES BEHIND AND 10 INCHES ON EITHER SIDE AND ABOVE. FULL ACCESS TO FRONT PANEL.
3. ALL WATER CONNECTIONS ARE ¾" FEMALE NPT.
4. GAS CONNECTIONS ½" FEMALE NPT.

PrecisionTemp Inc.

1006 Kieley Place - Cincinnati, OH 45217 - USA

PT-56 GAS BOOSTER HEATER

SIZE	DRAWN BY GLB	DWG NO. PT-56 PIPING	REV
DATE 1/10/03			



PrecisionTemp

PT56 WIRING DIAGRAM

X DB 0042

PROPRIETARY INFORMATION

C Results Reporting Sheets

Manufacturer:	Precision Temp Inc.
Model:	PT-56
Serial Number:	78-10-038
Date:	October 1999

Appliance Description.

Description of operational characteristics: Precision Temp's PT-56 gas-fired booster heater is rated at 55,000 Btu/h and features a microprocessor that controls a water pump and atmospheric gas burners below a solid copper heat exchanger. All stainless steel sides, bottom and top house all of the booster heater components.

Apparatus.

√ Check if testing apparatus conformed to specifications in section 6.

Deviations: None.

Energy Input Rate.

Gas Heating Value (Btu/scf)	1014
Name Plate (Btu/h)	55,000
Measured (Btu/h)	52,333
Percentage Difference (%)	4.85

Results Reporting Sheets

Preheat Energy and Time.

Gas Heating Value (Btu/scf)	1014
140°F Inlet Temperature:	
Duration (min)	2.67
Energy Consumption (Btu)	1,891
Electric Energy (Wh)	7.48
110°F Inlet Temperature:	
Duration (min)	3.83
Energy Consumption (Btu)	2.902
Electric Energy (Wh)	11.31

Idle Energy Rate.

Gas Heating Value (Btu/scf)	1015
Idle Energy Rate @ 350 °F (Btu/h)	1,082
Electric Energy Rate (W)	158.7

Energy Efficiency and Flow Rate at Maximum Capacity with 140°F inlet.

Gas Heating Value (Btu/scf)	1015
Test Time (min)	30.0
Minimum Inlet Temperature (°F)	137.3
Maximum Inlet Temperature (°F)	138.3
Minimum Outlet Temperature (°F)	182.8
Maximum Outlet Temperature (°F)	184.9
Temperature Rise (°F)	45.7
Flow Rate (gal/h)	110.8 ± 4.7
Gas Energy Rate (Btu/h)	46,734
Electric Energy Rate (W)	162.9
Energy Efficiency (%)	86.5 ± 1.2

Results Reporting Sheets

Energy Efficiency and Flow Rate at Maximum Capacity with 110°F inlet.

Gas Heating Value (Btu/scf)	1015
Test Time (min)	30.0
Minimum Inlet Temperature (°F)	107.8
Maximum Inlet Temperature (°F)	108.5
Minimum Outlet Temperature (°F)	181.0
Maximum Outlet Temperature (°F)	183.9
Temperature Rise (°F)	74.5
Flow Rate (gal/h)	70.4 ± 2.2
Gas Energy Rate (Btu/h)	47,867
Electric Energy Rate (W)	163.7
Energy Efficiency (%)	87.6 ± 0.3

Energy Efficiency and Flow Rate at 50% Capacity with 140°F inlet.

Gas Heating Value (Btu/scf)	1017
Test Time (min)	30.0
Minimum Inlet Temperature (°F)	137.8
Maximum Inlet Temperature (°F)	138.6
Minimum Outlet Temperature (°F)	187.1
Maximum Outlet Temperature (°F)	192.2
Temperature Rise (°F)	52.6
Flow Rate (gal/h)	57.5 ± 0.5
Gas Energy Rate (Btu/h)	28,624
Electric Energy Rate (W)	164.5
Energy Efficiency (%)	83.7 ± 1.2

Energy Efficiency and Flow Rate at 50% Capacity with 110°F inlet.

Gas Heating Value (Btu/scf)	1017
Test Time (min)	30.0
Minimum Inlet Temperature (°F)	108.0
Maximum Inlet Temperature (°F)	109.0
Minimum Outlet Temperature (°F)	182.0
Maximum Outlet Temperature (°F)	189.8
Temperature Rise (°F)	78.9
Flow Rate (gal/h)	37.9 ± 1.5
Gas Energy Rate (Btu/h)	28,331
Electric Energy Rate (W)	164.6
Energy Efficiency (%)	83.7 ± 2.3

D Energy Efficiency Data

Table D-1. Maximum Capacity at 140°F Inlet Test Data.

	Repetition #1	*Repetition #2*	*Repetition #3*
Measured Values			
Electric Energy Consumption (Wh)	81.74	81.35	81.28
Gas Energy Consumption (Btu)	23,367	23,580	23,154
Test Time (min)	30.0	30.0	30.0
Average Temperature Rise (°F)	46.5	45.8	44.7
Water Consumption (gal)	54.29	56.12	55.78
Flow Rate (gal/min)	1.81	1.87	1.86
Flow Rate (gal/h)	108.6	112.2	111.6
Inlet			
Average Inlet Temperature (°F)	137.9	137.9	138.1
Minimum Inlet Temperature (°F)	137.3	137.6	137.0
Maximum Inlet Temperature (°F)	138.3	138.2	138.4
Outlet			
Average Outlet Temperature (°F)	184.4	183.6	182.8
Minimum Outlet Temperature (°F)	182.5	182.5	181.3
Maximum Outlet Temperature (°F)	185.9	185.0	183.9
Energy Efficiency (%)	86.4	87.1	86.0
Thermal Efficiency (%)	87.4	88.1	87.0
Gas Energy Rate (Btu/h)	46,735	47,160	46,308
Electric Energy Rate (W)	163.5	162.7	162.6

Table D-2. Maximum Capacity at 110°F Inlet Test Data.

	Repetition #1	*Repetition #2*	*Repetition #3*	*Repetition #4*
Measured Values				
Electric Energy Consumption (Wh)	81.38	81.09	81.22	83.79
Gas Energy Consumption (Btu)	23,417	24,484	24,528	23,304
Test Time (min)	30.0	30.0	30.0	30.0
Average Temperature Rise (°F)	74.7	75.0	75.3	73.1
Water Consumption (gal)	34.32	35.81	35.67	34.99
Flow Rate (gal/min)	1.14	1.19	1.19	1.17
Flow Rate (gal/h)	68.7	71.6	71.3	70.0
Inlet				
Average Inlet Temperature (°F)	108.3	108.0	108.2	108.0
Minimum Inlet Temperature (°F)	107.9	107.7	107.8	107.7
Maximum Inlet Temperature (°F)	108.8	108.4	108.5	108.4
Outlet				
Average Outlet Temperature (°F)	183.0	183.1	183.4	181.1
Minimum Outlet Temperature (°F)	180.0	181.8	182.1	180.2
Maximum Outlet Temperature (°F)	184.0	184.3	184.5	182.6
Energy Efficiency (%)	87.5	87.7	87.5	87.8
Thermal Efficiency (%)	88.5	88.7	88.5	88.9
Gas Energy Rate (Btu/h)	46,834	48,968	49,056	46,609
Electric Energy Rate (W)	162.8	162.2	162.4	167.6

Energy Efficiency Data

Table D-3. 50% Capacity at 140°F Inlet Test Data.

	Repetition #1	*Repetition #2*	*Repetition #3*
Measured Values			
Electric Energy Consumption (Wh)	82.86	82.09	81.79
Gas Energy Consumption (Btu)	14,550	13,735	14,650
Test Time (min)	30.0	30.0	30.0
Average Temperature Rise (°F)	53.6	50.5	53.8
Water Consumption (gal)	28.80	28.87	28.65
Flow Rate (gal/min)	0.96	0.96	0.95
Flow Rate (gal/h)	57.6	57.7	57.3
Inlet			
Average Inlet Temperature (°F)	138.2	138.6	137.8
Minimum Inlet Temperature (°F)	137.8	138.2	137.4
Maximum Inlet Temperature (°F)	138.6	139.0	138.3
Outlet			
Average Outlet Temperature (°F)	191.9	189.0	191.5
Minimum Outlet Temperature (°F)	191.0	180.9	189.5
Maximum Outlet Temperature (°F)	192.6	190.7	193.2
Energy Efficiency (%)	84.0	83.9	83.2
Thermal Efficiency (%)	85.6	85.6	84.8
Gas Energy Rate (Btu/h)	29,101	27,471	29,301
Electric Energy Rate (W)	165.7	164.2	163.6

Energy Efficiency Data

Table D-4. 50% Flow at 110°F Inlet Test Data.

	Repetition #1	*Repetition #2*	*Repetition #3*	*Repetition #4*
Measured Values				
Electric Energy Consumption (Wh)	82.41	81.52	82.78	82.53
Gas Energy Consumption (Btu)	13,974	13,711	14,745	14,234
Test Time (min)	30.0	30.0	30.0	30.0
Average Temperature Rise (°F)	78.4	77.3	78.7	81.3
Water Consumption (gal)	18.95	19.03	19.51	18.33
Flow Rate (gal/min)	0.63	0.63	0.65	0.61
Flow Rate (gal/h)	37.9	38.1	39.0	36.7
Inlet				
Average Inlet Temperature (°F)	108.5	108.8	108.2	108.2
Minimum Inlet Temperature (°F)	108.0	108.5	107.9	107.7
Maximum Inlet Temperature (°F)	109.1	109.0	108.8	109.1
Outlet				
Average Outlet Temperature (°F)	186.8	186.1	186.9	189.4
Minimum Outlet Temperature (°F)	180.1	180.1	180.2	187.5
Maximum Outlet Temperature (°F)	189.3	188.8	190.3	190.8
Energy Efficiency (%)	84.2	85.1	82.5	82.9
Thermal Efficiency (%)	85.9	86.8	84.1	84.5
Gas Energy Rate (Btu/h)	27,947	27,421	29,490	28,467
Electric Energy Rate (W)	164.8	163.0	165.6	165.1

Energy Efficiency Data

Table D-5. Energy Efficiency.

	Energy Efficiency (%)			
	Max Capacity @ 140°F	*Max Capacity @ 110°F*	*50 % Capacity @ 140°F*	*50 % Capacity @ 110°F*
Replicate #1	86.4	87.5	84.0	84.2
Replicate #2	87.1	87.7	83.9	85.1
Replicate #3	86.0	87.5	83.2	82.5
Replicate #4	---	87.8	---	82.9
Average	86.5	87.6	83.7	83.7
Standard Deviation	0.5	0.2	0.4	1.2
Absolute Uncertainty	1.2	0.3	1.0	1.9
Percent Uncertainty	1.4	0.3	1.2	2.3

Table D-6. Flow Rates.

	Flow Rates (gal/h)			
	Max Capacity @ 140°F	*Max Capacity @ 110°F*	*50 % Capacity @ 140°F*	*50 % Capacity @ 110°F*
Replicate #1	108.6	68.7	57.6	37.9
Replicate #2	112.2	71.6	57.7	38.1
Replicate #3	111.6	71.3	57.3	39.0
Replicate #4	---	70.0	---	36.7
Average	110.8	70.4	57.5	37.9
Standard Deviation	1.9	1.4	0.2	0.5
Absolute Uncertainty	4.7	2.2	0.5	1.5
Percent Uncertainty	4.2	3.1	0.9	4.1