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WARNING
If the information in this manual is not followed exactly, a fire or explosion may result causing property damage, personal injury or loss of life.

Do not store or use gasoline or other flammable vapors or liquids in the vicinity of this or any other appliance.

Installation and service must be performed by a qualified installer, service agency, or the gas supplier.

WARNING It is essential to read, understand, and follow the recommendations of this manual before installing, operating, or servicing this equipment.

WARNING Installation and service must be performed by a qualified and knowledgeable individual who has been trained on the P-K THERMIFIC® boiler. The same features which permit this boiler to achieve high-efficiency performance make it unlike most other boilers of this general size, so it is important to understand how this boiler operates.

What to do if you smell gas:

- Do not try to light any appliance.
- Do not touch any electrical switch; do not use any phone in your building.
- Immediately call your gas supplier from a neighbor's phone. Follow the gas supplier's instructions.
- If you cannot reach your gas supplier, call the fire department.

1 INTRODUCTION

The P-K THERMIFIC® gas-fired boiler combines a radial pre-mix fan-assisted burner with a compact, finned-tube heat exchanger to provide maximum efficiency in a minimum of space. The high-quality materials and thoroughly tested design of the boiler should provide years of trouble-free, hot-water service, if the instructions in this manual are followed carefully.

This manual covers installation of P-K THERMIFIC® boilers. The model numbers may be followed by a prefix or suffix letter in some cases to indicate special features or different options.

While details may differ slightly, basic operation is the same for all models. Boilers may be built to operate with natural gas or liquefied petroleum gas (propane). Check the rating plate for correct fuel usage and gas pressures.

The boiler is only a part of the complete heating system. This boiler may be fully operational and yet because of poor circulation, control or other operating characteristics, not deliver heat to the desired location. Additional equipment such as temperature sensors, pumps, flow switches, balancing valves and check valves will be required for satisfactory operation of any system. Harsco Industrial, Patterson-Kelley cannot be responsible for the design or operation of such systems and a qualified engineer or contractor must be consulted.

2 SAFETY

2.1 GENERAL

The P-K THERMIFIC® gas-fired boiler **must** be:

- Installed, operated, and serviced in accordance with instructions contained in this manual.
- Installed by qualified personnel in accordance with designs prepared by qualified engineers including: structural, mechanical, electrical, and other applicable disciplines.
- Operated and serviced in accordance with a comprehensive safety program determined and established **by the customer**. Do not attempt to operate or service until such a program has been established.
- Operated and serviced by experienced, qualified, properly trained personnel in accordance with all applicable codes, laws, and regulations.

NOTICE! Each safety device must be maintained and checked per the recommended schedule. Refer to Section 5.1 of this manual.

2.2 TRAINING



It is **essential** to read, understand, and follow the recommendations of this manual before installing, operating, or servicing this equipment. Failure to do so could result in fire or explosion and serious injury, death, and/or property damage. Proper training is the best protection against accidents.

Operating and service personnel must be thoroughly familiar with the basic construction of the P-K THERMIFIC® boiler, the use and locations of the controls, the operation of the boiler, adjustment of its various mechanisms, and all applicable safety precautions. If any of the provisions of this manual are not fully and completely understood, contact the Harsco Industrial, Patterson-Kelley Technical Service Department toll-free at (877) 728-5351 for assistance.

2.3 SAFETY FEATURES

It is the responsibility of the customer to maintain the safety features of this appliance, such as but not limited to: guards, safety labels, safety controls, interlocks and lockout devices.

2.4 SAFETY LABELS

The following words are used in this manual to denote the degree of seriousness of the individual hazards.

⚠ DANGER indicates an imminently hazardous situation which, if not avoided, **will** result in death or serious injury. This signal word is to be limited to the most extreme situations.

⚠ WARNING indicates a potentially hazardous situation which, if not avoided, **could** result in death or serious injury.

⚠ CAUTION indicates a potentially hazardous situation which, if not avoided, **may** result in minor or moderate injury. It may also be used to alert against unsafe practices.

NOTICE/NOTE: - NOTICE is the preferred signal word to address practices not related to personal injury. The safety alert symbol is not used with this signal word.

<p>⚠ AVERTISSEMENT</p> <p>Une installation, un réglage, un changement ou un entretien inappropriés peuvent causer des dommages matériels, des blessures corporelles ou la mort.</p> <p>Lire et bien comprendre le Manuel d'installation et du propriétaire fourni avec cette chaudière. L'installation et le service doivent être effectués par un personnel expérimenté et compétent qui a reçu une formation sur la chaudière de cette série.</p>	 	<p>⚠ WARNING</p> <p>Improper installation, adjustment, alteration, service, or maintenance can cause property damage, personal injury, or loss of life.</p> <p>Read and understand the installation and Owner's manual provided with this boiler. Installation and service must be performed by experienced and knowledgeable personnel who have been trained on this series boiler.</p>
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<p>⚠ AVERTISSEMENT</p> <p>Risque électrique.</p> <p>Un contact causera un choc électrique et des blessures.</p> <p>Suivre les procédures de verrouillage/signalisation lors de l'entretien.</p>	 	<p>⚠ WARNING</p> <p>Electrical hazard.</p> <p>Contact may cause electrical shock and injury.</p> <p>Follow lockout/tagout procedure when servicing.</p>
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<p>⚠ ATTENTION</p> <p>Risque de brûlures.</p> <p>Certains composants sont très chauds.</p> <p>Attendez un temps de refroidissement après l'arrêt et ne pas toucher pendant le fonctionnement.</p>		<p>⚠ CAUTION</p> <p>Burn hazard.</p> <p>Some components are hot to the touch.</p> <p>Allow time to cool after shutdown and do not touch during operation.</p>
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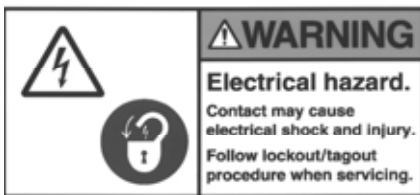
	<p>⚠ WARNING</p> <p>Improper use may result in fire or injury.</p> <p>Read instructions/safety manual before installing, operating or servicing boiler.</p>
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The safety labels shown above are affixed to your boiler. Although the labels are of high quality, they may become dislodged or unreadable over time. Contact Harsco Industrial, Patterson-Kelley toll-free at (877) 728-5351 for replacement labels.

2.5 SAFETY PRECAUTIONS

Provide a suitable location for the boiler, away from normal personnel traffic, with adequate working space, adequate clearances, proper ventilation and lighting, with a structure sufficiently strong and rigid to support the weight of the boiler, all piping, and accessories.

2.5.1 Electrical Hazards



- Shock hazard! Properly lockout/tag out the electrical service and all other energy sources before working on or near the boiler.
- Shock hazard! Boiler is not rated for wash-down service. Do not spray water directly on this boiler or on any electrical components.
- Electrical Hazard! Do not alter wiring connections.

2.5.2 Burn, Fire, and Explosion Hazards



General Warning

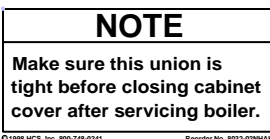


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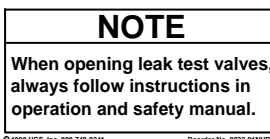


Hot Surface



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- Burn, fire, and explosion hazards! Installation must be in strict conformance to all applicable codes and standards including NFPA 54, ANSI Z223.1 and CAN/CGA B.149, latest edition. Install all required vent lines for gas devices. Refer to Section 3.6.2 below.
- Hazard from incorrect fuels! Possible fire, explosion, overheating, and damage. Do not use any fuels except the design fuel for the unit.
- Over fire hazards! High pressure in gas or propane supply could result in over firing of other devices supplied from the same source.
- Fire and explosion hazards! Close the main gas shutoff before servicing boiler.
- Fire and explosion hazards! Do not store or use gasoline or other flammable vapors or liquids in the vicinity of this or any other gas fired appliance.
- Burn hazard! Possible hot surfaces. Do not touch the exhaust vent during firing operation. Use only factory recommended vent components.
- Burn hazard! Pipes, vents, and boiler components could be hot. Do not touch piping or exhaust vent surfaces during operation or immediately after shutdown of the boiler.
- Burn hazard! Hot fluids. Allow boiler to cool before servicing or draining boiler.
- Fire and explosion hazards! Use caution when servicing burner. Propane (LPG) is heavier than air and may linger in the combustion chamber, vent lines, or elsewhere.

- Gas leak hazard! Make sure all connections and unions to main burner are tight when reassembling the burner. These connections cannot be tested after the burner is assembled.
- Gas leak hazard! All threaded gas connections must be made using a pipe compound that is resistant to liquefied petroleum. **Do not** use Teflon™ tape on threaded gas piping.
- Gas leak hazard! If there is a smell of gas, shut down the boiler and obtain immediate assistance from trained service personnel and/or your local fire department.

⚠ WARNING	Gas may lose its odor. Proper gas sensing equipment and procedures should be used for leak checks.
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- Over fire hazard! Possible fire and explosion from excess gas pressure. Make sure the gas inlet pressure does not exceed 14" W.C. to the regulator.
- Over fire hazard! Possible fire and explosion. Possible malfunction of regulators and/or motorized gas valves. Maintain all gas train components in good condition. Do not alter wiring connections. Annual inspection by factory-trained personnel for proper set-up and operation is recommended.
- Over fire and under fire hazards! Possible fire, explosion, overheating, and component failure. Do not attempt to adjust firing rate of the boiler. The firing rate must be adjusted **only** by factory trained personnel.

2.5.3 Crush Hazards



General Warning

- Lifting hazards! Use properly rated lifting equipment to lift and position the boiler. The load is unbalanced. Test balance before lifting 3 ft. above the floor. Do not allow personnel beneath the lifted load. Refer to approximate weights in the table at right:

Boiler Size	Weight in Pounds
700,000 Btu	595
1,000,000 Btu	595
1,200,000 Btu	685
1,500,000 Btu	985
1,700,000 Btu	990
2,000,000 Btu	1,025

- Bump hazard from overhead piping. Install piping with adequate vertical clearance.

2.5.4 Chemical Hazards



General Warning

- Environmental hazard! The motorized gas valves may contain hydraulic oil. Use safe procedures for the disposal of all lubricants.
- Chemical hazards from cleaning products. Use caution when cleaning the system. The use of professional assistance is recommended. Use safe procedures for the disposal of all cleaning solutions.

2.5.5 Pressure Hazards



General Warning

- Pressure hazard! Hot fluids. Install isolation valves on boiler water inlet and outlet. Make sure isolation valves are closed before servicing boiler.
- Pressure hazard! Hot fluids. Annually test safety relief valve for proper operation. Do not operate boiler with faulty relief valve.

2.5.6 Slip, Fall Hazards



- Tripping hazard! Do not install piping on floor surfaces. Maintain clear path around boiler.
- Slip and fall hazard! Use drip pan to catch water while draining the boiler. Maintain dry floor surfaces.
- Slip and fall hazard! **Do not** locate intake or exhaust terminations directly above a walkway; dripping of condensation can cause icing of the walking surface.

3 INSTALLATION

3.1 RECEIVING AND STORAGE

3.1.1 Initial Inspection

Upon receiving the boiler, inspect it for signs of shipping damage. Since some damage may be hidden, we recommend unpacking the boiler, removing the top and front covers to inspect the boiler. Pay particular attention to the control panel on the top of the boiler and the components mounted on the back, which may show damage from mishandling. Verify that the total number of pieces shown on the packing slip agrees with those actually received.

NOTICE! Note any damage, suspected potential damage, or shortage of materials on the freight bill and immediately notify the carrier. File all claims for shortage or damage with the carrier. Claims for hidden damages must be filed with your carrier within 7 days. The boiler carton is equipped with a "Tip (N) Tell". If "Tip (N) Tell" arrow point is blue, that indicates that the package has been on its side or tipped over in transit.

The exterior cabinet must be reasonably air-tight for the burner to operate correctly. Leaks caused by dents in the sheet metal or panels out of position may cause the limit control to illuminate the Low Air indicator light. Check to be sure that the mixer core in the top burner is centered and has not moved in shipment (see Section 5.2 "Cleaning the Burner" for proper location).

3.1.2 Storage Prior to Installation

If the boiler is not installed immediately, it must be stored in a location adequately protected from the weather, preferably indoors. If this is not possible, then it should remain in the shipping container and be covered by a tarpaulin or other waterproof covering.

NOTICE! Controls and other equipment that are damaged or fail due to weather exposure are not covered by warranty.

3.2 COMPLIANCE WITH CODES

The P-K THERMIFIC® boiler with standard components and many options complies with American National Standard/CSA Standard ANSI Z21.13/CSA 4.9, Gas-Fired Low Pressure Steam and Hot Water Boilers, latest edition.

The heat exchanger is constructed and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section IV for 160 psig maximum operating pressure and/or 250° F maximum operating temperature.

Installation of the boiler must conform to all the requirements of all national, state and local codes established by the authorities having jurisdiction or, in the absence of such requirements, in the U.S. to the National Fuel Gas Code, ANSI Z223.1/NFPA 54, latest edition. In Canada, the equipment shall be installed in accordance with the current Installation Code for Gas Burning Appliances and Equipment, CAN/CGA-B.149, and applicable Provincial Regulations, which should be carefully followed in all cases. Authorities having jurisdiction should be consulted before installations are made.

Where required by local codes, the installation must conform to American Society of Mechanical Engineers Safety Code for Controls and Safety Devices for Automatically Fired Boilers (ASME CSD-1).

In the Commonwealth of Massachusetts, see Massachusetts Installation & Owner’s Manual Supplement.

3.3 SETUP

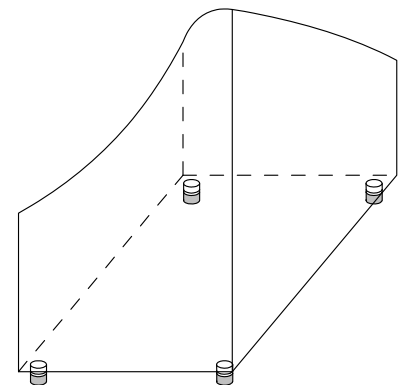
3.3.1 Foundation

Provide a firm, level foundation, preferably of concrete.

NOTICE! The boiler may be installed on a combustible floor; however, the boiler must **never** be installed on carpeting.

3.3.2 Placement

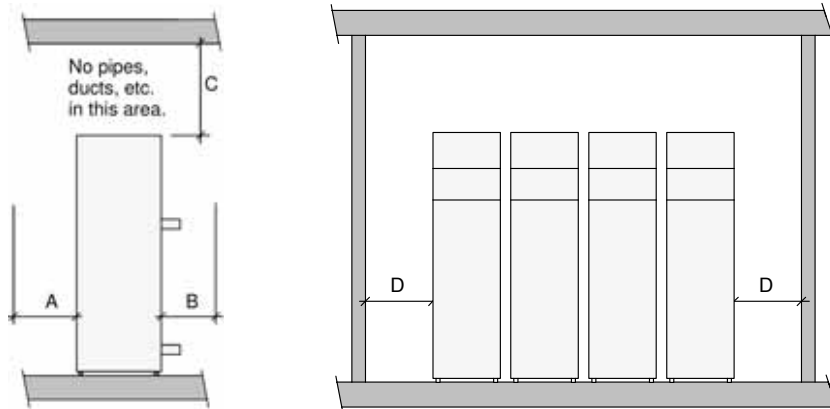
The boiler must be level to function properly. To assist in leveling the boiler, the four (4) leg bolts (1/2"- 13 NC) holding the boiler to the shipping skid must be reinstalled in the threaded legs on the bottom. The adjustable legs are also necessary to provide adequate floor clearance and prevent distortion of the cabinet, (twisting, etc.) in addition to leveling.



Adjustable Legs for Leveling and Floor Clearance

3.3.3 Clearances

If the boiler is to be installed near combustible surfaces, the minimum clearances shown in the table below must be maintained. Failure to provide for the service access clearances, even with non-combustible surfaces, may cause future problems servicing the boiler. The boiler must be installed in a space large in comparison to the boiler as described in Section 6.3 of the National Fuel Gas Code, ANSI Z223.1, latest edition.



Minimum Clearances from Adjacent Walls, Ceiling, and Obstructions

Type of Surface	Dimensions (inches)			
	A	B	C†	D
Combustible Surfaces	30	24*	30	24
Recommended Service Clearance	30	24	30	24**

† "C" dimension includes clearance to remove the burner. Do not put pipes, ducts, etc. in this area above the boiler.

* CSA minimum. Actual clearance depends upon venting requirements.

** Service access need be only on one side of a boiler or row of boilers.

Boilers may be installed immediately adjacent to each other. However, Harsco Industrial, Patterson-Kelley recommends this clearance between **each boiler** when there is insufficient access at the rear to allow for service and adjustment.

⚠ CAUTION	Bumping hazard from overhead ducts! Install all components with adequate vertical clearances.
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In Canada: The boilers are approved for installation with zero clearance to combustible surfaces, but 24 inch service clearances are recommended.

3.4 ELECTRICAL CONNECTIONS

The boiler is wired for 120 volts, single phase, 60 hertz. The electrical connections should be made in the junction box on the rear of the boiler. The total operating amperage is indicated on the rating nameplate. The 700 and 1000 series require less than 8 amps; while the 1500, 1700, 2000 series requires less than 12 amps. Before starting the boiler, check to ensure that the proper voltage and amperage is connected to the boiler.

An external electrical disconnect (not supplied with the boiler) with adequate overload protection is required. The boiler must be grounded in accordance with local codes or in the absence of such requirements, in the U.S. with National Electrical Codes, ANSI/NFPA No. 70, latest edition and in Canada, wire according to the current Canadian Electrical Code, Part I, CSA C22.1.

NOTICE! A dedicated earth ground (green wire) is required to avoid nuisance shutdowns. Do not ground through the conduit. It is also important that proper polarity be maintained.
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3.5 INLET AIR AND EXHAUST VENTING

3.5.1 Applicable Codes & Standards

CODES

United States:

NFPA 54/ANSI Z223.1

NFPA/ANSI 211

National Fuel Gas Code

Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances

Canada

CAN/CSA B149.1

Installation Codes for Gas Burning Equipment

STANDARDS

UL cUL 441 Type B Gas Vent (Category I)

These codes and standards contain information for the venting of gas fired appliances, including, but not limited to vent sizing, location, clearance to combustibles, and safe installation practices. The installation must comply with all applicable national, state, provincial and local codes.

⚠ WARNING

Design and installation of venting systems should be done only by qualified and knowledgeable venting systems personnel and in accordance with vent system manufacturer's installation instructions. Installing a boiler or vent system using improper installation methods or materials can result in serious injury or death due to fire or asphyxiation.

Before connecting a boiler to a venting system, it must be determined whether the boiler is to be installed in a conventional or Direct Vent configuration

⚠ WARNING

Use of improper vent material may result in rapid deterioration of the venting system. Improper vent installations may allow toxic fumes to be released into the living area. This may cause property damage, serious bodily injury or death.

NOTICE! Failure to use a proper vent system (types and materials), as described in this manual may void the boiler warranty.

3.5.1.1 Gas Vent Categories

Several codes and standards have categorized appliances in accordance with the flue gas temperature and pressure produced by the appliance. Categories are defined as follows:

- **Category I** An appliance that operates with a non-positive vent static pressure and with a vent temperature that avoids excessive condensate production in the vent.
- **Category II** An appliance that operates with a non-positive vent static pressure and with a vent temperature that may cause excessive condensate production in the vent.
- **Category III** An appliance that operates with a positive vent static pressure and with a vent temperature that avoids excessive condensate production in the vent.
- **Category IV** An appliance that operates with a positive vent static pressure and with a vent temperature that may cause excessive condensate production in the vent.
- **Direct Vent** An appliance that is constructed and installed so that all air for combustion is derived directly from outdoors and all flue gases are discharged to the outdoors.

3.5.1.2 Venting Materials for Flue/Exhaust Systems

P-K THERMIFIC® boilers are Category I appliances, as it is defined in NFPA 54/ANSI Z223.1. The P-K THERMIFIC® boiler may be vented in accordance with NFPA 54/ANSI Z223.1. Venting material may include Type "B" gas vent, chimney, single-wall metal pipe, listed chimney lining system for gas venting, or special gas vent listed for Category I appliances.

⚠ WARNING

Use of plastic vent will result in vent failure and may cause serious injury or death. This boiler is not suitable for use with any type of plastic or non-metallic venting.

In Canada, the boiler is certified for installation with a "Power Venter" by the Canadian Gas Association when installed with the "listed accessories." Consult your local distributor for information on proper selection.

⚠ WARNING The venting materials listed below are intended for the venting of gas burning appliances only. Do not use these venting materials for venting liquid or solid fuel (such as oil, kerosene, wood or coal) appliances

Maintain clearances to combustibles as listed in the vent manufacturer's installation instructions or as set forth in the codes and standards listed in this section.

Do not use these vent pipes for incinerators of any sort.

Table of Applicable Vent Materials by P-K THERMIFIC® Boiler Model

Model	B-Vent	Chimney	Single Wall Metal Pipe	Listed Gas Vent System	Special Gas Vent System	UL 1738 listed Cat II/III/IV
United States						
N700-N1000	X	X	X	X	X	
N1500-N2000 On-Off	X	X	X	X	X	
N1500-N2000 LHL	X	X	X	X	X	
N700-N2000 Sealed Combustion	No	No	No	No	No	X
Canada						
N700-N1000	X	X	X	X	X	
N1500-N2000 On-Off	X	X	X	X	X	
N1500-N2000 LHL	X	X	X	X	X	
N700-N2000 Sealed Combustion	No	No	No	No	No	X

3.5.2 Combustion Air

Combustion air must be free from dust, lint, etc. The presence of such materials in the air supplied to the burner could cause nuisance "Low Air" shutdowns or premature burner failure. The boiler should not be operated during construction while the possibility of drywall dust, demolition dust, etc. exists.

The combustion air supply must be completely free of chemical fumes which may be corrosive when burned in the boiler. Common chemicals which must be avoided are fluorocarbons and other halogenated compounds, most commonly present as refrigerants or solvents, such as Freon, trichloroethylene, perchloroethylene, chlorine, etc. These chemicals, when burned, form acids which quickly attack the boiler and the boiler stack. The result is improper combustion and premature boiler failure.

⚠ WARNING Under no circumstances shall the boiler room ever be under a negative pressure. Particular care should be taken when exhaust fans, compressors, air-handling units or other equipment may rob air from the boiler. Note that this equipment might be in rooms other than the boiler room.

3.5.2.1 Air Inlet Requirements – United States (NFPA 54/ANSI Z223.1 & NFPA/ANSI 211)

When air is supplied from inside the building, the total required volume shall be the sum of the required volume for all the appliances located in the mechanical room. Adjacent rooms furnished with fixed openings communicating directly with the mechanical room are considered part of the required volume. The minimum volume is 50 ft³ per 1000 Btu/hr (4.8 m³/kW) of installed appliance input capacity.

Openings used to connect indoor spaces to obtain the required minimum volume shall be sized as follows:

- When rooms are on the same floor, each opening shall have an area equal to 1 square inch for each 1000 Btu/hr (2200mm² / kW) of installed appliance input capacity, but not less than 100 square inches. One opening should commence less than 12 inches above the floor and the other less than 12 inches below the ceiling. The minimum dimension of air openings shall be 3 inches.
- When rooms are on different floors, each opening shall have an area equal to 2 square inches for each 1000 Btu/hr (4400mm² / kW) of installed appliance input capacity.

When combustion air is supplied from outside the building, the boiler room shall be provided with one or two openings to ensure adequate combustion air and proper ventilation.

When using one permanent opening, the opening shall commence within 12 inches of the ceiling and shall communicate directly with the outdoors or through a vertical or horizontal duct that communicates to the outdoors.

- Minimum free area of the opening is 1 square inch for each 3000 Btu/hr (700mm² / kW) of installed appliance input capacity, and
- Not less than the sum of the areas of all vent connectors in the room.

When using two permanent openings, one opening shall commence within 12 inches above the floor and the other within 12 inches below the ceiling, preferably on opposite walls. The openings shall communicate directly, or by way of ducts, with free outdoor air. The minimum net free area of the openings shall be calculated in accordance with the following:

- When air is taken directly from outside the building, each opening (minimum of two, as outlined above), 1 square inch for each 4,000 Btu per hour (550mm²/kW) of total boiler input is required.
- When air is taken from the outdoors through a vertical duct into the mechanical room, 1 square inch per 4,000 Btu per hour (550mm²/kW) of total boiler input is required.
- When air is taken from the outdoors through a horizontal duct into the mechanical room, 1 square inch per 2,000 Btu per hour (1100mm²/kW) of total boiler input is required.

NOTICE!
 1.The required size of openings for combustion and ventilation air shall be based on the net free area of the opening.
 2.Screens shall be not smaller than ¼”
 3.Motorized louvers shall be interlocked with the appliance so that they are proven open prior to main burner ignition and operation.

Table of US Minimum area of ventilation openings per boiler (sq inches)

P-K THERMIFIC® MODEL	AIR SOURCE					
	INDOOR AIR SUPPLY		OUTDOOR AIR SUPPLY			
	SAME FLOOR	DIFF FLOORS	ONE OPENING	TWO OPENINGS		
				DIRECT	VERT DUCT	HORIZ DUCT
N700	700	1400	234	175	175	350
N1000	1000	2000	333	250	250	500
N1500	1500	3000	500	375	375	750
N1700	1700	3400	567	425	425	850
N2000	2000	4000	668	500	500	1000

3.5.2.2 Air Inlet Requirements – Canada (CAN/CSA B149.1)

- A. Ventilation of the space occupied by fuel burning appliance(s) or equipment shall be supplied by a ventilation opening at the highest practicable point communicating with the outdoors. The total cross sectional area of the ventilation opening must be either 10% of the net free area required for combustion air or 10 sq. in. (6500 mm²), whichever is greater.
- B. Use the following opening calculation for MACH® condensing boilers or MODU-FIRE® Forced Draft boilers:
- When combustion air is supplied for a forced draft burner by natural airflow from the outdoors and there is no draft regulator or draft hood in the same space, there shall be a permanent opening with a cross sectional area not less than 1 sq. in/ 30,000 Btu/Hr (70 mm²/kW) of the total rated input to the burner(s). This opening must not interfere with the ventilation air opening defined in paragraph A.
- C. Use the following opening calculation for P-K THERMIFIC® boilers or other natural draft or fan-assist appliances:
- When combustion air is supplied for natural or fan-assisted burners by natural airflow from the outdoors, there shall be a permanent opening with a cross sectional area not less than 1 sq. in/ 7000 Btu/Hr (321 mm²/kW) up to and including 1,000,000 Btu/Hr plus 1 sq. in. / 14,000 Btu/Hr (155 mm²/kW) in excess 1,000,000 Btu/Hr. This opening must be either located at or ducted to a point not more than 18 in. (450 mm) or less than 6 in. (150 mm) above floor level. This opening is in addition to the ventilation air opening defined in paragraph A.
- D. When combustion air is supplied by natural airflow into a space containing both types of appliance described in paragraphs B and C, the cross sectional area of the opening shall be not less than the sum of the cross sectional areas for all appliances in the space as calculated by the applicable method . This opening is in addition to the ventilation air opening defined in paragraph A.
- E. When a duct is used to meet the requirement for combustion air supply, as described in paragraphs A through D, above, the opening of the duct shall be located so there is no possibility of cold air affecting steam or water piping, electrical equipment or mechanical equipment.
- F. When combustion air is supplied by mechanical means, an airflow-sensing device must be installed. It must be wired into the pre-ignition limit string to prevent the burner from starting or to stop an operating burner in case of air supply failure.
- G. When all combustion air is supplied through a make-up air heater, and the appliance is interlocked to the heater, the requirements of paragraphs A through F do not apply.

NOTICE!

1. The free area of a combustion air supply opening is calculated by deducting the blockage area of any fixed louvers, grilles or screens from the total area of the opening.
2. Screens shall be not smaller than ¼"
3. Motorized louvers shall be interlocked with the appliance so that they are proven open prior to main burner ignition and operation

Table of Canadian Minimum Area of Combustion and Ventilation Air Openings

P-K THERMIFIC® Model #	Input Btu/Hr	Required Combustion Air Opening		Ventilation Air Opening	
		in ²	mm ²	in ²	mm ²
N700	700,000	100	64,516	10	6,452
N1000	1,000,000	143	92,257	14.3	9,226
N1500	1,500,000	179	115,484	17.9	11,548
N1700	1,700,000	193	124,516	19.3	12,452
N2000	2,000,000	214	138,064	21.4	13,806

3.5.3 Flue Venting

P-K THERMIFIC® boilers are Category I appliances, as defined in ANSI Z21.13/CSA 4.9, latest edition. The P-K THERMIFIC® boiler may be vented with any venting systems meeting the requirements of Category I venting systems as specified in the latest edition of NFPA 54/ANSI Z223.1 in the US or the latest edition of CAN/CSA B-149.1 in Canada.

This boiler is suitable for use with Type "B" vent.

The exhaust vent can be run horizontally or vertically.

Vent installations shall be in accordance with NFPA54/ANSI Z223.1, the National Fuel Gas Code, or CAN/CSA-B149.1, the Natural Gas and Propane Installation Code, or applicable provisions of the local building codes.

If the boiler is installed using sealed combustion / direct vent, see Section 3.5.5.

3.5.3.1 Vent Sizing

The vent must be sized in accordance with the ASHRAE Systems and Equipment handbook, Chapter 30 or according to the vent manufacturer's recommendations. When using manufactured venting systems, consult your vent supplier for correct sizing and structural support requirements. Vent diameter is dictated by the length and height of horizontal and vertical portions of the vent installation and materials of construction.

Table of Vent Design Parameters

P-K THERMIFIC® Model	Stack Draft	Stack Temperature	CO ₂ Natural Gas	CO ₂ LP Gas
N700-N2000	-0.04"	325°F	7.6%	8.9%

Design calculations should be based on a negative 0.04" W.C. with a stack temperature of 325° F (gross) and a CO₂ level of 7.6%; (these values are to be used for vent sizing calculations.) The **maximum** allowable length of the vent duct, including the boot tee/135° tee (not a standard tee) and the termination is 100 equivalent feet. See the table below for the equivalent length of fittings used in the venting system

Approximate Equivalent Length of Fittings

Fitting Description	Equivalent Length
90° Elbow	10 feet
45° Elbow	5 feet
Rain Cap*	10 feet
Open Termination	10 feet
Boot Tee/135° Tee	10 feet
Standard Tee used as a Vent Termination	10 feet

* Low loss rain cap (see illustration in Section 3.5.3.5)

3.5.3.2 Exhaust Vent Connection at the Boiler

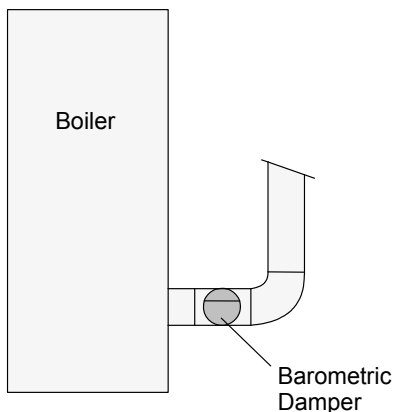
The connection from the boiler to the vent should be as direct as possible and the upward slope of any horizontal breeching should be at least 1/4 inch per linear foot. This boiler should not be connected into any portion of a mechanical draft system operating under positive pressure. Provisions must be made to maintain required clearances to combustibles.

NOTICE! The collar is not designed to support the weight of the vent. Assure that the weight of the vent is **not supported** by the boiler vent collar.

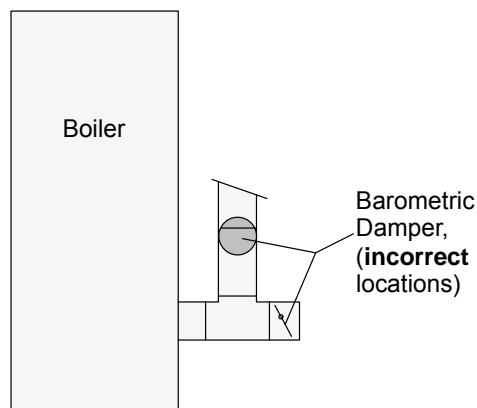
NOTICE! If using manufactured vent, assure that it is supported in accordance with the vent manufacturer's requirements.

3.5.3.3 Barometric Damper

Venting installations may require a barometric damper for smooth operation. A barometric damper is supplied with each boiler, and when used, should be installed according to the following guidelines.



Correct Damper Location



Incorrect Damper Locations

1. The barometric damper must be located immediately after the flue connector (left drawing above).
2. The damper may be located in either the left or right side of the horizontal section of stack.
3. In a multiple boiler installation, one barometric damper must be installed with each boiler.

Be sure that the damper is mounted horizontally (never vertically). Be sure to remove all three red stops from the damper before start-up. The damper door should swing freely. Carefully follow all the instructions provided with the barometric damper.

⚠ WARNING To avoid spillage into the boiler room of dangerous flue gas containing carbon monoxide, the opening in the damper (draft control gate) must never face against the flow of flue gas.

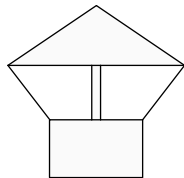
3.5.3.4 Horizontal to Vertical Transitions

The turn from horizontal to vertical should be made with two 45° ells, a long radius 90° ell, or a 135° boot tee. Do not use "short radius" ells.

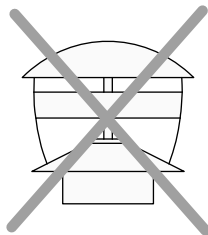
3.5.3.5 Vent Termination

The vent may be terminated with either no cap or a low-loss (non-restrictive) cap of adequate capacity. The cap must be approved by the vent manufacturer for use with their product.

Correct Listed Termination

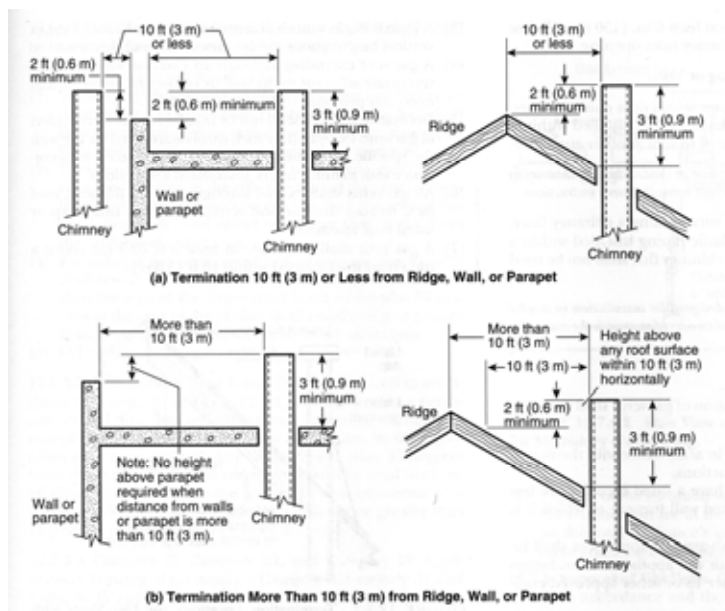


Incorrect Termination (too restrictive)



3.5.3.6 Required Clearances

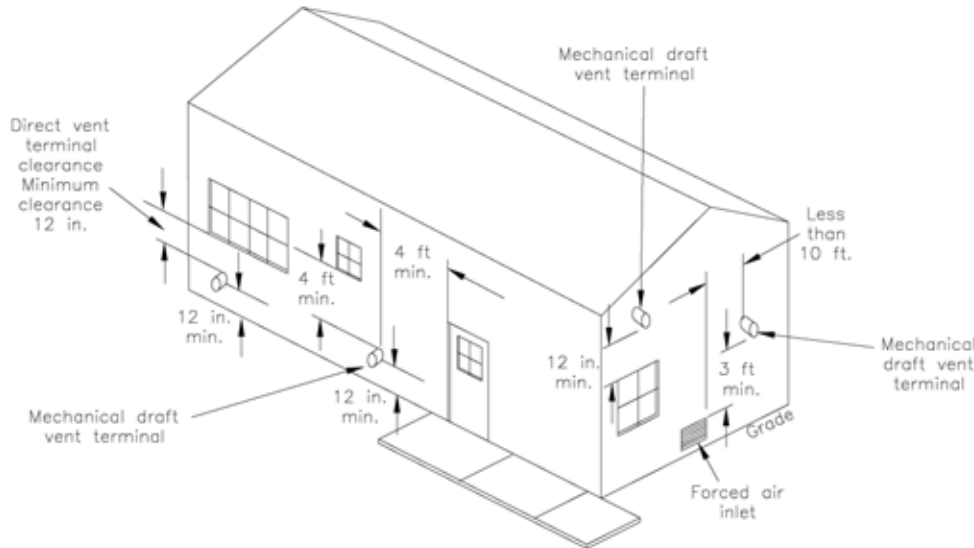
The vent must extend at least three (3) feet above the roof, or at least two (2) feet above the highest part of any structure within ten (10) feet of the vent (see diagram below):



Reference: NFPA 54/ANSI Z223.1
National Fuel Gas Code

To prevent the possible re-circulation of flue gases, the vent designer must take into consideration such things as prevailing winds, eddy zones, building configurations, etc. Harsco Industrial, Patterson-Kelley cannot be responsible for the effects such adverse conditions may have on the operation of the boilers. Dimensions listed above are minimums and may not be sufficient for conditions at a specific job site.

Provide clearances between combustion air intake, exhaust vent, roof and wall surfaces, doors and window as illustrated below. Also, provide clearances at least 2 feet above the expected snow line.



Exit Terminals of Mechanical Draft and Direct Vent Venting Systems
Reference: NFPA 54/ANSI Z223.1 National Fuel Gas Code

3.5.4 Fresh Air System (Ducted Combustion Air)

In some instances compliance with ANSI Z21.13 may not be required, in which case a "fresh air system" may be used. Consultation with qualified professionals is required to determine whether a "fresh air system" is suitable for any particular application and in compliance with all applicable codes and regulations.

All flue gas outlet (exhaust vent) material for a fresh air system must be certified for use with a Category I Appliance. (Standard B-vent is approved.) The exhaust vent may be run horizontally or vertically. Proper vent sizing by the vent manufacturer's recommendation must be followed.

3.5.5 Sealed Combustion/Direct Vent Systems

P-K THERMIFIC® boilers are certified for operation with a sealed combustion air inlet and a sealed non-pressurized venting system. These models are designated by the prefixes SN or SD

A sealed combustion system employs an air intake duct leading directly from outdoors to the boiler and an exhaust vent terminating outdoors. Air flow through the system is maintained by the combustion air fan and the stack draft. An exhaust fan is not required.

3.5.5.1 Sealed Combustion Intake Duct Materials and Sizes

The air intake duct can be fabricated from PVC, CPVC, single wall galvanized steel, or other suitable materials. The duct must be rigid enough to maintain the full required cross sectional area under all operating conditions. Proper sealing of the intake ductwork is necessary to prevent infiltration of air from conditioned space. Joints in PVC or CPVC must be cemented. For galvanized duct, wrap each joint and seam with adhesive aluminum tape or other sealant. Connect the air supply duct to the inlet air collar on the boiler. Securely fasten and seal the duct to the collar. The installation of a bird screen on the intake termination is recommended. Ensure that the screen does not become blocked with snow, ice, insects etc.

3.5.5.2 Sealed Combustion System Design - Pressure Drop

The air inlet duct system shall be designed for a maximum pressure drop of 0.05" W.C. at the given air flow, taking into account the equivalent length of all fittings. The equivalent length method is ONLY for use with a single boiler system. For multiple boiler systems, the air inlet duct system must be designed by a qualified ventilation professional.

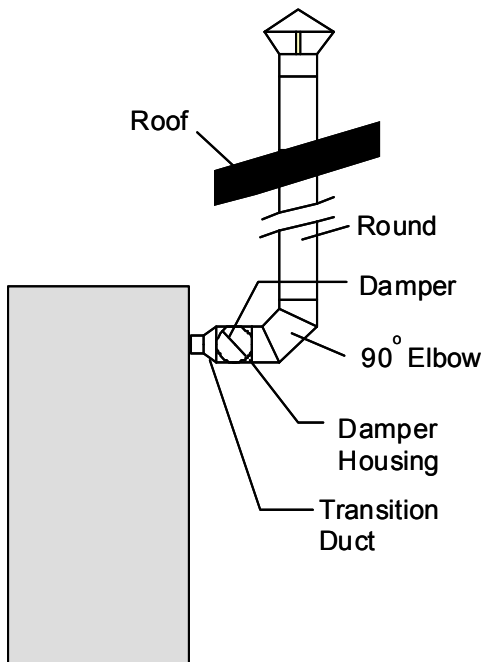
Combustion Air Requirement, SCFM

Series	Series	Series	Series	Series
700	1000	1500	1700	2000
170	251	364	413	501

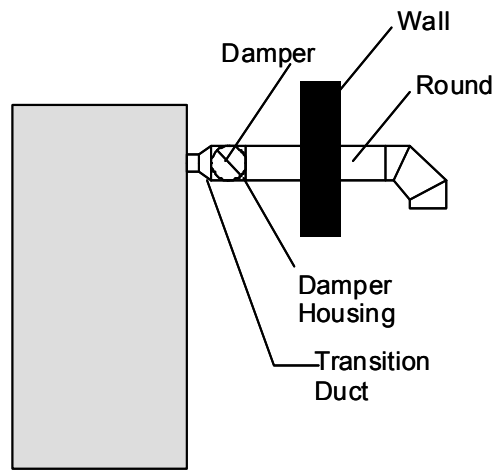
Equivalent Length of Fittings

Fitting Description	Equivalent Length
90° Elbow	10 feet
45° Elbow	5 feet
Air Intake	10 feet

3.5.5.3 Sealed Combustion Inlet Duct Assembly at the Boiler



Roof installation shown

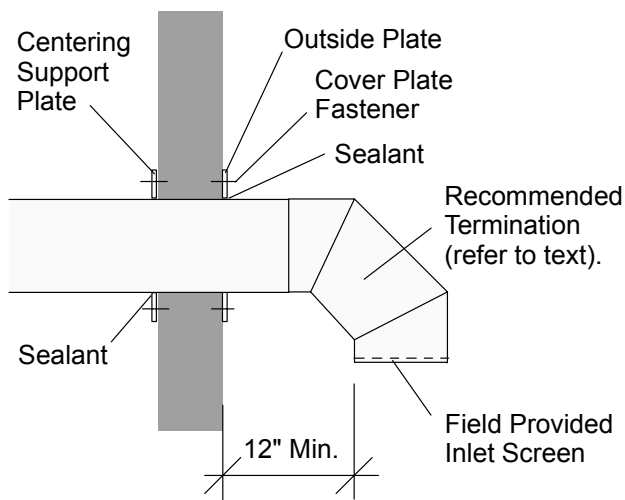


Sidewall installation shown

The sealed combustion boiler is equipped with a special collar attached to the air inlet opening on the back of the unit (at the blower housing on the 700 and 1000; at the back of the cabinet on the 1500, 1700 and 2000.). A separate box containing a 6 x 12 inch transition duct is sent with each boiler. Attach the 6 inch diameter end of the transition duct and the collar extension using a minimum of 4 sheet metal screws spaced approximately at 90 degree intervals. Attach the air supply duct to the 12 inch diameter end of the transition duct. All joints must be sealed.

NOTICE! Do not insulate the transition duct or extension.

3.5.5.4 Sealed Combustion Air Inlet Termination



The boiler combustion air inlet duct must be fitted with a termination device meeting the requirements of ANSI Z21.13. There are three recommended sidewall terminations:

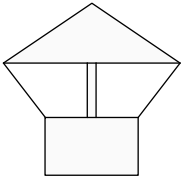
- Double wall B vent 90 degree elbow
- Two double wall B vent 45 degree elbows
- Schedule 40 PVC 90 degree elbow

The above terminations should be equipped with an inlet screen with sufficient cross-sectional area to allow for proper air flow. The termination must point down and be supported by a metal plate secured to the wall.

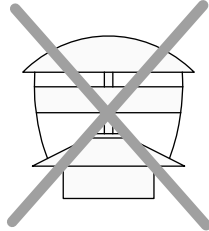
NOTICE! The chosen inlet termination must be included in the calculation of the maximum allowable equivalent length.

If the combustion air inlet duct is routed through the roof, the termination must be either the same type as described for a sidewall installation or a rain cap. The rain cap must be low loss cap similar to the illustration below.

Correct Listed
Termination



Incorrect
Termination
(too restrictive)



3.5.5.5 Sealed Combustion Inlet Damper and Control Panel (optional)

The inlet damper assembly and control panel prevents the flow of cold air through the boiler during the off cycle and helps prevent freeze up. These two items are **optional** in all installations.

The damper must be field installed into a section of horizontal or vertical inlet ductwork. Orient the damper such that the flow arrow points towards the boiler.

Field Wiring to Control Panel

The auxiliary control panel controls the inlet damper (if used). The auxiliary control panel does not have to be mounted on or near the boiler. It can be remotely mounted.

Use minimum 16GA MTW wire for all field wiring. See Section 6.1 for the logic and wiring diagrams for this auxiliary control panel and the sealed combustion boilers.

There are five (5) field run wires between the boiler and its associated auxiliary control panel; three (3) for main power supply and two (2) for boiler interconnect.

1. The boiler and the damper must be connected to the same power supply.
2. Remove the blue jumper wire in the terminal block on the boiler before connecting the wires from the auxiliary control panel to the boiler.

There are also five (5) field run wires between the auxiliary control panel and the inlet damper assembly; three (3) to the damper actuator and two (2) to the limit switch.

1. Terminals for the damper actuator:

- DO = Damper Open (Clockwise)
- DC = Damper Closed (Counter clockwise)
- DN = Neutral/Common

2. Terminals for the limit (end) switch

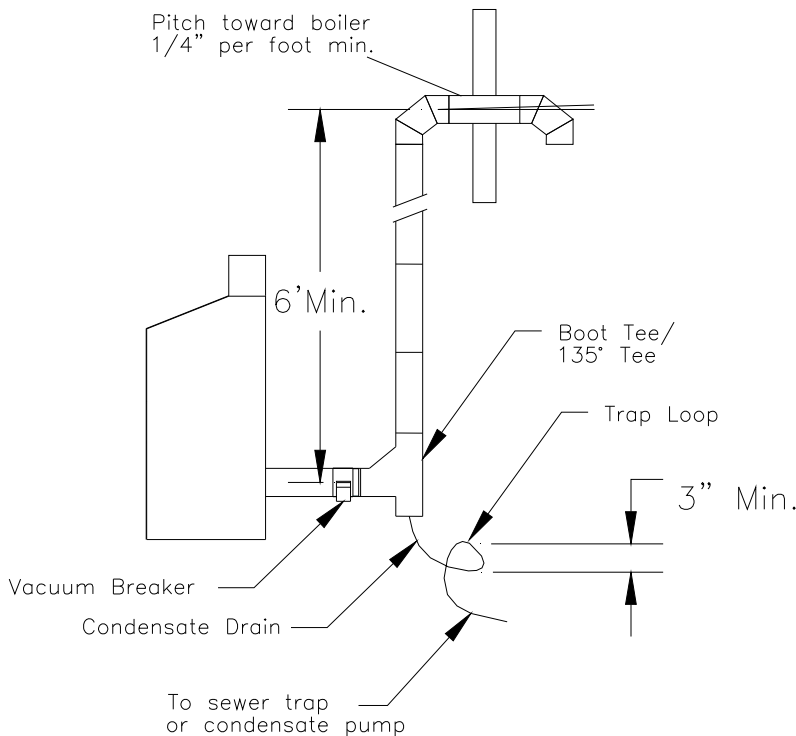
- SI = N.O. (Normally Open)
- S2 = Common

3.5.5.6 Sealed Combustion Exhaust Vent Materials and Sizes

All flue gas outlet (exhaust vent) material must comply with UL-1738 or ULC S636 (Category II/III/IV listed vent systems). The exhaust vent may be run horizontally or vertically. This boiler is certified for a 12" vent with a maximum length of **100 equivalent feet**.

NOTICE! Standard B-vent is **not** approved.

3.5.5.7 Sealed Combustion Exhaust Vent Connection at the Boiler



The vacuum breaker should be installed at the outlet of the boiler. It must be secured to the outlet collar by a minimum of 4 sheet metal screws spaced at approximately 90 degree intervals.

The silicone flap in the vacuum breaker must be facing down and flat (oriented in the horizontal plane). Gravity holds this flap closed against the metal grid.

The horizontal distance between the vacuum breaker and the tee must be between 2 and 3 ft.

In transitioning from the horizontal to the vertical, a boot tee/135° tee must be installed (not a standard tee).

NOTICE! A minimum vertical rise of 6 feet is required.

A drained tee is recommended for proper removal of the condensate. Corrosion resistant tubing rated for at least 500° F should be securely attached to the drain connection.

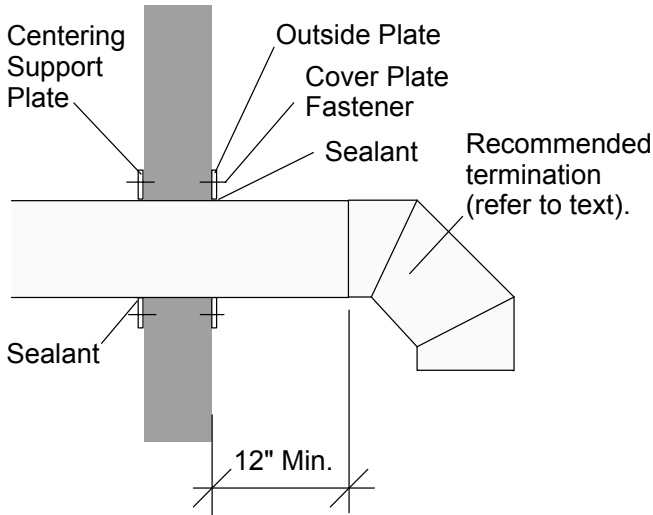
The condensate drain line can be routed to a sewer, trap or condensate pump. Consult the vent manufacturer's instructions for proper installation of drain line.

Do not locate sidewall terminations over area of pedestrian or vehicular traffic due to potential condensate dripping and ice build-up. See Section 3.5.3.6 Required Clearances for more information.

When joining double wall vent pipe and fittings, it is important to orient the female end of the section toward the boiler. The male end is positioned away from the boiler towards the vent termination. Follow the vent manufacturer's instructions for proper installation.

3.5.5.8 Sealed Combustion Flue Gas Termination

3.5.5.8.1 Sidewall Termination



The exhaust vent termination must be one of the following four approved sidewall terminations:

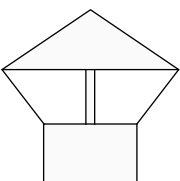
- 90° elbow pointing down, or
- Two 45° elbows pointing down, or
- 45° elbow pointing down, or
- Standard tee pointing up/down.

When installing a sidewall exhaust system the termination must be either backed by a metal plate secured to the wall as shown in the figure or incorporate an approved vent manufacturers wall penetration kit.

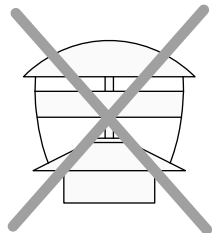
NOTICE! The equivalent length of the chosen termination must be included in the calculation of the maximum allowable equivalent length. See Section 3.5.3.1 for equivalent lengths.

3.5.5.8.2 Vertical Termination (including through the roof)

Correct rain cap,
unrestricted.



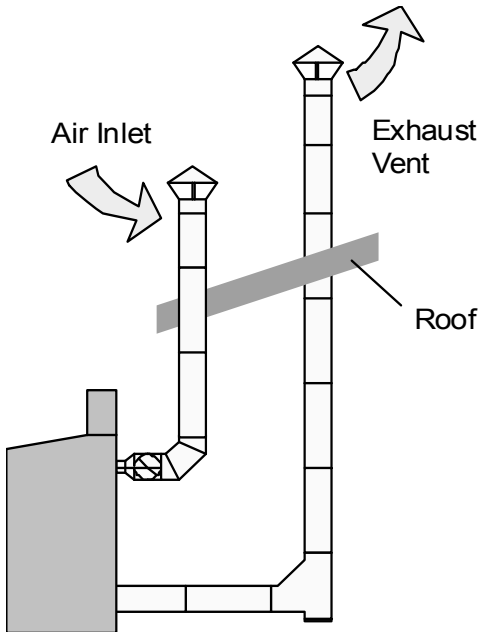
Typical incorrect
rain cap.



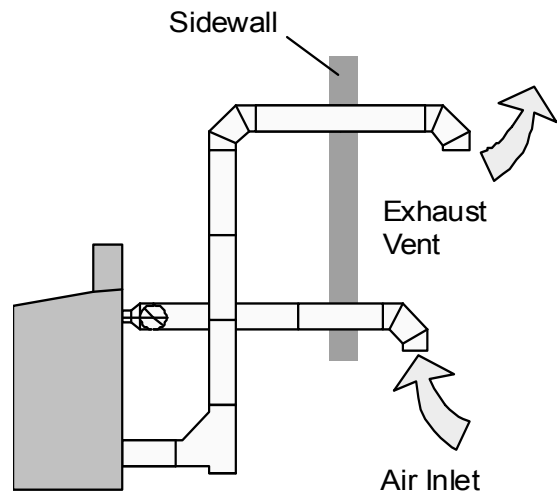
The preferred method to terminate the exhaust vent is with a rain cap. The rain cap should be an unrestrictive type similar to the figure above.

3.5.5.9 Sealed Combustion/Direct Vent System Configurations

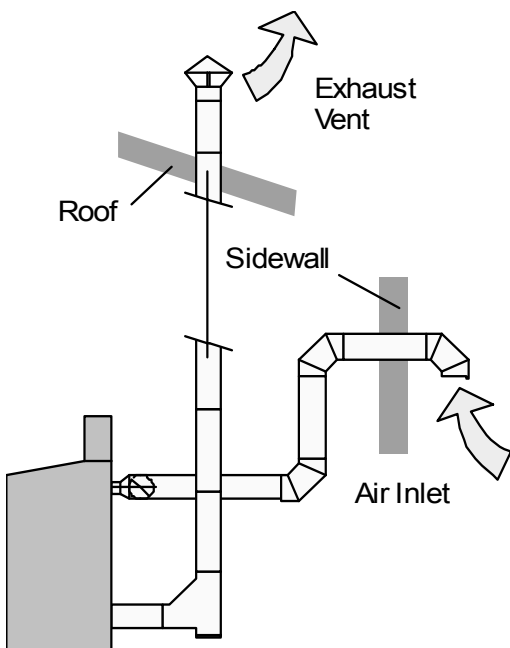
Four basic configurations are allowable for the combustion air inlet and flue gas exhaust vent, and are shown below.



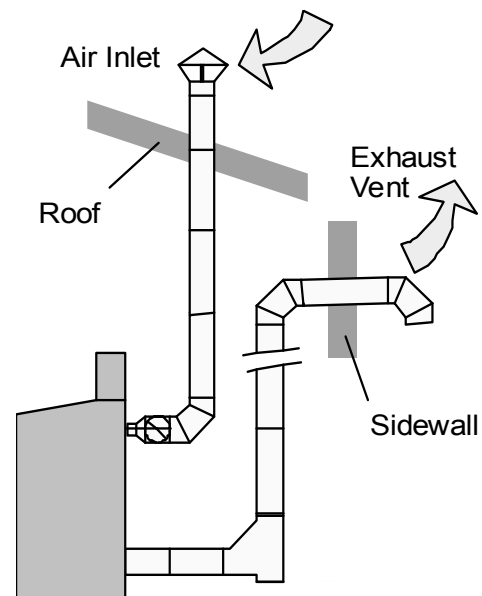
1. Both the combustion air inlet and flue gas exhaust through the roof.



2. Both the combustion air inlet and flue gas exhaust through the sidewall.



3. Combustion air inlet duct through the sidewall and flue gas exhaust through the roof.



4. Combustion air inlet through the roof and flue gas exhaust through the sidewall.

3.5.6 Venting for Multiple Boilers

The venting instructions in this manual apply to a **single** boiler.

Venting systems for multiple boilers must be designed by experienced and knowledgeable professionals. The venting system must prevent backflow of exhaust gas through idle boilers.

3.5.7 Removing an Existing Boiler

(from a common venting system)

When an existing boiler is removed from a common venting system, the common venting system is likely to be too large for proper venting of the appliances remaining connected to it.

At the time of removal of an existing boiler, while the other appliances remaining connected to the common venting system are not in operation, the following steps should be followed with each appliance remaining connected to the common venting system placed in operation:

1. Seal any unused openings in the common venting system.
2. Visually inspect the venting system for proper size and horizontal pitch and determine that there is no blockage or restriction, leakage, corrosion or other deficiency which could cause an unsafe condition.
3. Insofar as is practical, close all building doors and windows and all doors between the space in which the appliances remaining connected to the common venting system are located and other spaces of the building. Turn on clothes dryers and any appliances not connected to the common venting system. Turn on any exhaust fans, such as range hoods and bathroom exhausts, so they will operate at maximum speed. Do not operate a summer exhaust fan. Close fireplace dampers.
4. Place the appliance being inspected in operation. Follow the lighting instructions. Adjust the thermostat so that the appliance will operate continuously.
5. Test for spillage at the draft hood relief opening after 5 minutes of main burner operation. Use the flame of a match or candle or smoke from a cigarette, cigar or pipe.
6. After it has been determined that each appliance remaining connected to the common venting system properly vents when tested as outlined above, return doors, windows, exhaust fans, fireplace dampers and any other gas-burning appliance to their previous conditions of use.

Any improper operation of the common venting system should be corrected so the installation conforms with the National Fuel Gas Code, NFPA 54/ANSI Z223.1. When resizing any portion of the common venting system, the common venting system should be resized using the appropriate tables in Part II of the National Fuel Gas Code, NFPA 54/ANSI Z223.1.

3.6 GAS PIPING

Before making the gas hook-up, make sure the boiler is being supplied with the type of fuel shown on the boiler nameplate located on the back of the boiler.

The boiler shall be installed such that the gas ignition system components are protected from water.

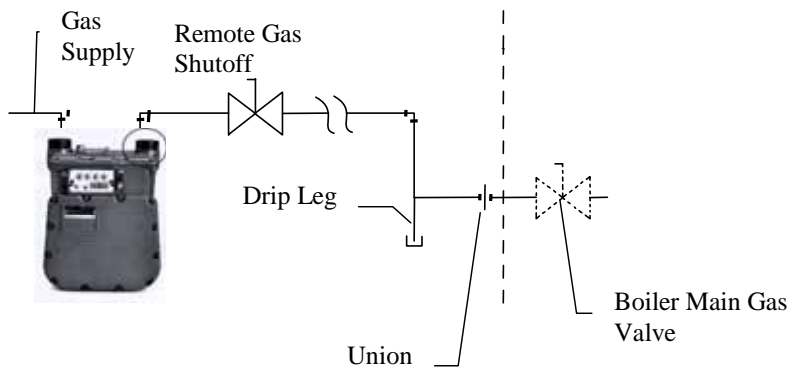
Gas supply pressure must be between 5" and 14" W.C. for natural gas and between 7" and 14" W.C. for propane. A low pressure option is available for natural gas through your local representative. If the available gas pressure exceeds 14" W.C., an additional intermediate gas pressure regulator of the "lock up" type must be provided to reduce the pressure to less than 14" W.C.

NOTICE! The gas train components are certified to handle a maximum inlet pressure of 14" W.C. (1/2 psig.).

⚠ WARNING All threaded connections must be made using a pipe compound that is resistant to the action of liquefied petroleum gases. **Do not use Teflon tape on gas line threads.**

3.6.1 Gas Supply Piping by Installer

Gas Piping Schematic



Install a sediment trap (drip leg) and a union connection ahead of the primary manual shutoff valve on the boiler. Gas piping should be installed in accordance with National Fuel Gas Code, NFPA 54/ANSI Z223.1, latest edition, and any other local codes which may apply in the U.S. In the Commonwealth of Massachusetts, the gas cock must be a “T-handle type.” Gas piping should be installed in accordance with CAN/CSA-B.149.1, latest edition in Canada.

NOTICE! See chart below for required pipe size, based on overall length of pipe from meter plus equivalent length of all fittings. Approximate sizing may be based on 1 cubic foot of natural gas per 1,000 Btu per hour input. For example, 900,000 Btu per hour requires about 900 cubic feet per hour. (See Typical Boiler Operating Conditions, Section 4.3 for more information.)

Pipe Capacity for Natural Gas

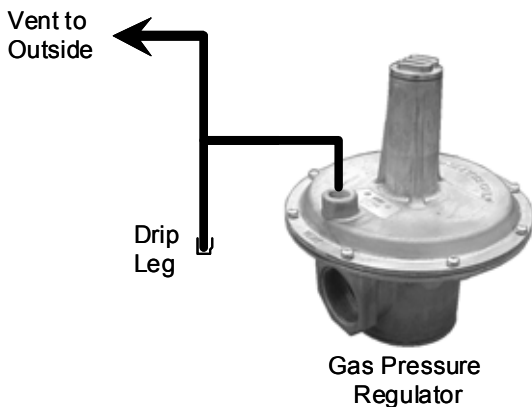
Nominal Iron Pipe Size (Inches)	Internal Diameter (Inches)	Equivalent Pipe Length		Maximum Capacity in Cubic Feet of Natural Gas per Hour Pressure Drop of 0.5 inch Water Column/Equivalent Length of Pipe (in feet)							
		90° Ell (Feet)	Tee (Feet)	20	40	60	80	100	150	200	
1-1/4	1.380	3.5	6.9	950							
1-1/2	1.610	4.0	8.0	1,460	990	810					
2	2.067	5.2	10.3	2,750	1,900	1,520	1,300	1,150	950	950	
2-1/2	2.469	6.2	12.3	4,350	3,000	2,400	2,050	1,850	1,500	1,280	
3	3.068	7.7	15.3	7,700	5,300	4,300	3,700	3,250	2,650	2,280	
4	4.026	10.1	20.2	15,800	10,900	8,800	7,500	6,700	5,500	4,800	

The boiler and all gas piping connections must be pressurized and checked for leaks before being placed into service. Pressurize with compressed air or inert gas if possible.

The boiler must be **disconnected** at the boiler manual shut-off valve (located at the end of the supplied gas train) from the gas supply piping system during any pressure testing of the system at pressures in excess of 1/2 psig (14" W.C.). Excessive pressure could cause component damage.

Some leak test solutions, including soap and water, may cause corrosion. These solutions should be rinsed-off with water after testing.

3.6.2 Gas Bleeds and Vents



The vent line connection on the main gas pressure regulator must be piped to outdoor air by the installer in accordance with the National Fuel Gas Code NFPA54/ANSI Z223.1, latest edition.

NOTICE! The installer must provide a drip leg, as shown, in all vent/bleed lines. All vent lines should be pitched up at all times to prevent building a trap into the vent line.

“Vent limiters” are NOT to be installed on the primary gas regulator on this boiler.

The pilot regulator is equipped with a vent limiting device and does not require external venting!

If a N.O. vent valve is provided, it must be vented independently.

On units supplied with diaphragm gas valves, the bleed vents have been factory-piped to terminate at the burner, as required by ANSI Z21.13. This feature provides combustion of any gas which leaks past a ruptured diaphragm during operation. When installing per ASME CSD-1, disconnect factory piped bleed vents and vent the diaphragm gas valves to outdoor air (field piping.)

CAUTION

All vent/bleed line must be piped by the installer in accordance with the National Fuel Gas Code NFPA 54/ANSI Z223.1, latest edition, which states:

“In the case of vents leading outdoors, means shall be employed to prevent water from entering this piping and also to prevent blockage of vents by insects and foreign matter.”

The National Fuel Gas Code Handbook goes on to say that “Insects, insect nests, ice, or freezing rain can block outdoor vents....”

3.7 BOILER WATER PIPING

3.7.1 Piping Design

3.7.1.1 Water Flow in System

Ideal operation of the P-K THERMIFIC® boiler consists of a 20° F temperature differential across the heat exchanger. The operating thermostat has an adjustable temperature differential. Incorrect flow may result in excessive short cycling of the boiler and eventual damage or premature failure of the equipment. Water flow parameters including minimum flow, maximum flow, temperature differentials and pressure differential charts are provided below.

In any case, Minimum Return Water Temperature should be greater than 130° F to avoid condensation on the outside of the heat exchanger or in the flue passages.

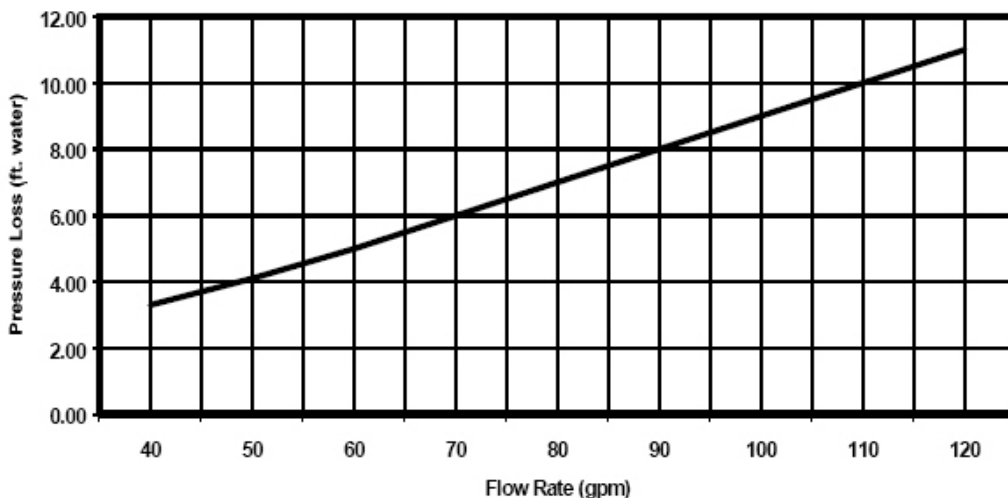
NOTICE! Return water temperatures below 130°F will cause condensation and may lead to premature failure of the heat exchanger.

Proper flow rates and return water temperature may be achieved through a combination of primary and secondary flow loops. Multiple zones and pumps may result in different flow rates at different times. Consideration must be given to all possible conditions and their consequences.

Water Flow Parameters – P-K THERMIFIC® N700-N1000 Boilers

P-K THERMIFIC® Model	Minimum Flow (GPM)	Delta T (°F)	Maximum Flow (GPM)	Delta T (°F)
N700	45	26.4	120	9.9
N1000	60	28.3	120	14.2

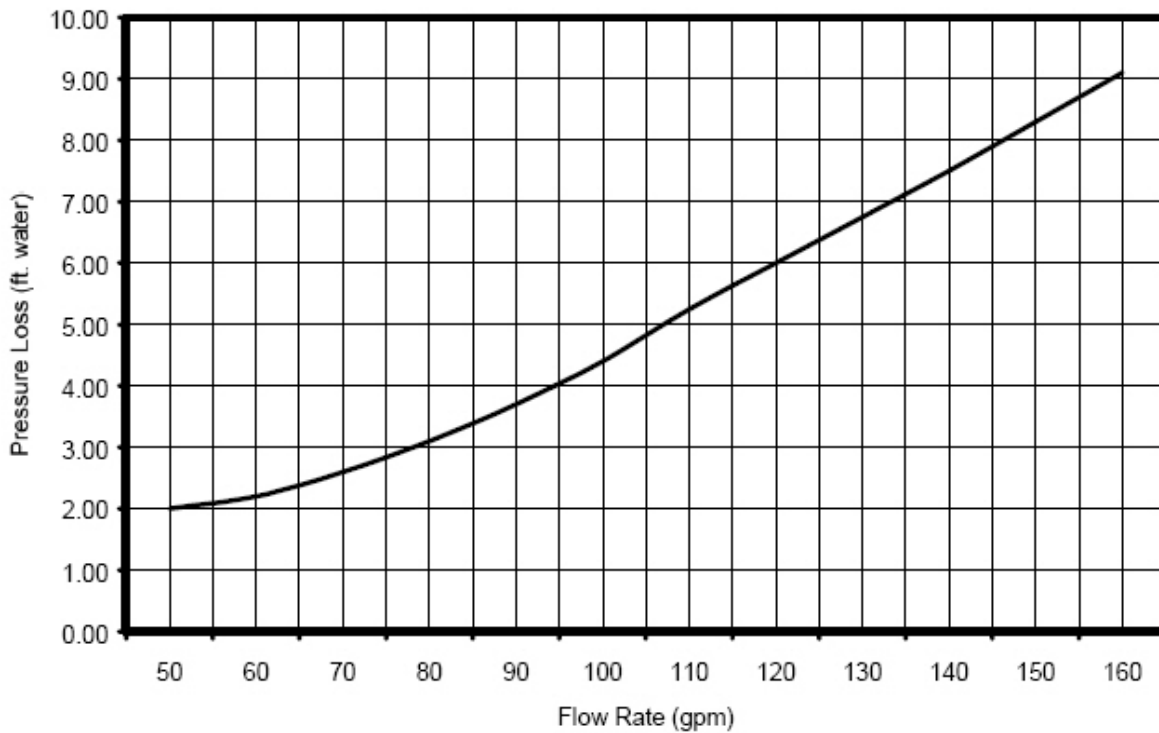
Pressure Drop Curve - P-K THERMIFIC® N700-N1000 Boilers



Water Flow Parameters – P-K THERMIFIC® N1500-N2000 Boilers

P-K THERMIFIC® Model	Minimum Flow (GPM)	Delta T (°F)	Maximum Flow (GPM)	Delta T (°F)
N1500	90	28.3	150	17.0
N1700	100	28.9	150	19.3
N2000	120	28.3	150	22.7

Pressure Drop Curve - P-K THERMIFIC® N1500-N1700-N2000 Boilers



3.7.1.2 Piping with Refrigeration Machines

When used with a refrigeration system, the boiler shall be installed so that chilled medium is piped in parallel with the boiler. Valves should be installed to prevent chilled water from entering the boiler when the system is operated in the cooling mode.

3.7.1.3 Piping with Air Handling Units

The boiler piping system of a hot water heating boiler connected to heating coils located in air handling units, where they may be exposed to refrigerated air circulation, must be equipped with flow control valves or other automatic means to prevent gravity circulation of the boiler water during the cooling cycle.

3.7.2 Boiler Inlet and Outlet Connections

All water connections should be in compliance with national, state, and local code requirements.

NOTICE! Pipe unions and isolating valves must be installed in both water connections for ease of service.

The bottom connection to the boiler is the **INLET** and must be used for the return from the system.

The top connection to the boiler is the **OUTLET** and must be connected as the supply to the system.

3.7.3 Boiler Water Piping by Installer

3.7.3.1 Strainer

To avoid possible contamination of the boiler with dirt, rust or sediment from the system, a strainer near the boiler inlet is strongly recommended. Even new systems may contain sufficient foreign material to eventually reduce the performance of the heat exchanger. Adequate circulation of good, clean water is essential to maximum efficiency and long life of the boiler (see Section 3.7.5).

3.7.3.2 Relief Valve and Piping

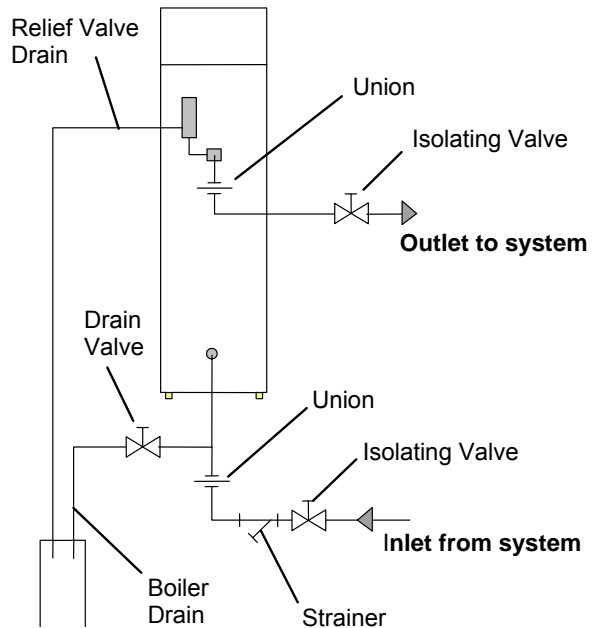
Each boiler is supplied with a pressure-relief valve sized in accordance with ASME requirements. The relief valve should be piped to a suitable floor drain. Reducing couplings or other restrictions are not permitted in the discharge line.

3.7.3.3 Low Water Cut-off

The boiler is furnished with a flow-switch-type low water cut-off as required by Section IV ASME Code; no field piping is required. If the flow switch does not sense water flow, the boiler will shut down and a red indicator will be illuminated on the control panel.

NOTICE! The flow switch only proves that flow is present. It does not prove adequate flow as required by this boiler.

Installation of an external low water cut-off or manual reset low-water switch may be required by certain codes or in certain installations. Consult your local code for details.



⚠ WARNING

Never install a valve that can isolate the flow switch (low water cut-off) from the boiler.

3.7.3.4 Drain Valve and Piping

An external drain connection is not supplied with the boiler. A drain valve must be provided and installed, by the installing contractor, near the inlet (system return) connection to the boiler and piped to a suitable floor drain. If necessary, the boiler can be completely drained through the bottom header by removing the flush plug in the front of the bottom header.

This plug may also be used to flush accumulated sediment from the bottom of the boiler.

⚠ WARNING

Burn hazard! Hot fluids! Use caution when servicing or draining the boiler.

3.7.4 Flushing and Filling

3.7.4.1 Flushing the System

Before filling the boiler, flush the system to remove the debris. Clean and flush old piping thoroughly before installing the boiler.

Under no circumstances should the hydronic system be flushed while the boiler is attached to the system since the debris or corrosion products could accumulate in the boiler and plug the boiler heat exchanger.

If the piping system attached to this unit will be chemically cleaned, the boiler must be disconnected from the system and a bypass installed so that the chemical cleaning solution does not circulate through the boiler.

3.7.4.2 Filling

To be sure that the boiler is not air-bound, open the pressure-relief valve located at the rear of the boiler. Leave the relief valve open until a steady flow of water is observed at the floor drain. Close the valve and finish filling the system.

3.7.5 Water Quality

3.7.5.1 Heating Boiler Applications (N-Series)

A heating boiler is designed to operate in a closed-loop system. As such, the system should be tight and not require make-up water. A high percentage of untreated make-up water can cause premature failure due to buildup of scale; such failure is not covered by warranty.

Scale can also reduce efficiency. For example, a scale thickness of 1/16" will result in a 12.5% loss of efficiency.

Note: see water quality standard in the back of this manual.

Consult your water conditioning or chemical treatment supplier for analysis and recommendations.

3.7.5.2 Hot Water Supply Boiler Application (D-Series)

A hot water supply boiler is designed to operate in an open system. The water quality should be within the guidelines established by the National Sanitation Foundation (NSF) or the local water authority guidelines.

Ideally hardness should be between 1 grain and 6 grains per gallon (between 17 ppm and 103 ppm). Use of excessively hard water may cause premature failure due to buildup of scale; such failure is not covered by warranty. Scale can also reduce efficiency. For example, a scale thickness of 1/16" will result in a 12.5% loss of efficiency.

Do not use deionized water. The amount of oils, fats, grease, and other organic matter should be limited to 10 ppm.

The flow for a D-series boiler should be within the top half of the range specified in Section 3.7.1.1. These ranges are:

Model #	Minimum Flow	Maximum Flow
D700	83	120
D1000	90	120
D1200	95	120
D1500	120	150
D1700	125	150
D2000	135	150

Consult your water conditioning supplier for analysis and recommendations.

3.8 PRE-START CHECK LIST

Before attempting to start the boiler, make sure the following items have been completed.

1. Inspect the burners to be sure nothing was damaged or knocked loose during shipment. Make sure that the mixer core in the top of the burner is centered in the burner head. Inspect the pilot line, main gas train and ignition electrode to be sure they were not damaged during shipment or installation. Check to see that the pilot is securely attached and that it is properly positioned to ignite the main burner
2. Flue gas from the boiler is properly vented (refer to Section 3.5).
3. Gas connection has been made, pressure tested for leakage, and the line purged of air. Make sure all required bleeds and vents have been installed (refer to Section 3.6).
4. Water connections are complete, and the boiler and system have been filled and purged of air (refer to Section 3.7).
5. Check boiler pump rotation and make sure the direction of water flow through the boiler is correct (refer to Section 3.7.2).
6. The boiler must be connected to a 120 volt / 60 Hz power source with proper polarity and dedicated ground. Provide a disconnect having adequate overload protection (refer to Section 3.4).
7. Combustion air openings are not obstructed in any way and have adequate capacity (refer to Section 3.5).
8. The boiler is placed the proper distance from any combustible walls or substances (refer to Section 3.3).

9. Relief valves have been piped to an acceptable drain (refer to Section 3.7).

3.9 SAFETY CHECKS

The following checks of safety systems must be made before putting the boiler into normal operation. Before firing the boiler refer to Sections 4.1 and 4.2 for information on the use of the controls, lighting, and shut-down procedures.

⚠ WARNING Never attempt to operate a boiler that has failed to pass all the safety checks described below.

⚠ WARNING After checking controls by manual adjustment, make sure they are always reset to their proper settings.

NOTICE! If the expected fault does not occur, call for qualified service.

3.9.1 Test of Ignition Safety System

Test the ignition system safety shutoff as follows:

1. Close the gas cock that is downstream from the two safety shut off valves (in the vertical line).
2. With the main gas cock (manual gas valve) open and the pilot gas cock open, the burner should be cycled on. When air flow is established and all the safety limits on gas pressure, water flow and temperature are satisfied, the blower will run and pre-purge the boiler.
3. When the pre-purge is complete, the ignition transformer and pilot will operate.
4. If a satisfactory pilot is established the pilot will remain on, alone, for 10 seconds.
5. After 10 seconds, the "Main" light (on flame safeguard) will go on. However, gas cannot flow to the burner with the gas cock closed (Step 1). The "Pilot" (on flame safeguard) will remain on, along with the "Main", for another 10 seconds and then go out. Since the main flame cannot be burning at this point, there will be no flame signal and the flame safeguard programmer will "lockout". The boiler will lockout on high gas pressure or main flame failure and display a red light. Either lockout will require a manual reset.

After completing this test, turn off the boiler and open the gas cock that was closed in Step 1.

3.9.2 Test of Low Water Cut-off (Flow Switch)

Test the low water cut-off flow switch as follows:

Operation of the switch can be checked by first turning the boiler off and then turning the boiler pump off, stopping water flow in the boiler. After turning off the pump, turn the boiler back on. It should not operate, and a red indicator for "Water Flow" should be illuminated. Do not shut the pump off while the boiler is operating.

Perform appropriate tests on any external probe-type low water cutoff.

3.9.3 Test of Temperature Controls

Fire the boiler and test the high limit control as follows:

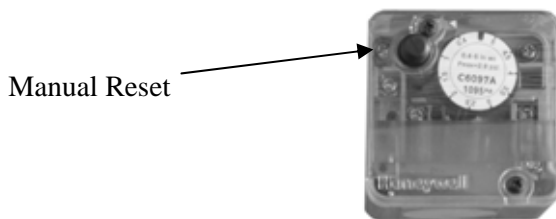
With the main burner operating, turn down the temperature setting on the "high-limit" thermostat until the main burner shuts off. The high-limit switch will trip and must be manually reset by pushing the reset button after testing.

A similar check should also be made for the "Operating Temperature" control. (See Section 3.10.2 for Adjustment Procedures for Lo-Hi-Lo units).

The green "Heat" indicator will go out during either test.

Readjust thermostats to desired operating temperature and set high-limit temperature, typically 20° F above operating temperature.

3.9.4 Test of Low Gas Pressure Switch



The boiler is furnished with a low gas pressure switch. The operation of this switch must be checked by slowly closing the main gas cock while the burner is operating. The switch should shut down the main burner. When the gas pressure switch opens, the "Gas Press." indicator will light. Upon reopening the main gas cock, the "Gas Press." indicator should remain on until the low gas pressure switch is manually reset.

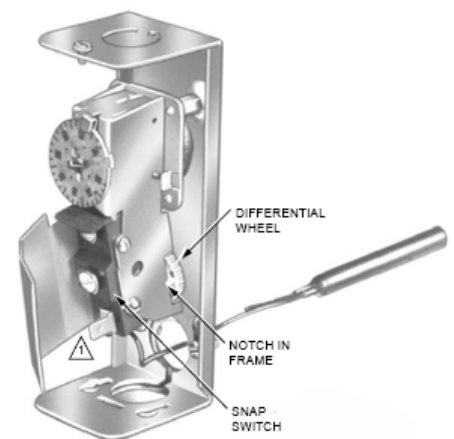
3.9.5 Test of High Gas Pressure Switch

The correct setting of the high gas pressure switch is essential for proper operation of the boiler. This switch is set by the factory at 4.0" W.C. and must not be changed. This switch must be checked by factory-trained personnel.

3.10 INITIAL ADJUSTMENTS

3.10.1 Operating Temperature Controller for On-Off P-K THERMIFIC® Boiler

The On-Off boiler is operated by an aqua stat that measures the outlet water temperature. The boiler is enabled when the water temperature is at or below the setpoint minus the differential, and disabled when the water temperature reaches the setpoint. The differential is changed via a rotating dial inside the aqua stat.



3.10.2 Operating Temperature Controller for Lo-Hi-Lo P-K THERMIFIC® Boiler

The Lo-Hi-Lo boiler is operated by a two stage temperature control that measures the outlet water temperature. The two stages of this boiler are operated by programming both relay set points and both differentials into the operating controller. Relay 1 turns the boiler on or off. Relay 2 is for high and low fire operation. The boiler will turn on at or below Relay 1 Setpoint minus its differential and turn off at Relay 1 Setpoint. The Hi fire operation of the boiler is energized at or below Relay 2 Setpoint minus its differential and de-energized at Relay 2 Setpoint.



Example:

Relay 1: Setpoint of 180°F with a 20°F differential

Relay 2: Setpoint of 170°F with a 15°F differential

Boiler will turn off at 180°F and turn back on at 160°F (180°F - 20°F).

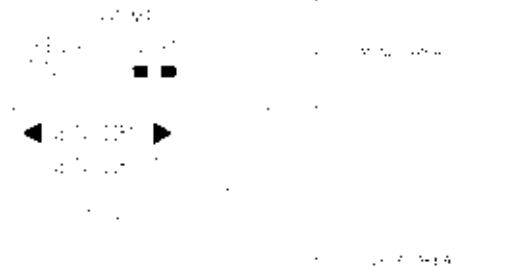
When boiler temperature reaches 170°F, unit will modulate to Low Fire. If boiler does not reach 180°F, it will continue to fire at Low Fire until temperature drops to 155°F (170°F - 15°F). It will then modulate to Hi Fire.

NOTICE! The set points and differentials should be adjusted for system requirements. Contact your local Harsco Industrial, Patterson-Kelley service representative for assistance adjusting your Lo-Hi-Lo operating temperature control to meet system requirements. Record settings in the following programming worksheet for future reference.

Programming the Honeywell T775B2032

Relay 1:
SETPOINT _____
DIFFRNTL _____

Relay 2:
SETPOINT _____
DIFFRNTL _____



Turn the boiler ON. The controller will display the HOME screen similar to one shown (right). The home screen consists of three (3) primary areas, the menu area (top), data area (middle) and 6 button keypad (bottom).

MENU AREA: The LCD displays the relays that are configured and whether or not they are active. On the unit furnished by PK, there should be two relays configured and active (ON).

DATA AREA: The LCD displays the sensors and output status. On the T775B, there should be one sensor (labeled Sensor A) with the current sensed temperature displayed. At the bottom of the DATA AREA, there should be a statement indicating DI OFF, meaning all digital input options are turned off.

SIX BUTTON KEYPAD: The 6 button keypad consists of a HOME button, MENU button and left and right arrow (◀ ▶) buttons and up and down arrow (▲ ▼) buttons. Pressing the ◀ or ▶ arrow buttons from the



HOME screen cycles through each modulating output displaying the values (these values cannot be changed using this screen). PK only provides one sensor (SENSOR A).

As shipped from the factory, the relays are set as follows:

Relay 1 SETPOINT 180 °F
DIFFRNTL 20 °F

Relay 2 SETPOINT 170 °F
DIFFRNTL 15 °F

To Change the Relay Setpoint, do the following:
From the HOME SCREEN:

Set SETPOINT and DIFFRNTL for Relay 1

1. Press MENU - PROGRAM should be displayed and highlighted
2. Press ► - RELAY 1 should be displayed and highlighted
3. Press ► - SETPOINT for Relay 1 should be displayed and highlighted
4. Press ► - SETPOINT value for Relay 1 should appear and be blinking
5. Use the ▲ ▼ buttons to raise or lower the set point temperature. Range is -40 °F to 248 °F (-40 °C to 120 °C).
6. Press ► - to accept change and/or display the next option.
7. After changing the set point and pressing ►, DIFFRNTL should be displayed and highlighted.
8. Press ► - DIFFRNTL value for Relay 1 should appear and be blinking
9. Use the ▲ ▼ buttons to raise or lower the DIFFRNTL value for Relay 1. Range is 1°F to 150°F (0.5°C to 66°C).
10. Press ► - to accept change and display the next option.
11. SENSOR ► should be displayed and highlighted

Set Relay 1 to SENSOR A

12. Press ► SENSOR A should be displayed and highlighted
 - If SENSOR A is highlighted, press ►
 - If SENSOR B is highlighted, press ▲ and then ►

Set SENSOR A to HEAT

13. HEAT/COOL should be highlighted and displayed
14. Press ► HEAT should be highlighted and displayed
 - If HEAT is displayed, press ►
 - If COOL is displayed, press ▲ and then ►
15. EXIT should be highlighted and displayed
16. Press MENU to get back to the Program Menu

Set SETPOINT and DIFFRNTL for Relay 2

17. PROGRAM should be displayed and highlighted
18. Press ► - RELAY 1 should be displayed and highlighted
19. Press ▼ - RELAY 2 should be displayed and highlighted
20. Press ► - SETPOINT for Relay 2 should be displayed and highlighted
21. Press ► - SETPOINT value for Relay 2 should appear and be blinking
22. Use the ▲ ▼ buttons to raise or lower the set point temperature. Range is -40 °F to 248 °F (-40 °C to 120 °C).
23. Press ► - to accept change and/or display the next option.
24. After changing the set point and pressing ►, DIFFRNTL should be displayed and highlighted.
25. Press ► - DIFFRNTL value for Relay 2 should appear and be blinking
26. Use the ▲ ▼ buttons to raise or lower the DIFFRNTL value for Relay 2. Range is 1°F to 150°F (0.5°C to 66°C).
27. Press ► - to accept change and display the next option.
28. SENSOR ► should be displayed and highlighted.

Set Relay 2 to SENSOR A

29. Press ► SENSOR A should be displayed and highlighted
 - If SENSOR A is highlighted, press ►
 - If SENSOR B is highlighted, press ▲ and then ►

Set SENSOR A to HEAT

30. HEAT/COOL should be highlighted and displayed
31. Press ► - HEAT should be highlighted and displayed
32. If HEAT is displayed, press ►
33. If COOL is displayed, press ▲ and then ►
34. EXIT should be highlighted and displayed
35. Press MENU to get back to the Program Menu
36. Press HOME – Should go back to the HOME screen.

To Check New Set Points:

1. From HOME screen, Press ► - Set Point of relay 1 should be displayed along with the actual sensed temperature.
2. Press ► - Set Point of relay 2 should be displayed along with the actual sensed temperature.
3. Press HOME. Set Up is complete.

3.10.3 Setting Combustion

NOTICE! Adjustments shall only be performed by service representative specifically trained and knowledgeable to perform maintenance on the Harsco Industrial, Patterson-Kelley P-K THERMIFIC® boiler. Verify proper operation after servicing.

NOTICE! A combustion analyzer must be used to adjust the boiler for local conditions.

The boiler is factory fire-tested and adjusted for proper combustion.

3.10.3.1 Setting the boiler pilot

Turn on the boiler. After purge, when the pilot lights, switch the “run/test” switch to “test”. During pilot, adjust the pilot gas pressure as needed. The pilot flame should be about the same size as the pilot tube for 1-2” and then swirl off to the right. The flame should look mostly blue with a trace amount of yellow. If

the pilot flame doesn't hold the same size as the tube, looks very lazy, and/or very yellow, you may have too much gas or some of the pilot air holes may be partially restricted with dirt. Correct as needed. If the boiler uses sealed combustion and will use very cold combustion air you may need to use a higher gas pressure for the colder weather to avoid nuisance pilot flame failures.

3.10.3.2 Setting the boiler combustion

Combustion adjustments on the P-K THERMIFIC® boiler is a three step process that involves air and gas pressure adjustments in the following sequence:

1. Set the approximate cabinet air pressure (see Section 3.10.3.3).
2. Set the gas pressure by adjusting the gas pressure regulator (see Section 3.10.3.4).
3. Adjust the combustion for local conditions (see Section 3.10.3.5).

Adjust the oxygen (O₂) reading to approximately 7.5%, which corresponds to approximately 50% excess air. If the boiler has a ducted air supply, a range of air inlet temperatures will occur over the heating season. A special setup table is shown in Section 3.10.3.6 below and must be followed.

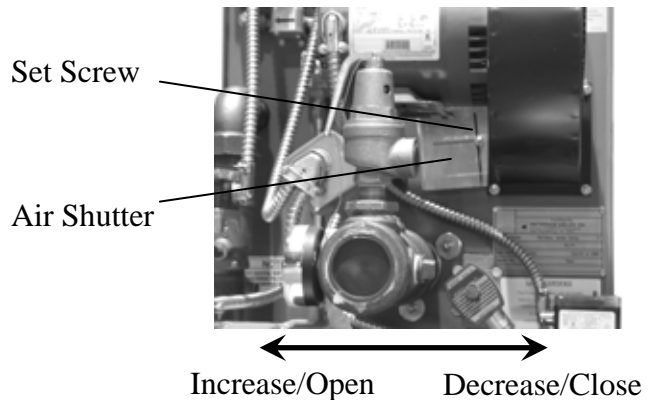
3.10.3.3 Cabinet Air Pressure Adjustment

The air flow is pre-set at the factory prior to shipment. Only minor adjustments should be required.

To set the approximate cabinet air pressure, lock the flame safeguard in test position during the purge cycle. Then adjust the air flow until the cabinet pressure is the same as shown on the "Factory Fire test" label.

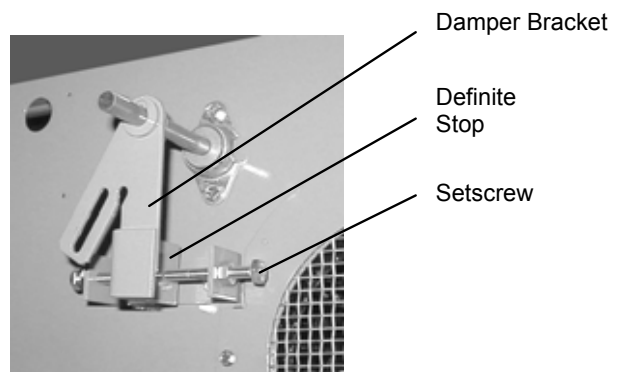
On/Off (700, 1000 Series only)

Loosen the setscrew on the air shutter and open or close the shutter as required to adjust the air flow. Re-tighten the holding screw after adjustment.



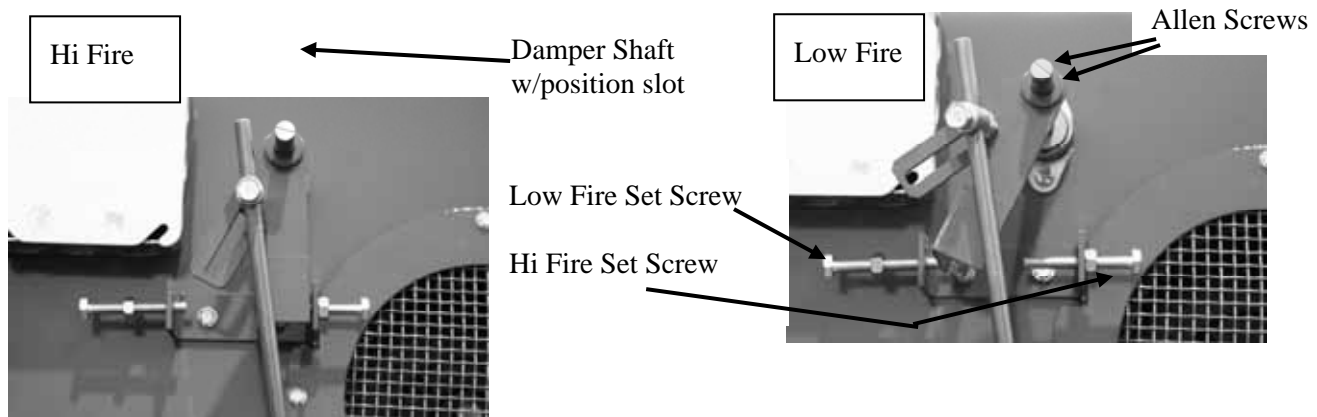
On/Off (1500, 1700, 2000 Series)

The setscrews on the damper bracket assembly hold the air damper in place. Loosen the nuts and rotate the setscrews as required for proper air flow. When the cabinet air pressure is correct, tighten each setscrew and lock it in place with the nut. Both setscrews must be touching the definite stop before they are locked in place. Do not adjust any other part of this mechanism.



Lo-Hi-Lo (1500, 1700, 2000 Series)

This is a two stage firing arrangement with the mechanical action provided by the two stage gas valve actuator via a vertical rod connected to the damper assembly shown below. The damper shaft is a horizontal shaft that enters the boiler (indicated in photo). Note the slot on the end of the shaft that indicates the position of the damper inside the boiler (i.e. horizontal is full open, vertical is closed). The boiler is factory fire-tested and adjusted for two firing rates: Hi fire (100% of rated input) and Low fire (60% of rated input).



Air adjustments corresponding to **both** Hi fire and Low fire are required. Adjust Hi fire air first, and Low fire air second.

Adjust Hi fire as follows:

Hi fire adjustments are made with the valve actuator in the Hi fire position. While in purge, set the flame safeguard to “TEST”. Grasp the damper rod with locking pliers (as shown in the photo right), loosen the two Allen screws (5/64”) on damper shaft, and make very small adjustment to the damper shaft position until proper cabinet air pressure is achieved.. Retighten the Allen screws.



CAUTION Do not attempt to adjust the linkage or vertical rod. Do not let go of the damper shaft during this operation.

- After damper shaft adjustments are complete, adjust the Hi fire setscrew until it just touches the definite stop and lock it with the nut.

NOTICE! Do not attempt to adjust hi fire by using the hi fire definite stop screw.

Adjust Low fire as follows:

Low fire adjustments are made with the valve actuator in the low fire position. Use the low fire stop screw (on the left) on the definite stop bracket to obtain desired Lo fire air and lock it with the nut.

After both adjustments are complete, return the flame safeguard to the run position and allow the boiler to start normally.

3.10.3.4 Gas Pressure Adjustment

See rating label for the minimum and maximum inlet gas pressure of the boiler. Each boiler is furnished with two plugged taps in the gas train for test gauge connections. One tap is located at the main gas cock for measuring the inlet gas supply pressure. The supply pressure during main burner operation must be greater than the minimum indicated on the rating label: 5" W.C. for natural gas, (4" W.C. for low pressure option), 7" W.C. for propane. The second tap is located downstream from the last main gas control where the gas line enters the back of the cabinet and is used for measuring the manifold gas pressure.

Fuel adjustments are made first at Hi fire and second at low fire. Hi fire gas pressure adjustments are made at the gas pressure regulator while the boiler is operating in hi fire. Low fire combustion adjustments are made second, with the valve actuator in the Low fire position. Low fire gas is set at the factory and cannot be adjusted.

Gas Pressure Regulator



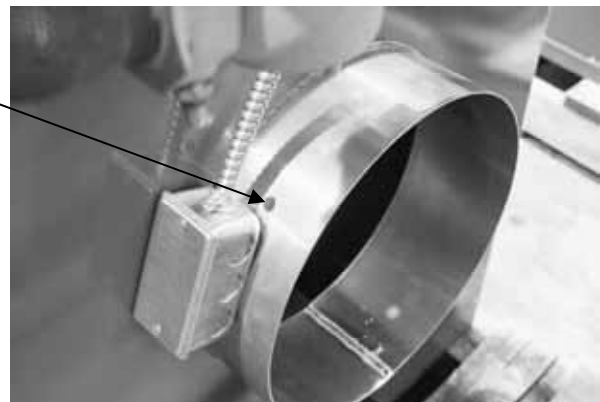
To adjust Hi Fire using the gas pressure, first connect appropriate pressure-sensing device (manometer) at the manifold tap, then remove cap from regulator. Turn adjusting screw clockwise to increase pressure, counter-clockwise to decrease pressure. The manifold gas pressure indicated on the "Factory Fire test" label (affixed on the back of the cabinet) should be used to achieve the proper firing rate of the individual boiler. Replace cap after adjustment.

If a replacement Lo-Hi-Lo actuator is required, follow the actuator manufacturer's instructions and pre-set the low fire setting of the actuator to the same position as the original actuator. This must be performed by qualified service personnel.

3.10.3.5 Adjust the combustion for local conditions

The final adjustment for the combustion is performed using a combustion analyzer. The analyzer probe should be inserted into the hole in the boiler vent outlet collar (shown right). The analyzer should be placed at the outlet, before the barometric damper or any other vent devices.

Put boiler in High fire. Adjust the gas pressure using main gas regulator adjusting screw to achieve an analyzer reading of 7.5% O₂ (allowable range is 6.5% to 8.0% O₂). Measure the stack draft. Verify that stack draft is between -0.02" W.C. and -0.1" W.C.



Put the boiler in low fire (Lo-Hi-Lo only), adjust the air pressure (as shown in Section 3.10.3.3) using the low fire set screw to achieve an analyzer reading of 7.5% O₂. Record all readings on the field fire test report and send to Harsco Industrial, Patterson-Kelley.

3.10.3.6 Sealed Combustion Operating Conditions

This burner is designed to operate at approximately 50% excess air at room temperature (70°F). Therefore, when taking combustion air from the outdoors in a direct vent system, adjustment of the combustion should not be made until the carbon dioxide or oxygen reading is referenced to these “standard” conditions as shown in the table.

The density of outdoor air will vary over the heating season. Colder air has a greater density than warm air and therefore contains more oxygen. Thus, the burner will run “leaner” in the colder temperatures of winter and richer in the warmer fall and spring shoulder seasons.

Identify the range of temperature operating conditions of your boiler. Write your 100° F outdoor air temperature range in the chart below. Start with the Minimum Outdoor Design Temperature at the top of the chart; and fill in the chart using 5° F increments. These temperatures correspond to an operational range of exhaust O₂ from 8.0% (coldest) to 6.0% (warmest).

When the chart is completed, find the current combustion air temperature on the chart. Use the corresponding combustion parameters to set up your boiler’s combustion. The changes in temperature during the heating season will cause the combustion exhaust to vary up and down the table.

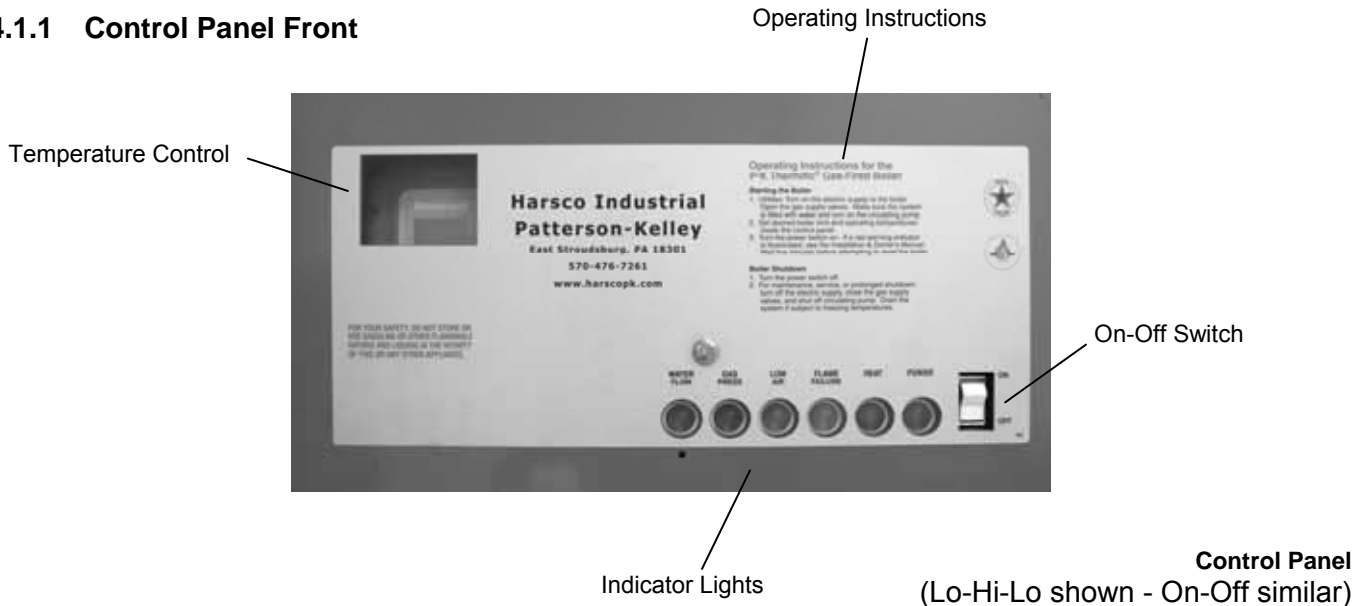
NOTICE! Measure combustion air temperature at the unit; **do not** assume the combustion air temperature is the same as the outside air temperature.

100° F outdoor air temperature range.	% O ₂	% CO ₂ (Nat Gas)
	8	7.2
	7.9	7.3
	7.8	7.4
	7.7	7.4
	7.6	7.5
	7.5	7.5
	7.4	7.6
	7.3	7.6
	7.2	7.7
	7.1	7.7
	7.0	7.8
	6.9	7.8
	6.8	7.9
	6.7	8
	6.6	8
	6.5	8.1
	6.4	8.1
	6.3	8.2
	6.2	8.2
	6.1	8.3
	6	8.3

4 OPERATION

4.1 GENERAL

4.1.1 Control Panel Front



Control Panel
(Lo-Hi-Lo shown - On-Off similar)

Become familiar with the basic operation of the boiler. The front of the control panel shows the operating instructions and a series of illuminated lights which indicate the status of the boiler.

4.1.2 Tests

All Harsco Industrial, Patterson-Kelley boilers are factory fire tested prior to shipment. This procedure includes testing of the limits and adjustment of combustion parameters specified in ANSI Z21.13/CSA 4.9, latest edition. This testing and setup information is recorded on the “Factory Firetest” label located on the back of the boiler.

4.2 LIGHTING AND SHUT-DOWN PROCEDURES

WARNING

Do not use this boiler if any part has been under water. Immediately call a qualified service technician to inspect the boiler and to replace any part of the control system and any gas control which has been under water.

4.2.1 Normal Lighting Procedure

1. Make sure the system is filled with water and water is circulating in the system. Turn on electrical supply and open the gas supply valves to the boiler.
2. Turn the on/off switch to the on position. If an error is indicated, see Section 5.6 of this manual to troubleshoot the problem and take the necessary corrective action before proceeding.
3. Set the desired high temperature limit and operating temperature.
4. Push the reset button on the flame safeguard programmer.
5. Push the reset button on the low and high gas pressure switches.
6. Check to be sure that the pilot has been established.

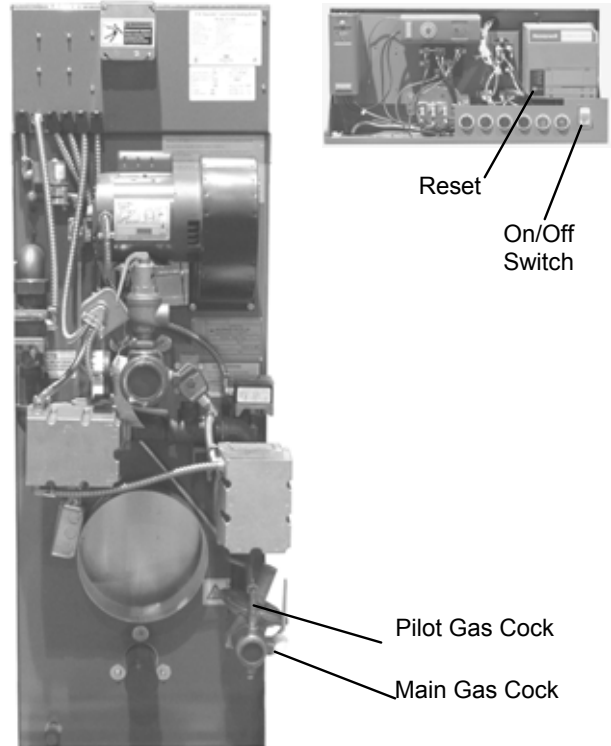
7. The controller will now complete the automatic firing sequence.

4.2.2 Normal Shut Down Procedure

1. Turn off the electric power using the on/off switch on the front of the boiler.
2. Close all manual gas valves (for extended shut-down only).

4.2.3 Emergency Shut Off

Main and pilot gas cocks should be closed immediately if an emergency situation occurs. These are shown in the picture above.



⚠ WARNING	If overheating occurs or the gas supply fails to shut off, do not turn off or disconnect the electrical supply to the pump. Instead, shut off the gas supply at a location external to the boiler.
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4.3 TYPICAL BOILER OPERATING CONDITIONS

Model Number		Input Rating (Btu/hr)	Natural Gas (1030 Btu/cu. ft.)		LP Gas (2500 Btu/cu. ft.)		Total Amperage (amps)
			Gas Rate (CFH)	Output Capacity (Btu/hr)	Gas Rate (CFH)	Output Capacity (Btu/hr)	
700		700,000	680	595,000	278	609,000	8
1000		1,000,000	971	850,000	397	870,000	8
1500		1,500,000	1,456	1,275,000	595	1,305,000	12
1700		1,700,000	1,650	1,445,000	674	1,479,000	12
2000		2,000,000	1,942	1,700,000	793	1,740,000	12
1500-2	max	1,500,000	1,456	1,275,000	595	1,305,000	12
	min	900,000	874	765,000	357	783,000	12
1700-2	max	1,700,000	1,650	1,445,000	674	1,479,000	12
	min	1,020,000	990	867,000	404	887,400	12
2000-2	max	2,000,000	1,942	1,700,000	793	1,740,000	12
	min	1,200,000	1,165	1,020,000	476	1,044,000	12

5 MAINTENANCE

5.1 MAINTENANCE AND INSPECTION SCHEDULE

The Daily and Weekly observations can be done by operating personnel. Monthly, Semi-Annually and Annually observations and any required adjustments, servicing, etc. should be performed by qualified service personnel.

This schedule applies when the boiler is in use. Local codes or jobsite conditions may require more frequent servicing. Verify proper operation after servicing.

⚠ WARNING

Proper lockout / tagout procedure must be employed when servicing this unit.

⚠ WARNING

Label all wires prior to disconnection when servicing controls. Wiring errors can cause improper and dangerous operation.

⚠ WARNING

Use care when reassembling main gas line to assure all connections are tight.

⚠ WARNING

Use care when servicing boiler in order to prevent the accumulation of gas in or around the combustion chamber.

⚠ WARNING

Determine the cause of any lockout or errors before resetting the boiler. If able to determine cause of lockout, then appropriate corrective action should be taken. If unable to determine cause of the problem, call a qualified service technician. Verify proper operation after servicing.

Verify proper operation after servicing.

5.1.1 Daily

Observe operating temperature and general conditions. Make sure that the flow of combustion and ventilating air to the boiler is not obstructed. Determine the cause of any illuminated red indicators, unusual noises or operating conditions and make the necessary corrections. Notify responsible individuals for required corrective action or repair.

⚠ WARNING

Check daily to be sure that the boiler area is free and clear of any combustible materials, including flammable vapors and liquids.

5.1.2 Weekly

Observe the conditions of the pilot and main flame. A normal flame is blue. If the high fire flame is yellow or if it pulsates, or if the burner starts with a rumble or puff, corrective action must be taken by qualified personnel.

Correct air adjustment is essential to the efficient operation of this boiler. If an adjustment in the combustion appears necessary, the flue gas composition should be checked with a carbon dioxide (CO₂) or oxygen (O₂) analyzer and compared to the values listed on the fire test sticker on the back of the boiler. If an adjustment is necessary, call a qualified installer or service agency that has been trained on the Harsco Industrial, Patterson-Kelley P-K THERMIFIC® boiler.

5.1.3 Monthly

1. Test flame detection by voltage reading at the control programmer.
2. Test high-limit control (refer to Section 3.9).
3. Test operating temperature controls by reducing or increasing temperature setting as necessary to check burner operation (refer to Section 3.9).
4. Check flue gas temperature at outlet. If there is a temperature increase over previous readings, the probable cause is soot or water-scale buildup.
5. Test the water flow switch (refer to Section 3.9).
6. Test low gas pressure switch (and high gas pressure switch if supplied) (refer to Section 3.9).
7. Inspect and clean the air inlet screen of any accumulated dust or lint.

Installation and service must be performed by a qualified installer or service agency that has been trained on the Harsco Industrial, Patterson-Kelley P-K THERMIFIC® boiler.

5.1.4 Semi-Annually

In addition to the recommended monthly service:

1. Clean burner of any accumulated dust or lint (refer to Section 5.2).
2. Inspect burner for any signs of deterioration or corrosion. Replace immediately if deterioration or corrosion is evident.

Installation and service must be performed by a qualified installer or service agency that has been trained on the Harsco Industrial, Patterson-Kelley P-K THERMIFIC® boiler.

The blower motor is permanently lubricated and does not require periodic lubrication.

5.1.5 Annually

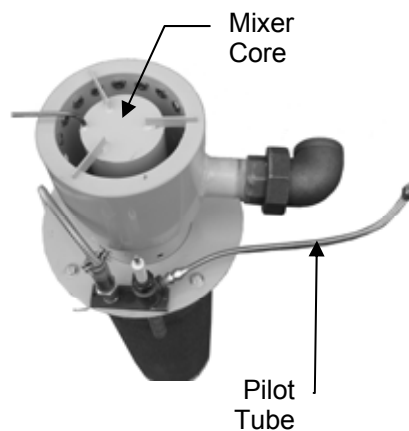
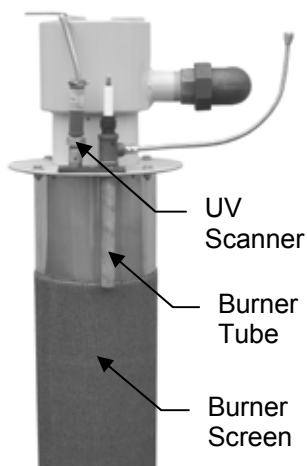
1. Test flame detection by voltage reading at the control programmer.
2. Test high-limit control (refer to Section 3.9).
3. Test operating temperature controls by reducing or increasing temperature setting as necessary to check burner operation (refer to Section 3.10).
4. Check flue gas temperature at outlet. If there is a temperature increase over previous readings, the probable cause is soot or water scale build-up.
5. Test the water flow switch (refer to Section 3.9).
6. Test low gas pressure switch (and high gas pressure switch if supplied) (refer to Section 3.9).
7. Inspect and clean blower fan and inlet screen of any accumulated dust or lint.

8. Check burner and clean off any soot or foreign material that may have accumulated. See Section 5.2 on "Cleaning the Burner." Check for corrosion of the burner and its parts. If there is evidence of deterioration or corrosion, replace burner immediately.
9. Inspect combustion chamber through access doors on front of boiler and burner area. To remove front doors, remove the screws at the top, then pull forward slightly, then pull upward. Note any signs of deterioration. Clean as necessary.
10. Inspect and clean heat exchanger. Clean exterior of finned tubes and flush inside of heat exchanger as required (separate from system flush).
11. Examine the venting system.
 - a. Check all joints and pipe connections for tightness.
 - b. Check vent pipe for corrosion or deterioration. If any venting needs replacing, do so immediately.
12. Perform combustion analysis and adjust if necessary.

Installation and service must be performed by a qualified installer or service agency that has been trained on the Harsco Industrial, Patterson-Kelley P-K THERMIFIC® boiler.

5.2 CLEANING THE BURNER

1. Lockout and tagout gas supply to the boiler
2. Lockout and tagout electrical power to the boiler.
3. Remove the top cover of the boiler.
4. Disconnect the electrode wire.
5. Disconnect the UV scanner.
6. Remove mixer core.



Burner Assembly

7. Disconnect the union in the line at the burner.
8. Disconnect pilot and vent line, being careful not to disturb position of pilot.
9. Loosen and remove the four burner hold-down nuts.

10. Carefully remove the burner.
11. Wash the burner with water. DO NOT wipe or brush the outside of the burner.
12. Check that the ceramic portion of the ignition electrode is not cracked. Verify that the three-armed spider is on the electrode.
13. Check the position of the ignition electrode, it should be flush with the end of the pilot tube. Check the tightness of the electrode clamp. It should be secure and snug. Do not over tighten or the electrode will crack.
14. Use a soft, clean cloth to remove accumulated contaminants from the UV scanner glass lens.
15. Before re-installing the burner, check the cleanliness of the exchanger. Remove the front aluminum panel and examine the exterior of the tubes as well.

5.3 REMOVING THE EXCHANGER

This work should only be performed by qualified service personnel.

⚠ WARNING

The heat exchanger is heavy; use proper lifting equipment and techniques.

1. Remove the burner as above.
2. Remove the front doors by pulling forward and upward.
3. Remove the top panel of the inner cabinet.
4. Close the isolation valves to the system.
5. Drain the boiler.
6. Disconnect the supply and return lines.
7. Remove the water outlet manifold containing the temperature-pressure indicator, relief valve, and the water flow switch (on the D series units disconnect at the grooved pipe coupling [Victaulic]).
8. Remove the nuts and bolts from the flanges of the inlet and outlet nozzles at the rear of the outer casing.
9. Remove the exchanger by sliding it forward and out of the cabinet.

NOTICE! The inner and outer cabinets are separate parts and reassembly is easier if the inner cabinet and exchanger are removed together as one unit. When re-assembling, reseal the top of inner cabinet with aluminum tape as needed.

5.4 AFTER ALL REPAIRS OR MAINTENANCE

1. Follow "Pre-Start Check List" (Section 3.8) and all "Safety Checks" (Section 3.9).
2. Verify proper operation after servicing.
3. Perform combustion check.
4. Check gas pressure and adjust gas flow if necessary. Check air pressure and adjust air flow if necessary (refer to Section 3.10.3.).

5.5 SEQUENCE OF OPERATION

Status indicator lights located on the front of the control panel or on the flame safeguard of this boiler are specifically designed to indicate the sequence of operations and the cause of common problems. Careful observation of indicators should provide a guide to most operational conditions and problems.

1. When the On/Off (main power) switch is turned on, a green indicator marked "Power" is illuminated. Power is applied through a series of limit switches, including water flow, hi and low gas pressure, high temperature, and the operating temperature control to the flame safeguard programmer.

NOTICE! When the On/Off switch is in the Off position, there is still power to the DP Contactor (motor relay) and the on/off switch. Lockout/tagout the boiler at a location external to the boiler before doing any work in the control panel.

2. The water flow limit switch is closed when there is water flow through the boiler.

NOTICE! The closing of this switch does not prove that flow is adequate. Refer to Section 3.7 for proper flow requirements.

3. When gas pressure is available, the low gas-pressure limit switch is closed. Manual reset is required following conditions resulting in low gas pressure.
4. If the temperature sensed by the high-limit temperature control is below the set limit, the normally closed position of the switch sends power to the operating temperature control. Manual reset is required following conditions exceeding high- temperature limit. The limit series is complete unless the red jumper wire is removed and another external control (Building Management System, sequencer, etc.) is put in its place.
5. When heat is required, as indicated by outlet water temperature, the operating limit control applies power the flame safeguard programmer, and the green "Heat" light.
6. The flame safeguard programmer supplies power to the blower motor and the air flow switch. The red "Low Air" indicator will remain on until sufficient air flow is sensed (approximately 5-8 seconds).
7. A purge period of 30 seconds occurs after the air proving switch closes. During this time period the combustion chamber is pre-purged to eliminate any residual combustible gas or combustion products.
8. After the purge, a 10-second "Pilot Trial For Ignition (PTFI)" period occurs, with the flame safeguard programmer powering the ignition transformer/spark and the pilot gas valve.
9. When a pilot flame is detected by the UV scanner, the ignition transformer/spark is shut down and the pilot remains on for the rest of the 10 seconds during the pilot flame establishing period.
10. After the pilot flame establishing period, a 10-second "Main Trial For Ignition (MTFI)" period occurs, with the flame safeguard programmer powering the pilot gas valve and the main gas valves. At the end of 10 seconds, the pilot valve is closed. The boiler reaches "Run" at this point and will operate until the heating load is satisfied. For the Lo-Hi-Lo models: The MTFI 10 second period occurs with the gas valve in the low fire position. After the boiler reaches Run, the Lo-Hi-Lo temperature controller may energize the high fire operation of the boiler, depending on the water temperature and the controller setpoints.
11. When the desired water temperature is reached, the operating control switch opens, thereby de-energizing the flame safeguard programmer and shutting off the green indicator for "Heat". This action also closes both automatic main gas valves.
12. When the water temperature is reduced by the load on the system, the operating control switch will close again. The operating sequence will recycle to step 5, provided that the limits on water flow, gas pressure, and high temperature are all met.

5.6 TROUBLESHOOTING

⚠ WARNING

If any "Manual Reset" limit device trips, DO NOT reset without determining and correcting the cause. (Manual Reset Limits include: Flame safeguard, high or low gas pressure, high temperature limit, stack temperature, low water level.)

Loss of Power

In the event of a power failure the "Power" indicator is not illuminated and the entire system is de-energized, closing all automatic valves and halting all boiler operations. When power is restored the sequence of operation will resume at Step 5, provided that all the limits are satisfied.

Loss of Water Flow

When the "Water Flow" indicator is illuminated, there is insufficient water flow to close the switch, and burner operation is interrupted. When water flow is re-established, the sequence returns to Step 5, provided that the other limits are satisfied.

Low or High Gas Pressure

When the "Gas Press" indicator is illuminated, there is (or has been) too little or too great gas pressure available for safe and proper operation of the boiler, and power to the programmer is interrupted. If a gas-supply shut-off valve is closed for any reason, a low gas condition will result.

When gas pressure is restored, the "Gas Press" indicator will remain on and the boiler will remain locked out until the low gas pressure switch is manually reset.

On boilers equipped with a High Gas pressure switch, the "Gas Press" indicator may also be illuminated to indicate high gas pressure. This is also a manual reset condition.

Once the switch is reset, the sequence returns to Step 5, provided that the other limits are satisfied.

High Water Temperature

When the boiler water has exceeded both the operating and high-limit temperature; power to the programmer is interrupted. When the water temperature falls below the high-limit temperature, the boiler will remain locked out until the switch is manually reset. Once the switch is reset, the sequence returns to Step 5 to await heat demand below the operating temperature, provided that the other limits are satisfied.

Low Air

If the "Low Air" indicator remains on for longer than 10 seconds, there is insufficient airflow through the burner. Check that the burner is clean (see Section 5.2 "Cleaning the Burner") before adjusting the air inlet damper (see Section 3.10.3). A low air indication does not necessarily mean that the low air switch is defective.

Ignition Failure

In the event the pilot flame is not detected by the UV scanner during the 10 second trial-for-ignition period (Step 8), the pilot gas valve and spark ignition are de-energized. At this time a safety lockout occurs which de-energizes all outputs from the programmer except Terminal A, which is connected to the "Flame Failure" indicator. A manual reset of the programmer (located inside the control panel) is required when a safety lockout occurs.

Flame Failure

In the event of a flame failure during a firing period, the main fuel valves are de-energized and the programmer immediately goes into a "lockout" mode. If flame failure occurs during a trail-for-ignition, a safety lock-out occurs (see Ignition Failure). If flame failure occurs and the indicator is illuminated, the programmer must be manually reset.

6 PARTS/TECHNICAL SUPPORT

Spare parts and replacement parts can be ordered from Harsco Industrial, Patterson-Kelley by calling (570) 476-7261 or Toll Free (877) 728-5351. Ask for the Heat Transfer Department. The fax number is (570) 476-7247. Refer to the parts list shown on the assembly drawing provided with this manual.

Technical information is also available at the above number.

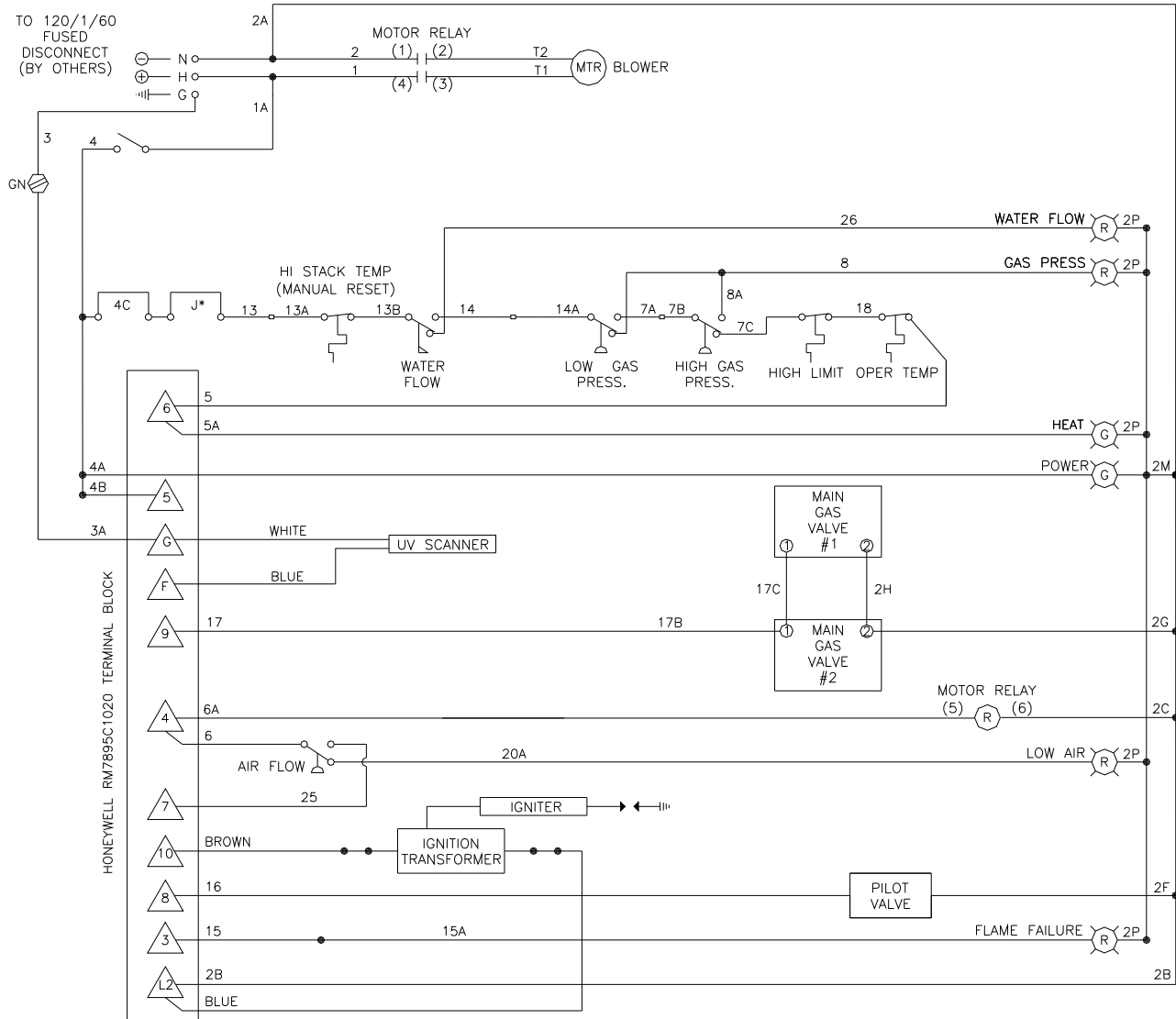
When ordering replacement parts please have the **model number** and **serial number** of your boiler available.

6.1 WIRING DIAGRAMS

Typical schematic drawings are shown on the following pages. Drawings specific to your particular equipment can be supplied by your local P-K representative.

6.1.1 On-Off

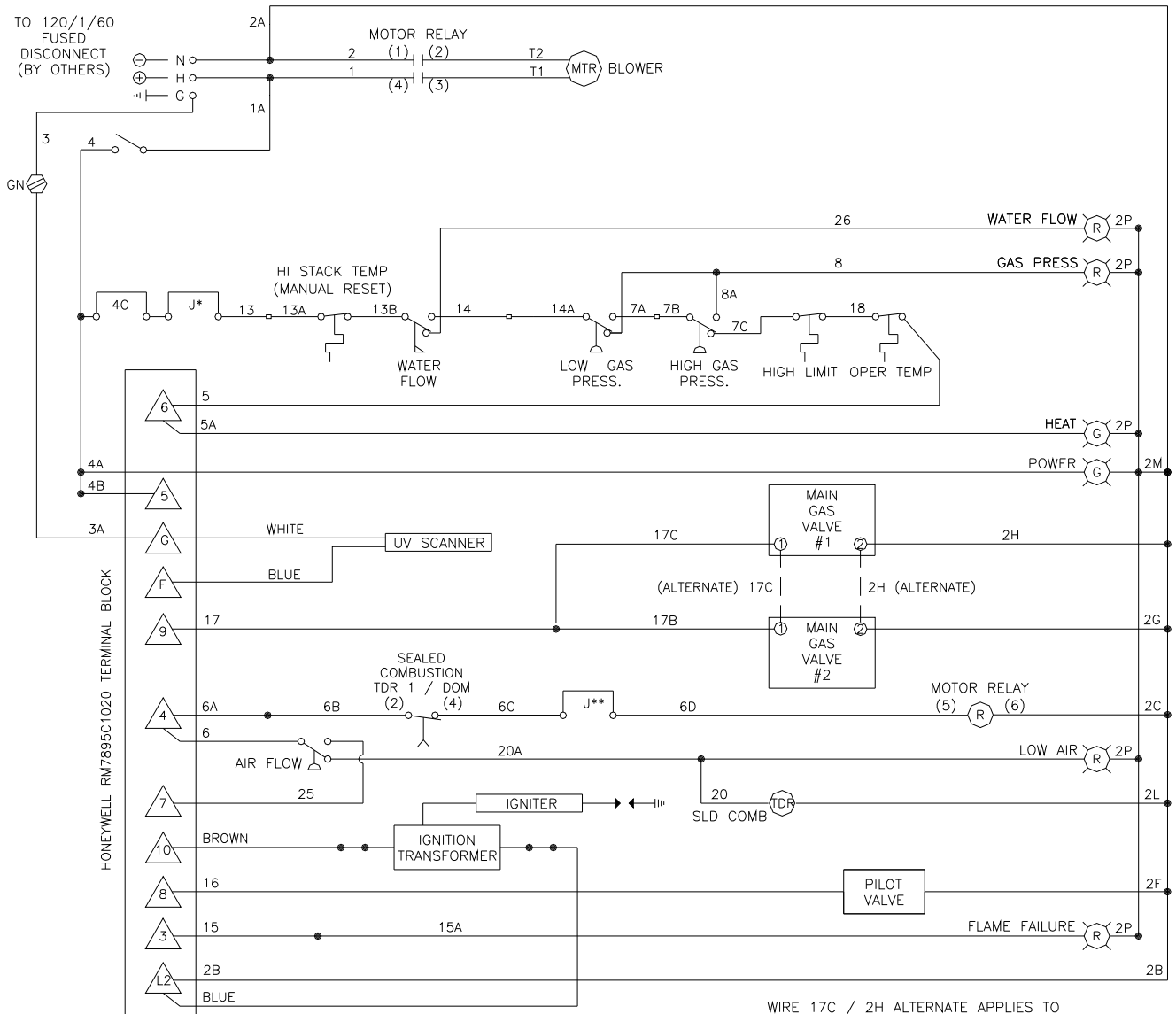
6.1.1.1 On-Off Wiring Diagram (700, 1000, 1500, 1700, 2000)



J* REMOVE RED JUMPER BEFORE INSTALLING EXTERNAL LIMIT CONTROL.

IF ANY OF THE ORIGINAL WIRE AS SUPPLIED WITH THE APPLIANCE MUST BE REPLACED IT MUST BE REPLACED WITH TYPE MTW (90° C) WIRE OR EQUIVALENT.

6.1.1.2 On-Off Sealed Combustion Diagram (700, 1000)



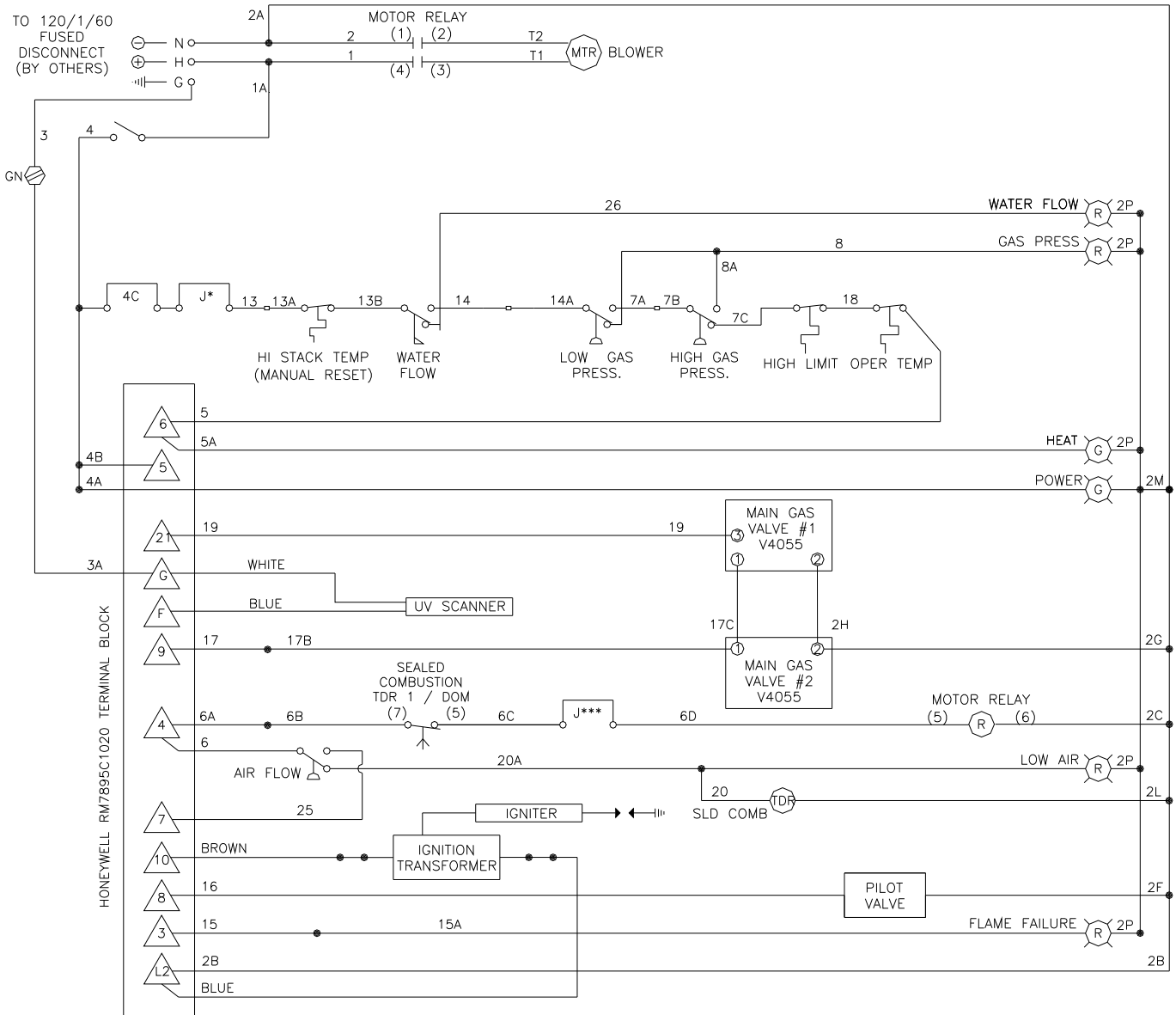
WIRE 17C / 2H ALTERNATE APPLIES TO BOILERS WITH MOTORIZED VALVES

J* REMOVE RED JUMPER BEFORE INSTALLING EXTERNAL LIMIT CONTROL.

J** REMOVE BLUE JUMPER BEFORE INSTALLING OUTSIDE AIR DAMPER

IF ANY OF THE ORIGINAL WIRE AS SUPPLIED WITH THE APPLIANCE MUST BE REPLACED IT MUST BE REPLACED WITH TYPE MTW (90° C) WIRE OR EQUIVALENT.

6.1.1.3 On-Off Sealed Combustion Diagram (1500, 1700, 2000)



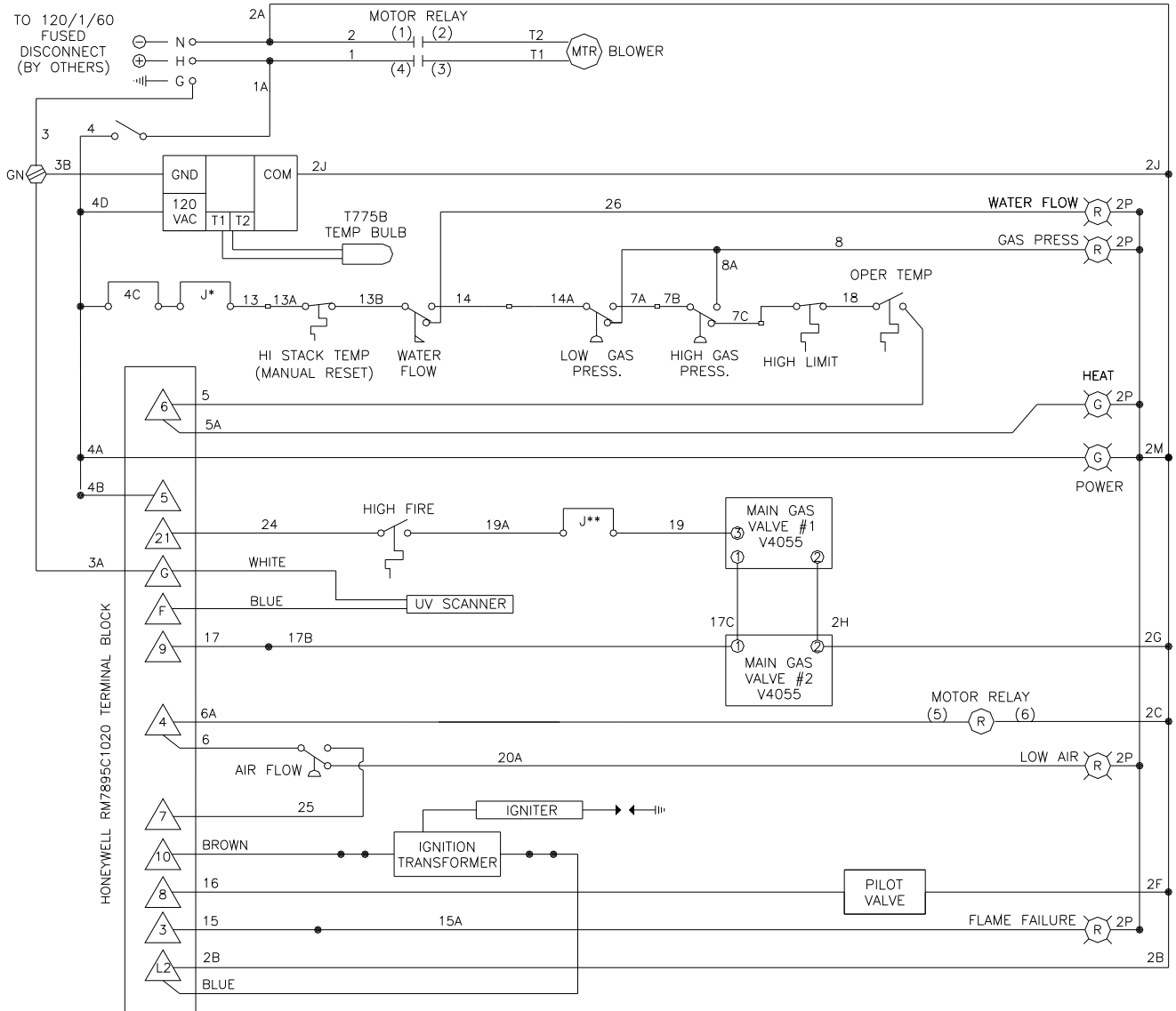
J* REMOVE RED JUMPER BEFORE INSTALLING EXTERNAL LIMIT CONTROL.

J*** REMOVE BLUE JUMPER BEFORE INSTALLING OUTSIDE AIR DAMPER

IF ANY OF THE ORIGINAL WIRE AS SUPPLIED WITH THE APPLIANCE MUST BE REPLACED IT MUST BE REPLACED WITH TYPE MTW (90° C) WIRE OR EQUIVALENT.

6.1.2 Lo-Hi-Lo

6.1.2.1 Lo-Hi-Lo Wiring Diagram (1500, 1700, 2000)

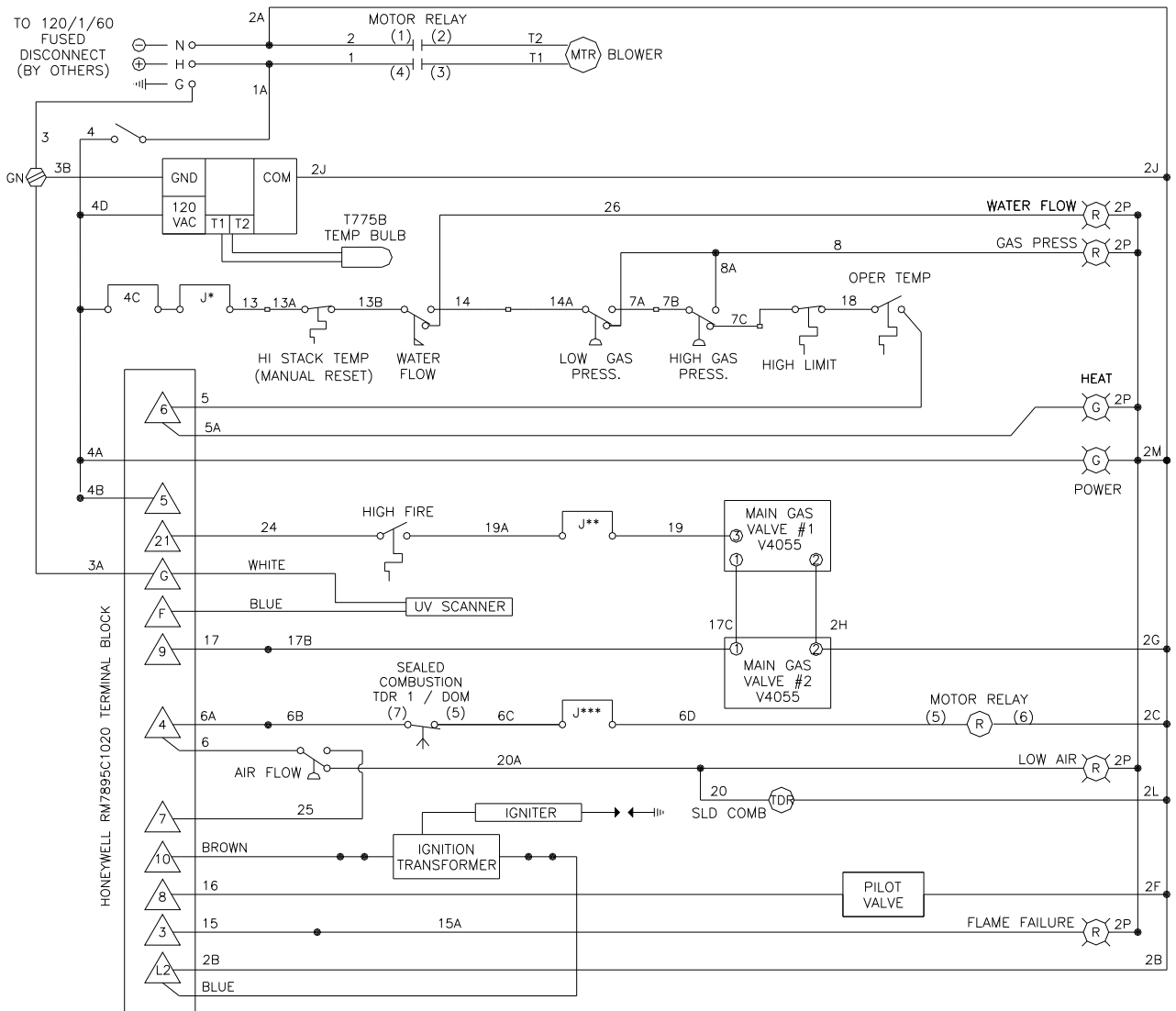


J* REMOVE RED JUMPER BEFORE INSTALLING EXTERNAL LIMIT CONTROL.

J** REMOVE YELLOW JUMPER IF EXTERNAL LIMIT CONTROL IS TO OPERATE HI-FIRE.

IF ANY OF THE ORIGINAL WIRE AS SUPPLIED WITH THE APPLIANCE MUST BE REPLACED IT MUST BE REPLACED WITH TYPE MTW (90° C) WIRE OR EQUIVALENT.

6.1.2.2 Lo-Hi-Lo Sealed Combustion Diagram (1500, 1700, 2000)



J* REMOVE RED JUMPER BEFORE INSTALLING EXTERNAL LIMIT CONTROL.

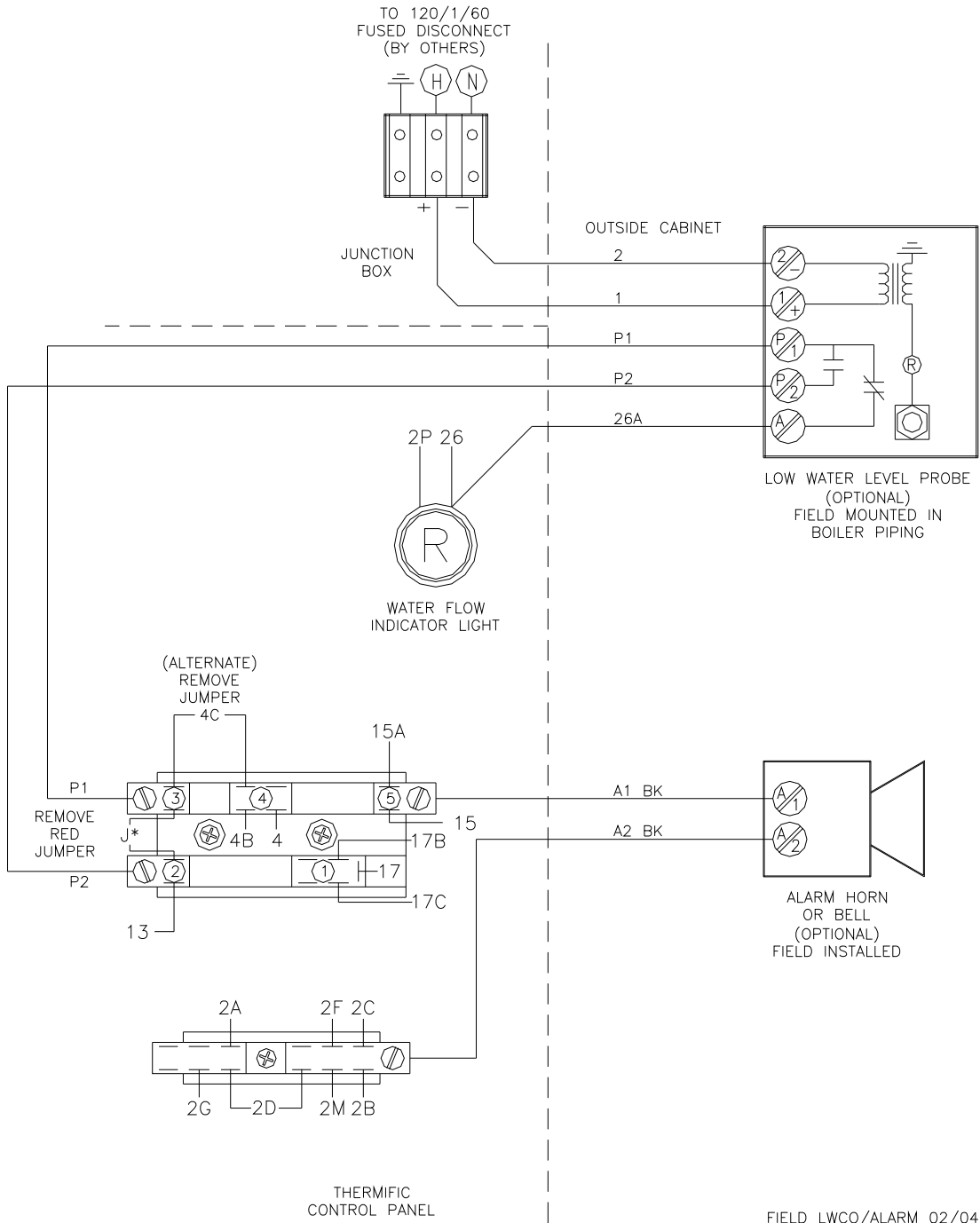
J** REMOVE YELLOW JUMPER IF EXTERNAL LIMIT CONTROL IS TO OPERATE HI-FIRE.

J*** REMOVE BLUE JUMPER BEFORE INSTALLING OUTSIDE AIR DAMPER

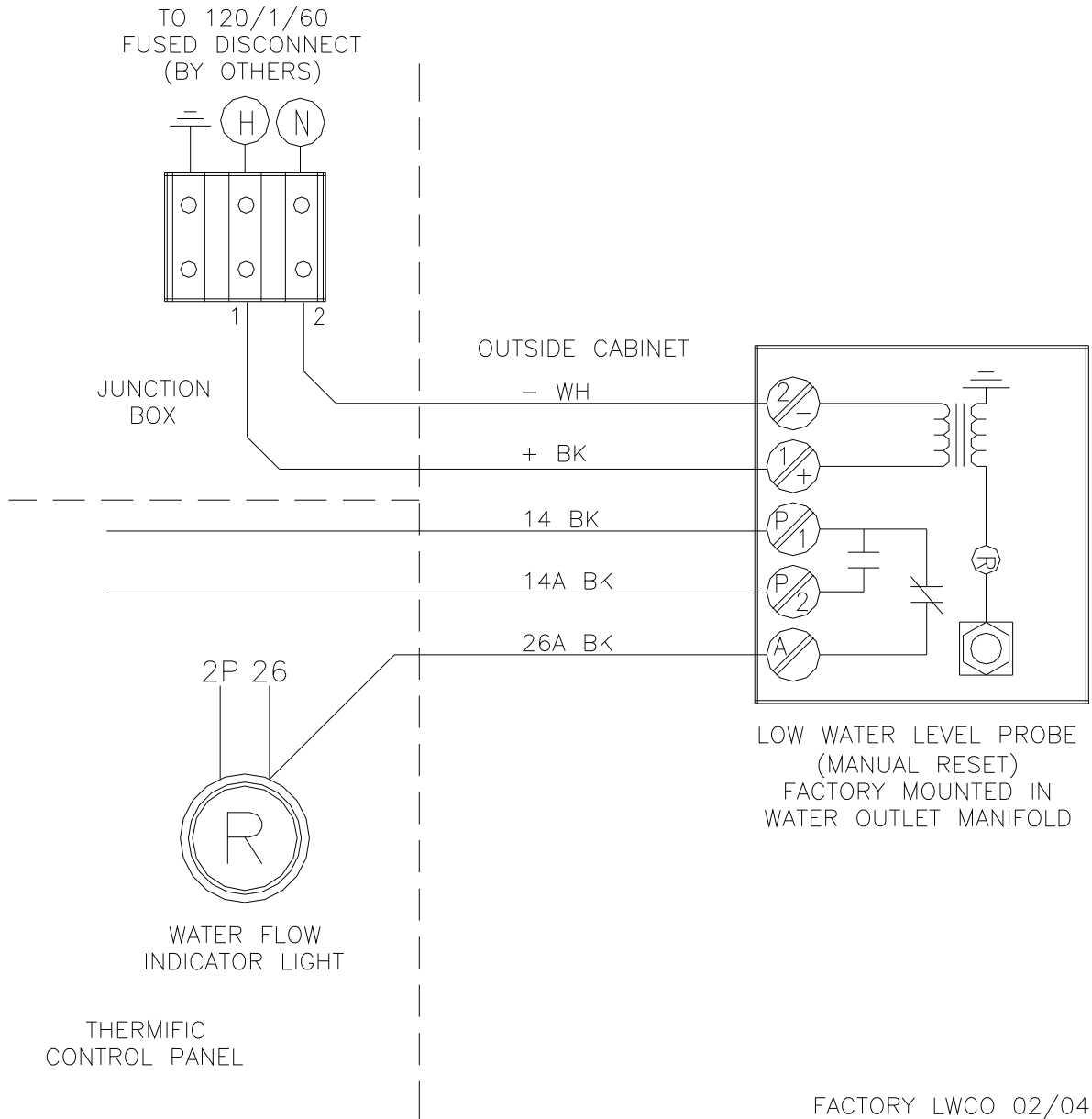
IF ANY OF THE ORIGINAL WIRE AS SUPPLIED WITH THE APPLIANCE MUST BE REPLACED IT MUST BE REPLACED WITH TYPE MTW (90° C) WIRE OR EQUIVALENT.

6.1.3 Low Water Cutoff

6.1.3.1 Field Installed Low Water Cut-Off Diagram



6.1.3.2 Factory Installed Low Water Cut-Off Diagram

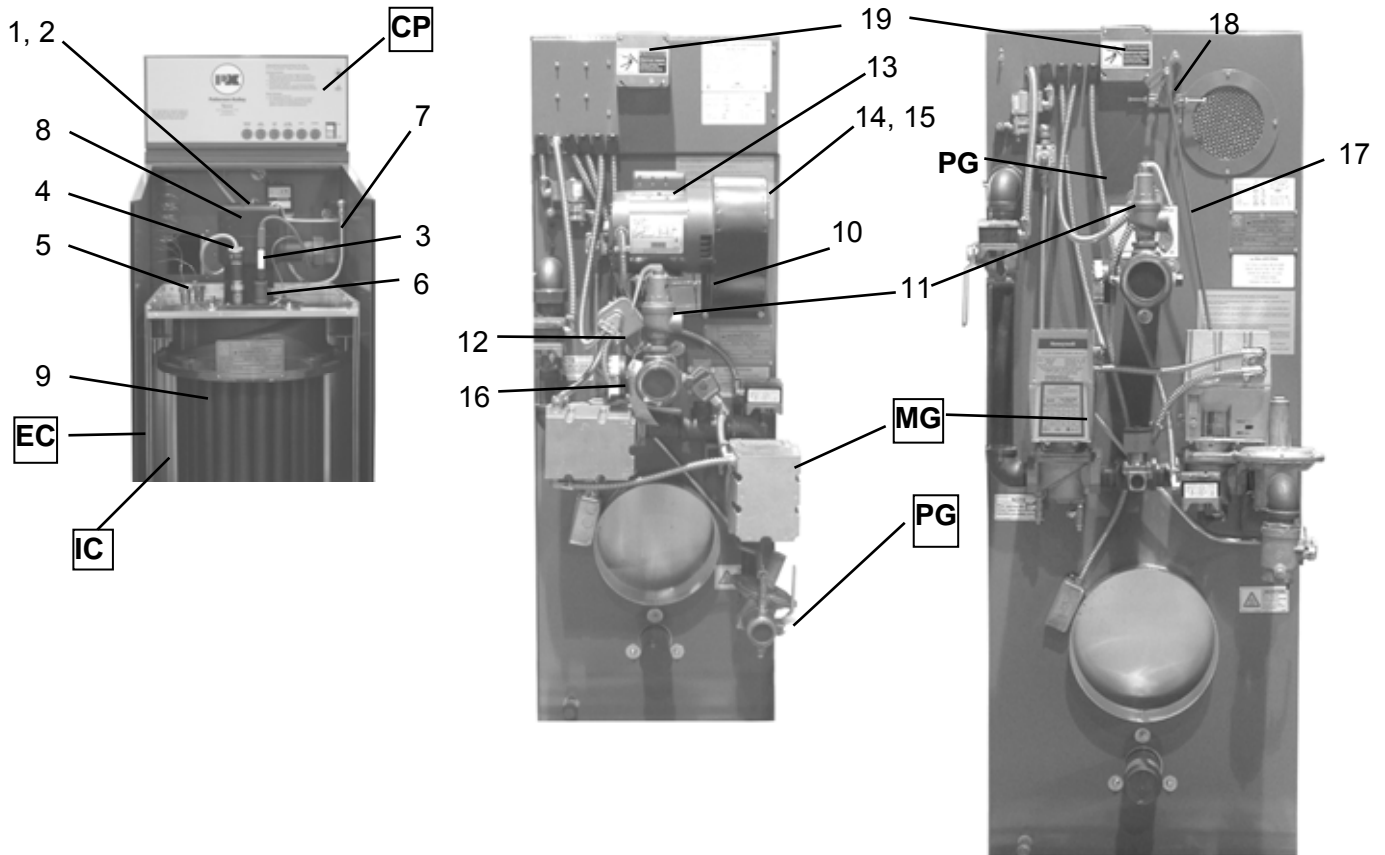


6.2 BOILER PARTS LIST

6.2.1 Main Assembly

700/1000 On/Off

1500/1700/2000 Lo-Hi-Lo



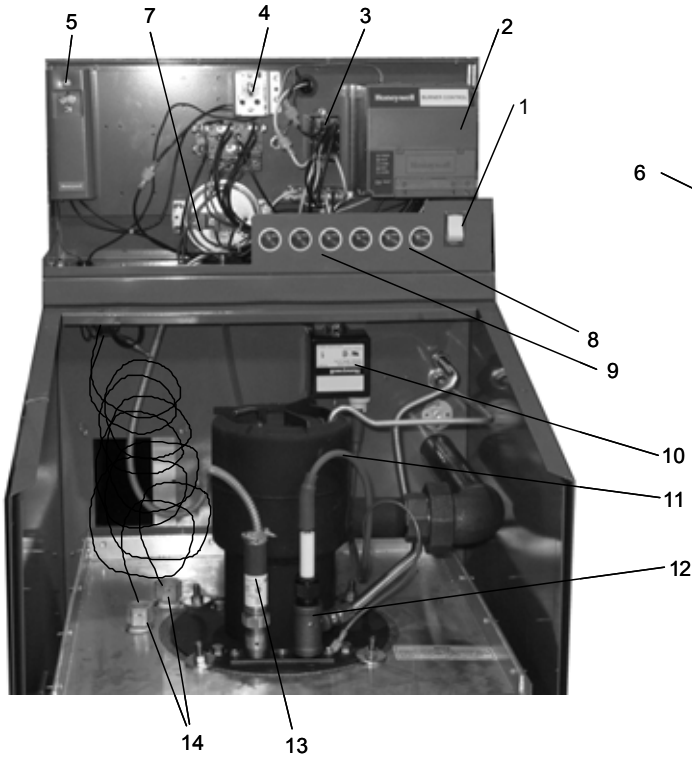
No.	Part
1	Mixer Core, Burner
2	Burner Orifice
3	Ignition Electrode
4	UV Scanner
5	Thermowell w/Clamp (2x)
6	Pilot Assembly
7	Pilot Tube
8	Burner Head
9	Heat Exchanger
10	Blower, Damper (inside cabinet)
11	Pressure Relief Valve (100 PSI)
12	Water Flow Switch
13	Blower, Motor
14	Blower, Housing

No.	Part
15	Blower, Wheel
16	Press./Temp. Gauge (w/ 100 PSI relief valve)
17	Damper Rod, Lo-Hi-Lo
18	Damper Bracket
19	Junction Box, Power

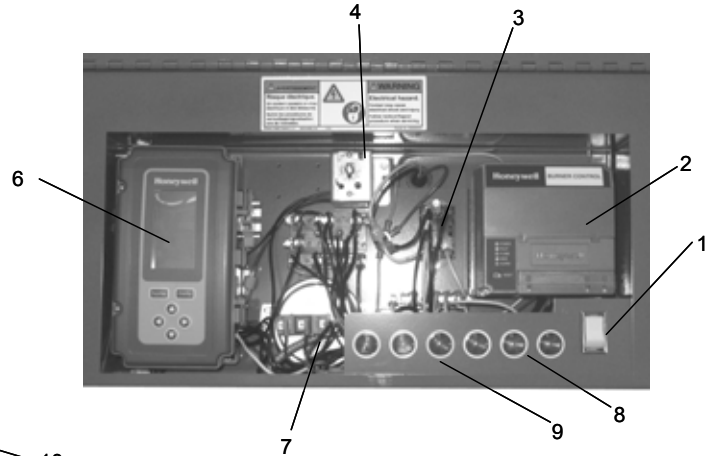
Installation & Owner's Manual	
CP	Control Panel (see Section 6.2.2)
EC	Exterior Cabinet (see Section 6.2.4)
IC	Interior Cabinet (see Section 6.2.4)
PG	Pilot Gas Train (see Section 6.2.3)
MG	Main Gas Train (see Section 6.2.3)

6.2.2 Control Panel

On-Off Panel



Lo-Hi-Lo Panel

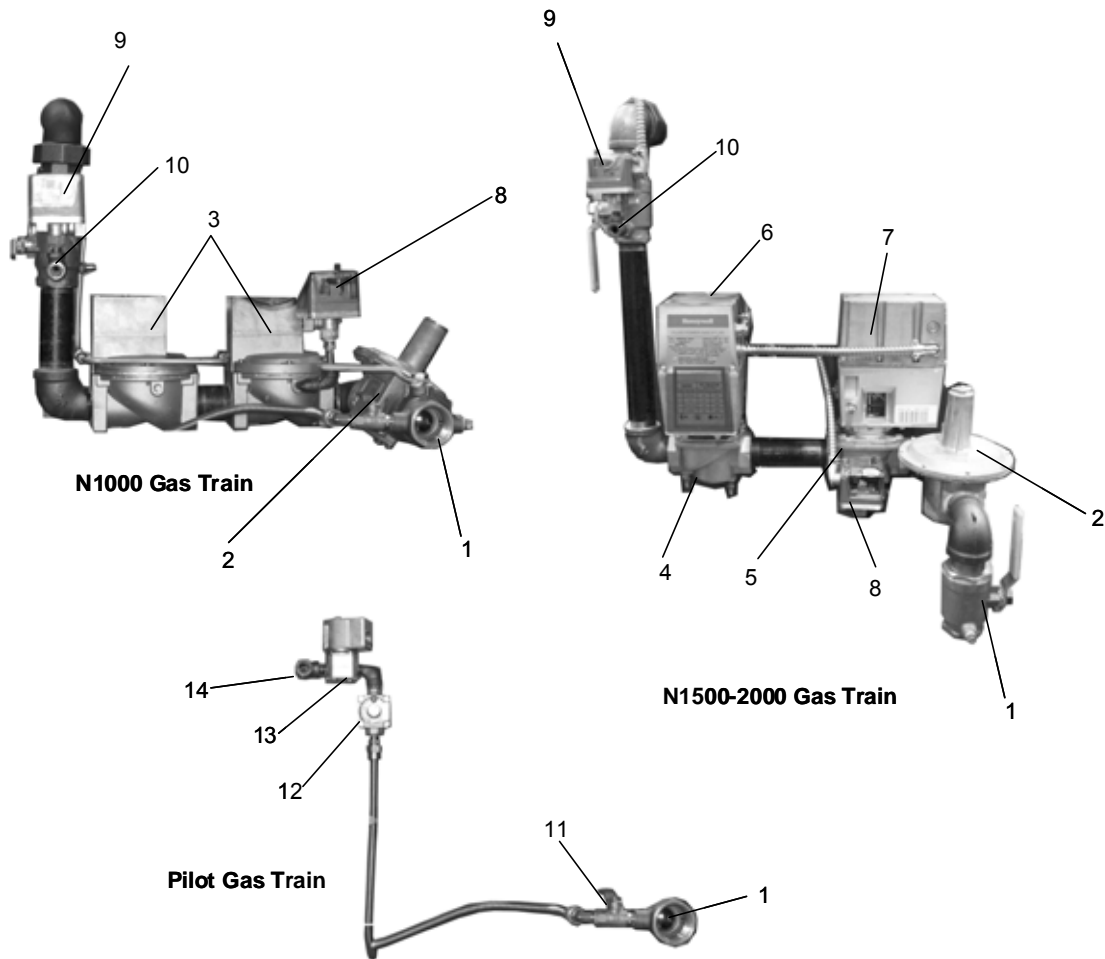


No.	Part
1	Switch, On/Off
2	Flame Safeguard Programmer with UV Amplifier & Timing Card
3	Motor Starter Relay
4	Thermostat (Manual Reset)
5	Thermostat (Operating Temp)
6	LHL Two Stage Thermostat (Operating Temp)
7	Air Flow Switch
8	Operating Lights, 2 (Green)
9	Error Lights, 4 (Red)

No.	Part
10	Ignition Transformer
11	Ignition Cable
12	Pilot Assembly (incl. Ignition Electrode)
13	UV Scanner
14	Thermostat Sensor Wells (2)

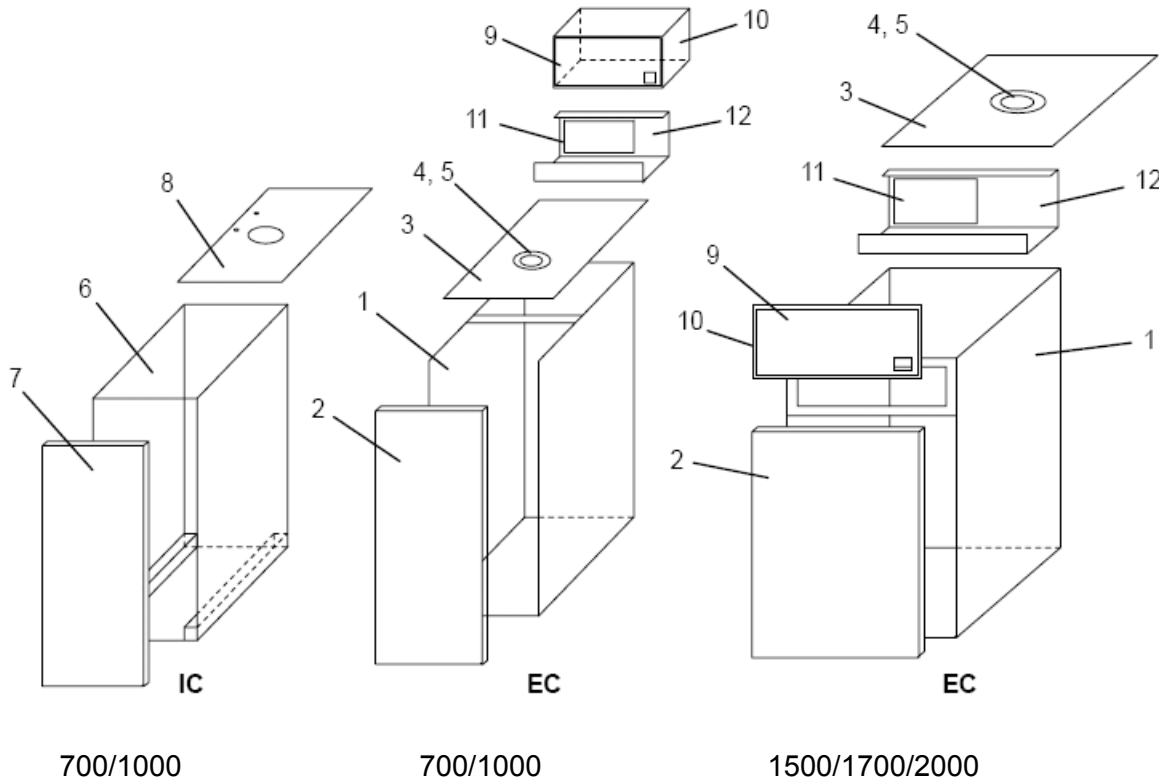
Not Shown	
	Low Water Switch (Optional)
	Alarm Bell (Optional)

6.2.3 Gas Train



No.	Part
1	Main Gas Shut-off Valve
2	Main Gas Regulator
3	Main Gas Valve (Diaphragm)
4	Main Gas Valve Body (On/Off)
5	Main Gas Valve Body (LHL)
6	Main Gas Valve Actuator (On/Off)
7	Main Gas Valve Actuator (LHL)
8	Low Gas Pressure Switch
9	High Gas Pressure Switch
10	Manifold Gas Test Port
11	Pilot Shut-off Valve
12	Pilot Regulator
13	Pilot Solenoid Valve
14	Pilot Gas Test Port

6.2.4 Cabinet



No.	Part
1	Exterior Cabinet, Assy.
2	Exterior Cabinet, Door
3	Exterior Cabinet, Top
4	Sight Glass
5	Sight Glass Bezel
6	Combustion Chamber, Assy.
7	Combustion Chamber, Door
8	Combustion Chamber, Top
9	Control Panel, Label
10	Control Panel, Cover
11	Control Panel, Sub Panel
12	Control Panel, Base Assy.

7 LIMITED WARRANTY

LIMITED WARRANTY

Subject to the terms and conditions herein, Harsco Industrial, Patterson-Kelley, Seller, warrants to the original owner at the original installation site that products manufactured by Seller will be free from defects in materials and workmanship for a period of one (1) year from date of start up (the "Warranty Period"), provided that start up is completed within six months from the date of shipment. The heat exchanger and burner will be warranted for a period of five (5) years and a ten (10) year warranty against failure due to thermal shock from the date of shipment (the "Warranty Period").

REMEDY

The sole remedy of this warranty is expressly limited to the repair or replacement of any part found to be defective under conditions of normal use within the Warranty Period. Installation is not included.

WARRANTY

The owner must notify the original installer of the Product and Seller (Attention: Harsco Industrial, Patterson-Kelley, 100 Burson Street, East Stroudsburg, PA 18301), in writing, within the Warranty Period, providing a detailed description of all claimed defects. Transportation to the factory or other designated facility for repairs of any products or items alleged defective shall, in all events, be the responsibility and at the cost of the owner.

EXCLUSIONS

Seller shall have no liability for and this warranty does not cover:

- 1) Incidental, special or consequential damages, such as loss of the use of products, facilities or production, inconvenience, loss of time or labor expense involved in repairing or replacing the alleged defective Product.
- 2) The performance of any Product under conditions varying materially from those under which such Product is usually tested under industry standards at of the time of shipment
- 3) Any damage to the Product due to abrasion, erosion, deterioration, abnormal temperatures or the influence of foreign matter or energy.
- 4) The design or operation of owner's plant or equipment or of any facility or system of which any Product may be made a part.
- 5) The suitability of any Product for any particular application.
- 6) Any failure resulting from misuse, modification not authorized by Seller in writing, improper installation or lack of or improper maintenance.
- 7) Equipment furnished by the owner, either mounted or unmounted, or when contracted for by the owner to be installed or handled.
- 8) Leakage or other malfunction caused by:
 - i) Defective installations in general and specifically, any installation which is made:
 - (a) In violation of applicable state or local plumbing housing or building codes,
 - (b) Contrary to the written instructions furnished with the unit
 - ii) Adverse local conditions in general and, specifically, sediment or lime precipitation in the tubes and/or headers or corrosive elements in the atmosphere.
 - iii) Misuse in general and, specifically, operation and maintenance contrary to the written instructions furnished with the unit, disconnection, alteration or addition of components or apparatus, not approved by Seller, operation with fuels or settings other than those set forth on the rating plate or accidental or exterior damage.
- 9) Production of noise, odors, discoloration or rusty water.
- 10) Damage to surrounding area or property caused by leakage or malfunction.
- 11) Costs associated with the replacement and/or repair of the unit including: any freight, shipping or delivery charges, any removal, installation or reinstallation charges, any material and/or permits required for installation, reinstallation or repair, charges to return the boiler and or components. Seller's liability under this warranty shall not in any case exceed the amount paid for the Product found to be defective.

THIRD-PARTY WARRANTIES

For goods or components not manufactured by Seller, the warranty obligations of Seller shall, in all respects, conform and be limited to one (1) year from the date of shipment.

SEVERABILITY

To the extent that any provision of this warranty would be void or prohibited under applicable law, such provisions shall be limited in effect to the minimum extent necessary to render the remaining provisions hereof enforceable.

NO OTHER WARRANTIES

Seller makes no implied warranty of merchantability or fitness for a particular purpose or other warranties with respect to any products or services except as expressly set forth in this limited warranty.

Multi-Metal Systems Water Quality Standards

HARSCO Industrial, Patterson-Kelley boilers are designed to be incorporated into any multi-metal hydronic heating system. All multi-metal hydronic systems require that attention be paid to water treatment. The chemical additives for any multi-metal system must be specifically formulated for use with all the various metals used in that system.

Any closed, hydronic heating systems should include a meter, to monitor water addition to the recirculating loop, and a filter, pursuant to ASHRAE Standard 189.1 and the AWT Handbook. Water added to a closed hydronic system should not exceed more than 10% of the system volume per year and meter readings should be recorded, at least monthly, to ensure system losses are minimized and corrective actions shall be taken when needed.

Treatment programs for multi-metal systems should meet or exceed the following generally accepted best practices water quality guidelines:

1. Proper cleaning and surface preparation must be completed prior to system start-up.
2. pH must be maintained in a range that is appropriate for the metals contained in the system (see chart below).
3. Total Alkalinity between 100-500 ppm as CaCO₃.
4. Filtration at or below 5 micron.
5. Total suspended solids below 10 ppm.
6. Corrosion inhibiting compounds to protect metals at or below:
 - a. Aluminum <0.25 MPY
 - b. Copper <0.1 MPY, soluble copper <0.25 ppm
 - c. Steel <3.0 MPY

According to ASTM D 2688
7. Addition of strong acids is not recommended.

Prior to initiating any treatment program, a water sample of the proposed fill water should be sampled for analysis. Once filled and bled of air, a pH neutral, industrial cleaner for use in multi-metal systems should be used to clean the entire hydronic system. Samples of the system water with cleaner should be taken and analyzed to ensure proper cleaner strength. Once cleaned, the system should be flushed with fresh (fill) water until the system water is within 100 micro Siemens in conductivity of the fresh water. When flushing is complete, a treatment program that is designed for use in that multi-metal system, after consideration of the metals it contains, must be used. Treatment programs should also comply with the standard water quality guidelines listed above.

Multi-Metal Systems with Aluminum	Multi-Metal Systems with Stainless Steel	Multi-Metal Systems with Copper
Proper surface cleaning required	Proper surface cleaning required	Proper surface cleaning required.
pH maintained between 6.0-8.5*	pH maintained between 7.0-9.5*	pH range may vary ***
Total Alkalinity 100-500 ppm as CaCO ₃	Total Alkalinity 100-500 ppm as CaCO ₃	Total Alkalinity 100-500 ppm as CaCO ₃
Best Practices Filtration	Best Practices Filtration	Best Practices Filtration
Suspended solids below 10 ppm	Suspended solids below 10 ppm	Suspended solids below 10 ppm
Corrosion rates below: 0.1 MPY copper 3.0 MPY steel 0.25 MPY aluminum	Corrosion rates below: 0.1 MPY copper 3.0 MPY steel	Corrosion rates below: 0.1 MPY copper 3.0 MPY steel Max. MPY other metals
Addition of strong acid not recommended	Addition of strong acids not recommended	Addition of strong acids not recommended
<i>When freeze protection is required, automotive grade glycols are not recommended and decomposition products should be monitored and maintained below concentrations that present corrosive conditions. For existing boiler water systems, additional requirements and operational conditions may be required to mitigate pre-existing conditions.</i>		
* Other system components may have more restrictive ranges.		
**Copper has a broad range of acceptable pH and the other metallic components may require a tighter range		