



# **P-K MACH® GAS FIRED BOILERS w/ NURO® CONTROL SYSTEM**

## **Natural Gas or Propane Gas**

## **C-1500H/C-2000H**

## **C-2500/C-3000/C-4000**

## Dual Fuel

# **C1500GG, C2000GG**

## **C2500GG, C3000GG, C4000GG**



Part # 1004905981



C.S.A Design-Certified  
Complies with ANSI Z21.13/CSA 4.9  
Gas-Fired Low Pressure Steam and Hot Water



ASME Code, Section IV  
Certified by Patterson-Kelley



C.S.A Design-Certified  
Complies with ANSI Z21.13/CSA 4.9  
Gas-Fired Low Pressure Steam and Hot Water Boilers

Model Number:

Serial Number:

Start-Up Date:

Harsco Industrial Patterson-Kelley

Markee Industrial, Inc.  
155 Burson Street

155 Burson Street  
East Stroudsburg, PA 18301

East Stroudsburg, PA 18301  
Telephone: 570 476 7261

Tell Free: 877 728 5351

Toll Free: 877.728.5551  
Fax: 570.476.7247 [www.pennscript.com](http://www.pennscript.com)

Fax: 570.470.7247 [www.flarscopk.com](http://www.flarscopk.com)

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# Safety

## General

### P-K MACH® C-1500H, C-2000H, C-2500, C-3000, C-4000

All P-K MACH® C-1500H, C-2000H, C-2500, C-3000, C-4000 Gas-Fired Boilers must be:

- Installed, operated, and serviced in accordance with instructions contained in this manual and other supplemental manuals.
- Installed by qualified personnel in accordance with designs prepared by qualified facility 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, and properly trained personnel in accordance with all applicable codes, laws, and regulations.

## 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.



### WARNING

Improper use may result in fire or injury.

Read instructions/safety manual before installing, operating or servicing boiler.

AVERTISSEMENT
Une installation, un réglage, un changement ou un entretien inappropriés peuvent causer des dommages matériels, des blessures corporelles ou la mort.  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.



### WARNING

Improper installation, adjustment, alteration, service, or maintenance can cause property damage, personal injury or loss of life.

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.

## NOTICE!

Each safety device must be maintained and checked per the recommended schedule. Refer to Section 6 for more information.

## SAFETY FEATURES

It is the responsibility of the customer to ensure external safety provisions, such as but not limited to: guards, safety labels, safety controls, interlocks, lockout devices are in place and operable.

## 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

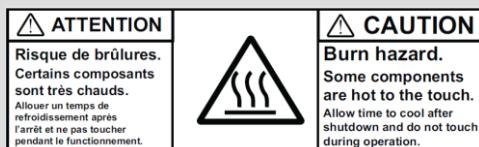
*Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices.*

## 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.

## NOTICE!

The safety labels shown below 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 at **570.476.7261** or toll-free at **877.728.5351** for replacements.



Gas may lose its odor. Proper gas sensing equipment and procedures should be used for leak checks. Failure to detect gas leaks could result in injury or death.

## Training

Proper training is the best protection against accidents. 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.

Operating and service personnel must be thoroughly familiar with the basic construction of the C-1500H, C-2000H, C-2500, C-3000, C-4000 boilers, the use and locations of the controls, the operation of the boilers, adjustment of their various mechanisms, and all applicable safety precautions. If any of the provisions of this manual are not fully and completely understood, contact Harsco Industrial, Patterson-Kelley Technical Service at **570.476.7261** or toll free at **877.728.5351**.

## Hazard Warnings

### Electrical Hazards

**Shock Hazard!** Properly Lockout/Tagout the electrical service and all other energy sources before working on or near the boiler.

**Shock Hazard!** Do not spray water directly on this boiler or any electrical components.

**Electrical Hazard!** Do not alter wiring connections.

### Crush Hazards

**Lifting Hazards!** Use properly rated lifting equipment to lift and position the boiler. The load is unbalanced. Test the balance before lifting off the floor. Do not allow personnel beneath the lifted load. Refer to the approximate weights in the table below.

Boiler Model	Weight in Pounds	Dual Fuel Model	Weight in Pounds
C-1500H	1,200 lbs.	C-1500GG	1,300 lbs.
C-2000H	1,400 lbs.	C-2000GG	1,530 lbs.
C-2500	1,550 lbs.	C-2500GG	1,650 lbs.
C-3000	1,600 lbs.	C-3000GG	1,700 lbs.
C-4000	1,900 lbs.	C-4000GG	2,050 lbs.

### Bump Hazard from Overhead Ductwork and Piping

**Injury Hazard!** Install components with adequate vertical clearance.



### Pressure Hazards

**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(s) for proper operation. Do not operate boiler with faulty relief valve(s).



## Slip, Fall Hazards



**Tripping Hazard!** Do not install piping on floor surfaces. Maintain a clear path around the boiler.

**Slip and Fall Hazard!** Use a drip pan to catch water while draining the boiler. Maintain dry floor surfaces.

**Slip and Fall Hazard!** Do not locate intake or exhaust terminations above a walkway; dripping of condensate can cause icing of the walking surface. Refer to Section [2.5](#).

**Fall Hazard!** Do not stand on boiler.

## Chemical Hazards



### 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.



**Combustion Condensate** – An acidic pH of

approximately 3.0 to 5.0 can be expected. Use PVC, CPVC, or other corrosion resistant piping for drainage. Collection and disposal must be in accordance with all applicable regulations. A condensate neutralization kit is available. Please contact your local Harsco Industrial, Patterson-Kelley representative for more information.

## Burn, Fire and Explosion Hazards



**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/CSA B.149. Install all required vent lines for gas devices. Refer to Section [3.7](#).

**Hazard from Incorrect Fuels!** Possible fire, explosion, overheating, and damage. Do not use any fuels except the design fuels for the unit.

**Overfire Hazards!** High pressure in gas supply could result in the overfiring of this, or 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 gas 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 stack surfaces during operation or immediately after shutdown of the boiler.

**Burn Hazard!** Hot flue! Use caution when 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 the burner is installed correctly and blower/transition is securely fastened following any maintenance performed on them. These connections may leak gas if assembled incorrectly.

**Gas Leak Hazard!** All threaded gas connections must be made using a pipe compound that is resistant to liquefied petroleum gas. Do not use Teflon™ tape on threaded gas piping.

**Gas Leak Hazard!** Check entire gas train for leaks after installation. 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.

**Overfire Hazard!** Possible fire and explosion from excess gas pressure. Make sure that gas inlet pressure does not exceed 14 inches W.C.

**Overfire Hazard!** Possible fire and explosion. Possible malfunction of regulators and/or gas safety shut off/control 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.

**Overfire and Underfire 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.

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## 1 Introduction

This manual describes the installation and operation of the following P-K MACH® boilers featuring NURO® controls.

### C-1500H, C-2000H & C-2500:

- Natural Gas, 120V (single phase)
- Propane Gas, 120V (single phase)

### C1500GG-C2000GG & C-2500GG:

- Dual Fuel, 120V (single phase), 60 Hertz

### C-3000 & C-4000:

- Natural Gas, 240V (three phase)
- Natural Gas, 480V (three phase)
- Propane Gas, 240V (three phase)
- Propane Gas, 480V (three phase)

### C3000GG-C4000GG:

- Dual Fuel, 240V (three phase), 60 Hertz
- Dual Fuel, 480V (three phase), 60 Hertz

**NOTICE!** This manual covers single fuel P-K MACH® boilers (Natural Gas **–or–** Propane Gas) **AND** dual fuel P-K MACH® boilers (Natural Gas **–and–** Propane Gas).

Individual differences between boiler models will be called out and defined in separate sections and the titles of these sections will include the boiler model number. If the boiler model numbers are not listed in the section title, that section is common to all boiler models.

If you have any questions on the information contained within, or do not fully and completely understand the content, please contact Harsco Industrial, Patterson-Kelley Technical Service at **570.476.7261** or toll free at **877.728.5351**.

The P-K MACH® gas-fired boiler is fully modulating using a variable speed combustion blower, sophisticated microprocessor controls, modulating gas safety shut off / control valves and a unique cast Aluminum heat exchanger capable of operating in a fully condensing mode to provide maximum efficiency in a minimum amount of space. The high-quality materials and design of the boiler should provide years of trouble-free service if the instructions in this manual are followed carefully.

The boiler is only a part of the complete heating system. This boiler may be fully operational but because of poor circulation, improper control, or other site related 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.

While specific details may differ slightly, basic operation is the same for all models. Check the rating plate for correct fuel usage and gas pressures.

## WARNING

If the information in this manual is not followed, 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.

### 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.

## WARNING

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 personal injury or death.

## WARNING

Installation and service must be performed by a qualified and knowledgeable individual who has been certified on the P-K MACH® boiler. The features which permit this boiler to achieve high-efficiency performance can be misused which could result in personal injury or death.

## 1.1 Purpose of this Document

It is the purpose of this Installation and Owner's Manual to provide complete documentation support for P-K MACH boilers featuring NURO controls. Harsco Industrial, Patterson-Kelley is constantly seeking ways to produce high quality HVAC products. Our operation is based on the premium quality control program and insures that Harsco Industrial manufactures quality products.

The primary concern of all Harsco Industrial, Patterson-Kelley equipment installation procedures is Safety. Safety instructions and considerations are presented and repeated throughout the document as needed. At any time during the installation if you have any questions on the information contained within, or do not fully and completely understand the content, please contact Harsco Industrial, Patterson-Kelley Technical Service at **570.476.7261** or toll free at **877.728.5351**.

## 1.2 Common Abbreviations

Abbreviation	Description
AMP	Ampere or Amperage
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
AWG	American Wire Gauge
BTU	British Thermal Unit
CH	Comfort Heat
CO <sub>2</sub>	Carbon Dioxide
CSA	Canadian Standards Association
CSD-1	Controls and Safety Devices
CPVC	Chlorinated Polyvinyl Chloride
DHW	Domestic Hot Water
HWR	Heating Water Return / Hot Water Return (From Building)
HWS	Heating Water Supply / Hot Water Supply (To Building)
ID	Inside Diameter
MBH	Thousands of BTU / Hour
MFD	Modu-Fire Forced-Draft Series Boiler or Water Heater
MODBUS	A serial communication protocol (not an abbreviation)
NFPA	National Fire and Protection Agency
NTC	Negative Temperature Coefficient
O <sub>2</sub>	Oxygen
OD	Outside Diameter
OEM	Original Equipment Manufacturer
SCFM	Standard Cubic Feet per Minute
SMACNA	Sheet Metal and Thermoplastic Duct Construction Manual Air Conditioning Contractors National Association
TB<#>	Terminal Block (1, 2, 3 etc.)
VAC	Volts Alternating Current
VDC	Volts Direct Current

## **⚠ WARNING**

Installation and service must be performed by a qualified installer, service agency, or gas supplier. Failure to install the equipment in accordance with this manual could result in an unsafe operating condition.

### **NOTICE!**

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

## **⚠ WARNING**

The wheels provided with this boiler are for positioning purposes only. When positioning this boiler, maintain positive control of it at all times.

Do not attempt to move the boiler on surfaces that are not level. Failure to heed this warning could result in personal injury or death.

### **NOTICE!**

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

## **⚠ WARNING**

Bumping hazard from overhead ducts! Install all components with adequate vertical clearances. Insufficient clearance can restrict the service access, increasing the possibility of injury.

## **2 Site Preparation**

### **2.1 Initial Inspection upon Receiving**

Upon receiving the boiler, inspect it for signs of shipping damage. Some damage may be hidden. Unpack the boiler, open the front and side doors and inspect the boiler. 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 carton is equipped with a "Tip (N) Tell". If the "Tip (N) Tell" arrow point is blue, that indicates the package has been on its side or tipped over in transit.

### **2.2 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.

## 2.3 Compliance with Codes

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

The P-K MACH® C-1500H, C-2000H, C-2500, C-3000 and C-4000 heat exchangers are constructed and stamped in accordance with ASME Boiler and Pressure Vessel Code, Section IV for 125 psig maximum pressure and 210°F maximum temperature. Other codes or approvals which apply will be labeled on the boiler.

<b>C-1500H, C-2000H, C-2500, C-3000 &amp; C-4000</b>	
<b>Code of Construction</b>	ASME Section IV – “H” (Latest Edition)
<b>Maximum Allowable Working Pressure</b>	125 PSIG
<b>Maximum Allowable Design Temperature</b>	210° F
<b>Hi-Limit Setpoint</b>	200° F
<b>Maximum Setpoint</b>	185° F

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, to the National Fuel Gas Code, ANSI Z223.1/NFPA 54 latest edition in the U.S. In Canada, the equipment shall be installed in accordance with the current Installation Code for Gas Burning Appliances and Equipment, CAN/CSA-B.149, latest edition, and applicable Provincial Regulations for the class, which should be carefully followed in all cases. Authorities having jurisdiction should be consulted before making any installation.

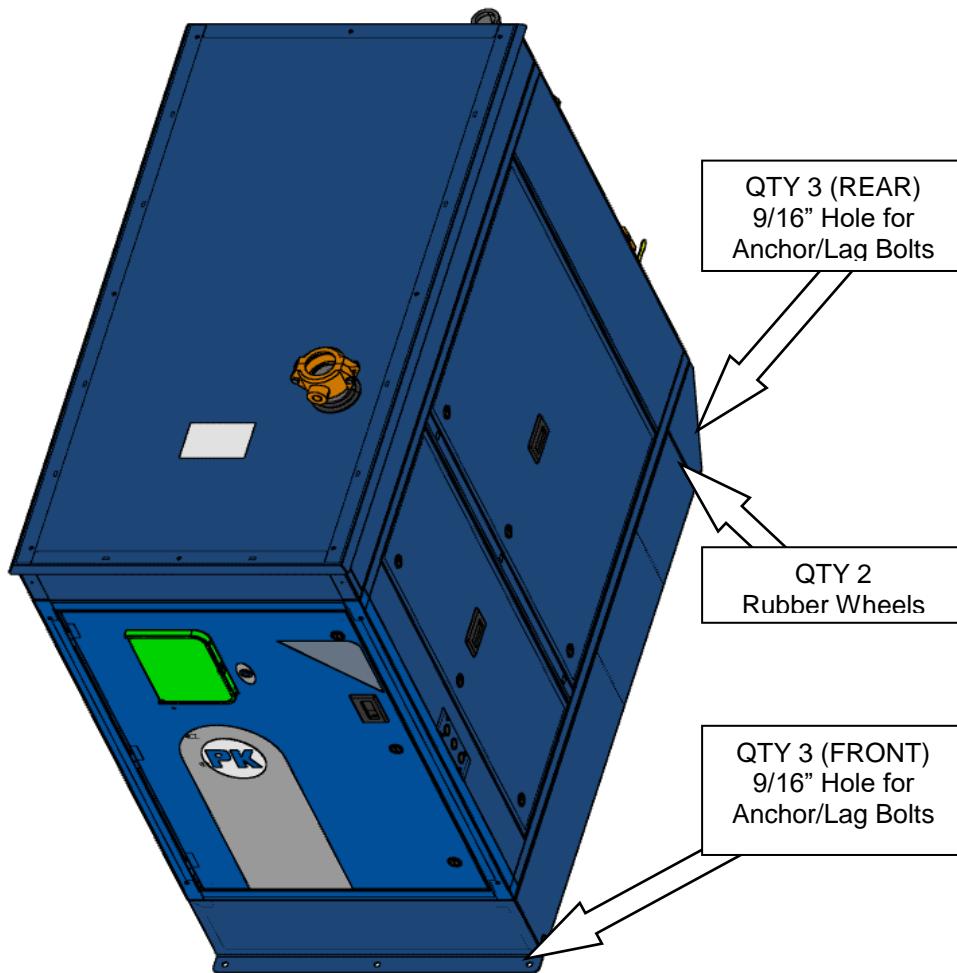
Where required by local codes, the installation must conform to American Society of Mechanical Engineers Safety Code for Controls and Safety Devices for Automatically Fired Boilers (ASME CSD-1).

In the Commonwealth of Massachusetts (a) this unit must be installed by a licensed pipe fitter/plumber, (b) field installed gas cocks must be “T” handle type, (c) piping of condensate shall conform to the State Plumbing Code, and (d) refer to the Massachusetts Supplement for further details.

## 2.4 Location Setup

### 2.4.1 Foundation

Provide a firm, level foundation, preferably made of concrete. The P-K MACH® boilers **must** be level and upright to function properly. There are six 9/16" holes in the base which may be used for 3/8" or 1/2" anchor bolts. Once the boiler is installed on the foundation and furnished with anchor/lag bolts, use a bubble level and adjust the anchor nuts until the appliance is secure and level.



Two wheels are provided for ease of movement. When the boiler is in position, the wheels can be disconnected and will recess up into the boiler's cabinet base. At a later date when the boiler is pulled out for maintenance, these wheels can be re-connected.

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

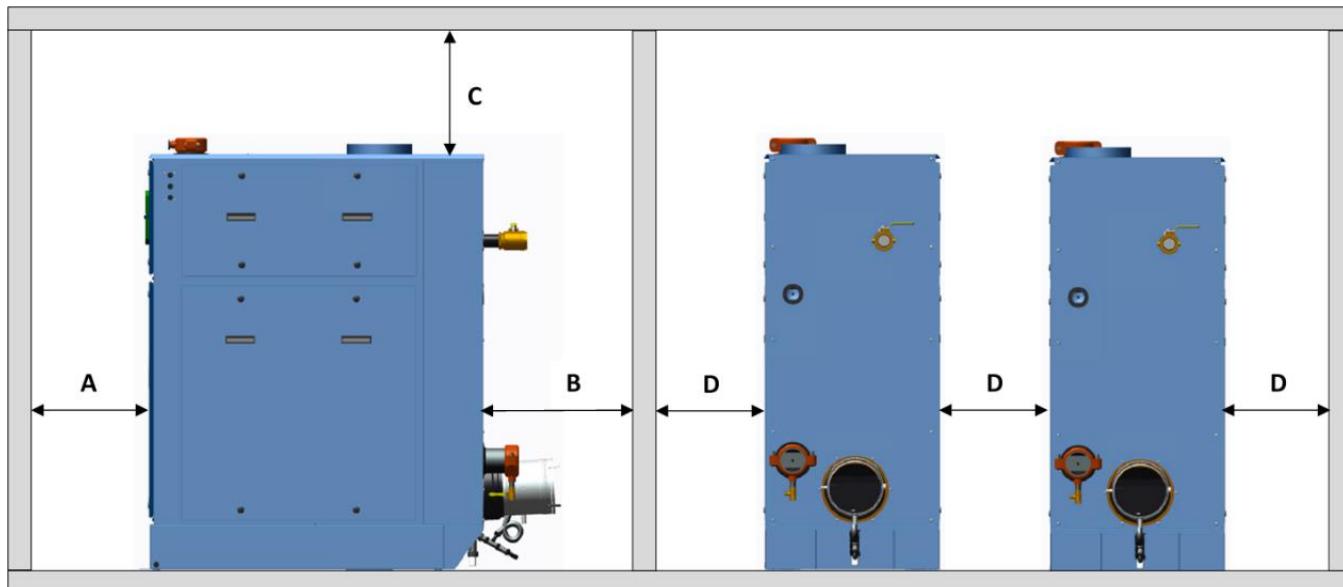
**NOTICE!** This appliance is certified for **INDOOR** use only!

### **⚠ WARNING**

**The boiler must be level within 0.25° in order to function properly. Failure to heed this warning could result in personal injury or death.**

## 2.4.2 Clearances

If the boiler is to be installed near combustible surfaces, the minimum clearances shown in the table and illustration below must be maintained. Failure to provide for service access clearances, even with non-combustible surfaces, may cause future problems servicing the boiler. Maintain a clearance from the vent to combustible surfaces of 24" or as specified by vent manufacturer's installation instructions. The boiler must be installed in a space large enough in comparison to the boiler as described in the National Fuel Gas Code, ANSI Z223.1, latest edition.



Type of Surface	Dimensions (inches)			
	A	B	C	D
Combustible Surfaces Minimum Clearances	18	6*	12†	6*
Clearance to Non-Combustible Surfaces	0	0	0	0
Recommended Clearances for Service Access	30	12**	12†	18**

\* "B" Clearance depends upon exhaust vent configuration.

† "C" Space required for pipes, ducts, etc. in this area above the boiler.

\*\* Do not put pipes, ducts, vents, etc. in this space. Electrical conduit must be installed vertically so that the side doors can be opened.

**Note:** Failure to provide recommended service clearances may make it difficult to perform service on the boiler(s).

## ⚠ 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.

## ⚠ WARNING

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. In the US, provisions for combustion air must be in accordance with NFPA 54/ANSI Z223.1, National Fuel Gas Code, latest edition, or applicable provisions of local building codes. In Canada, combustion and ventilation air openings shall comply with CAN/CSA B-149.1 Natural Gas and Propane Installation Code.

## ⚠ WARNING

For correct installation of a vent system, read all of these instructions and refer to the vent manufacturer's instructions.

Failure to use a proper vent system (types and materials), as described in this manual will void the boiler warranty and may result in rapid deterioration of the venting system, creating a health or life safety hazard.

Faulty vent installation can allow toxic fumes to be released into living areas. This may cause property damage, injury, or death.

## 2.5 Inlet Air and Exhaust Venting Considerations

### 2.5.1 Applicable Codes and Standards

#### United States Installation Codes:

NBIC – Part I	National Board Inspection Code - Installation
NFPA 54/ANSI Z223.1	National Fuel Gas Code
NFPA/ANSI 211	Chimneys, Fireplaces, Vents and Solid Fuel Burning Appliances

#### Canada Installation Codes:

CAN/CSA B149.1	Installation Codes for Gas Burning Equipment
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#### Flue Gas Exhaust Vent Standards:

UL 441 / ULC S605	Standard for Gas Vents
UL 1738	Venting Systems for Gas-Burning Appliances, Categories II, III and IV
ULC S636-95	Standard for Type BH Venting System Sheet Metal and Thermoplastic Duct Construction Manual Air Conditioning Contractors National Association (SMACNA)

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 both the above Federal Codes and with state, provincial, and local codes.

### 2.5.2 Combustion Air Inlet Planning (United States and Canada Considerations)

- Air inlet requirements for the U.S. are established by NFPA 54/ANSI Z223.1 & NFPA/ANSI 211.
- Air inlet requirements for Canada are established by CAN/CSA B149.1.

Refer to Section [3.4](#), for more details on combustion air inlet requirements in the United States and Canada.

### 2.5.3 Category II/IV Flue Gas Exhaust Vent Planning

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

- **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 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.

All P-K MACH® boilers are dual-certified as **Category II or IV** appliances, as defined in ANSI Z21.13/CSA 4.9, latest edition. The P-K MACH® series boilers are capable of operating with slightly negative to slightly positive exhaust pressure. It is critical to ensure the flue vent material is certified for **Category II or IV** operation.

**NOTE:** For **Category II** installations, ensure the flue venting system is designed to maintain a slightly negative exhaust pressure **between -0.01" W.C. and -0.04" W.C.**

**NOTE:** For **Category IV** installations, ensure the flue venting system is designed to maintain a slightly positive exhaust pressure which **MUST BE** in the following ranges:

- **+0.01" W.C. and +0.22" W.C. (Direct Vent / Sealed Combustion)**
- **+0.01" W.C. and +0.4" W.C. (Exhaust Only)**

The vent material to be used for US and Canada is listed in the Table of Acceptable Materials for Venting Systems located in Section [2.5.4](#).

Vent installations shall be in accordance with NFPA 54/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.

#### Vent Sizing for Category II / IV Operation

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.

P-K MACH® Boiler Model	Draft	Stack Temperature	CO <sub>2</sub> Natural Gas	CO <sub>2</sub> Propane Gas
C-1500H, C-2000H, C-2500, C-3000, C-4000	Category II -0.01" to -0.04" W.C.	220 °F (gross)	9.2%	10.4%
C-1500H, C-2000H, C-2500, C-3000, C-4000	Category IV (Sealed Combustion) +0.01" to +0.22" W.C.	220 °F (gross)	9.2%	10.4%
C-1500H, C-2000H, C-2500, C-3000, C-4000	Category IV (Exhaust Only) +0.01" to +0.4" W.C.	220 °F (gross)	9.2%	10.4%

## 2.5.4 Venting Materials for Flue/Exhaust Systems

The P-K MACH® boilers are dual certified as a **Category II** and **Category IV** appliances, which vents with a temperature that is likely to cause condensation in the vent. Therefore, any venting system used with the P-K MACH® boiler must comply with the requirements for either Category II or Category IV 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.

### CPVC Venting

**US:** CPVC pipe conforming to ASTM F441. Sch. 80 fittings conforming to ASTM F439. Joints are to be sealed with solvent conforming ASTM 493.

**Canada:** CPVC Pipe, Fitting and Sealant listed and labeled to ULC S-636 Standard for Type BH Venting Systems.

### Polypropylene Venting

**US and Canada:** Polypropylene such as InnoFlue® from Centrotherm or PolyPro® from DuraVent or Z-DENS from Z-Flex® or other listed manufacturers. When used, the same manufacturer's material must be used throughout the system. It is not permissible to use material from different manufacturers within the same system.

### As per ANSI Z21.13b-2012 \* CSA 4.9b-2012:

- The use of cellular core PVC, CPVC, and Radel® as venting materials is prohibited.
- The use of external insulation on plastic vent pipe is prohibited.

### Acceptable Venting Materials

Model	Country	AL29-4C	316L SS	PVC	CPVC	POLYPROPYLENE
C-1500H	US	Yes	Yes	No	Yes	Note 2
C-2000H	US	Yes	Yes	No	Yes	Note 2
C-2500	US	Yes	Yes	No	Yes	Note 2
C-3000	US	Yes	Yes	No	Yes	Note 2
C-4000	US	Yes	Yes	No	Yes	Note 2
C-1500H	Canada	Yes	Yes	No	Note 1	Note 1
C-2000H	Canada	Yes	Yes	No	Note 1	Note 1
C-2500	Canada	Yes	Yes	No	Note 1	Note 1
C-3000	Canada	Yes	Yes	No	Note 1	Note 1
C-4000	Canada	Yes	Yes	No	Note 1	Note 1
<b>NOTE 1:</b> When this material is used for venting, it must be listed to ULC-S636.						
<b>NOTE 2:</b> When this material is used for venting, it must be listed to either UL-1738 or ULC-S636 (depending on the local requirements). Consult the local boiler codes for more information.						

### WARNING

The venting materials listed 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!

This boiler is not certified for use with PVC venting. Use of PVC venting may result in vent failure and possible serious injury or death.

## 2.5.5 Required Clearances

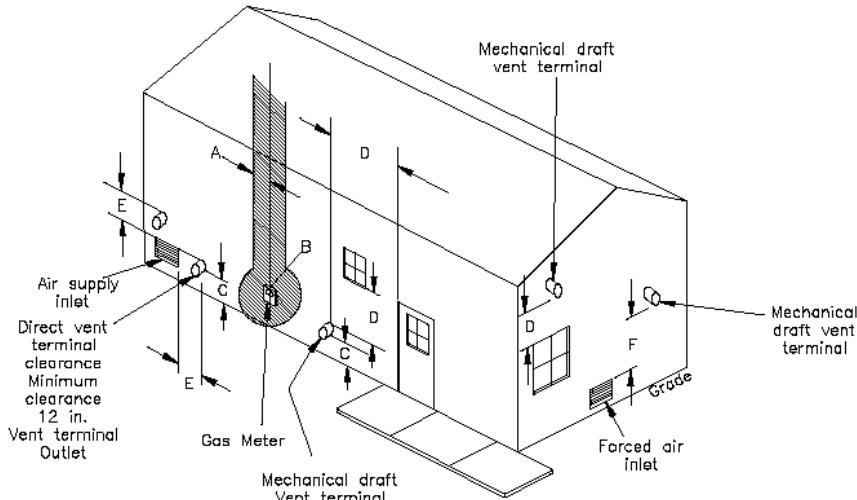
### Conventional Vent Systems Clearances

The following termination clearance requirements are for conventional non direct vent installations:

- The vent system shall terminate at least 3 ft. above a forced air inlet located within 10 ft. horizontally.
- The vent system shall terminate at least 4 ft. below, 4 ft. horizontally from, or 1 ft. above any door, operable window or gravity inlet into any building. The bottom of the vent terminal shall be at least 12 in. above grade or highest expected snow line (if applicable).
- Through the wall terminations shall not terminate over public walkways or over an area where condensate or vapor could create a nuisance or hazard or could be detrimental to the operation of regulators, relief valves, or other equipment.

### Direct Vent (Sealed Combustion) Systems Clearances

- The vent terminal shall be located at least 12 in. from any air opening into a building. The bottom of the vent terminal shall be at least 12 in. above grade. Both the vent and air intake terminals must be at least 12 in. above the highest expected snow line.
- Through the wall terminations shall not terminate over public walkways or over an area where condensate or vapor could create a nuisance or hazard or could be detrimental to the operation of regulators, relief valves, or other equipment.
- When multiple direct vent appliances are adjacent, the exhaust must terminate at least 10 ft. horizontally or 3 ft. vertically from the air intake of another appliance.



### WARNING

The boiler vent should not be connected into any portion of another mechanical draft system without consulting the vent manufacturer. The boiler shall not be connected to any part of a vent system serving a Category I appliance, nor shall a Category I appliance be connected to any part of the vent system serving this appliance. For Category II common venting, refer to local venting codes. Improper interconnection of venting systems may result in leakage of flue gases into occupied spaces.

Mark	Description	US Installations	Canadian Installations
A	Clearance to each side of center line extended above meter/regulator		3 ft. (91 cm) within a height of 15 ft. (4.6 m) above the meter/regulator assembly
B	Clearance to service regulator vent outlet		3 ft. (91 cm)
C	Clearance above grade, porch, deck, veranda, or balcony	12 in	
D	Clearance to window or door that may be opened	4 ft. (1.2 m) below or to side of opening 1 ft. (300 mm) above opening	6 in (15 cm) for appliances ≤ 10,000 Btuh (3 kW) 12 in (30 cm) for appliances > 10,000 Btuh (3 kW) and ≤ 100,000 Btuh (30 kW) 36 in (91 cm) for appliances > 100,000 Btuh (30 kW)
E	Clearance to non-mechanical air supply inlet to building or the combustion air inlet to any other appliance	4 ft. (1.2 m) below or to side of opening 1 ft. (300 mm) above opening	6 in (15 cm) for appliances ≤ 10,000 Btuh (3 kW) 12 in (30 cm) for appliances > 10,000 Btuh (3 kW) and ≤ 100,000 Btuh (30 kW) 36 in (91 cm) for appliances > 100,000 Btuh (30 kW)
F	Clearance to a mechanical air supply inlet	3 ft. (91 cm) above if within 10 ft. (3 m) horizontally	6 feet (1.83 m)

For clearances not specified maintain clearance in accordance with local installation codes and the requirements of the gas supplier

### Interior Component Clearances

All vent system components shall be installed so as to maintain the following minimum clearances:

Material	Combustible	Non-Combustibles
Unlisted single wall metal pipe	Do NOT Use	Do NOT Use
Single wall PVC pipe	Do NOT Use	Do NOT Use
UL 1738 listed Category IV vent	Per manufacturer's listing	Per manufacturer's listing

### Flue Connection

The connection from the appliance to the vent should be as direct as possible and the upward slope of any horizontal breaching should be at least 1/4 inch per linear foot. Examples of the complete exhaust system with drain is Section [3.5](#). The appliance connector should incorporate provisions to drain condensate formed in the vent system. The connector should include an appropriate drain section (not provided).

## 2.6 Gas Piping Considerations

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



Supplying a fuel other than that shown on the appliance's nameplate can lead to over firing of the appliance. This can cause damage to the equipment which could result in serious injury and/or death.

The boiler shall be installed such that gas ignition system components are protected from water (dripping, spraying, rain, etc.) during appliance operation and service (circulator replacement, control adjustment, etc.).

## 2.7 Water Quality Standard

The P-K MACH® boiler's heat exchanger is made of cast Aluminum. The heat exchanger requires proper water conditions to remain efficient and function properly. For more information, refer to Harsco Industrial, Patterson-Kelley's Water Quality Standards for Hydronic Boilers in Multi-Metal Systems in [Appendix C – Water Quality Standards Quality Standards for Hydronic Boilers in Multi-Metal Systems](#) as this applies to the warranty of your heat exchanger.

**NOTE:** Failure to maintain the water quality according to the requirements of the multi-metal systems water quality standards can void the heat exchanger warranty.

## 3 Installation

### 3.1 Overview

For site preparation follow the guidelines established in Section 2. Section 3 details the installation requirements for electrical connections, combustion air, and flue vent piping, hydronic piping, etc.

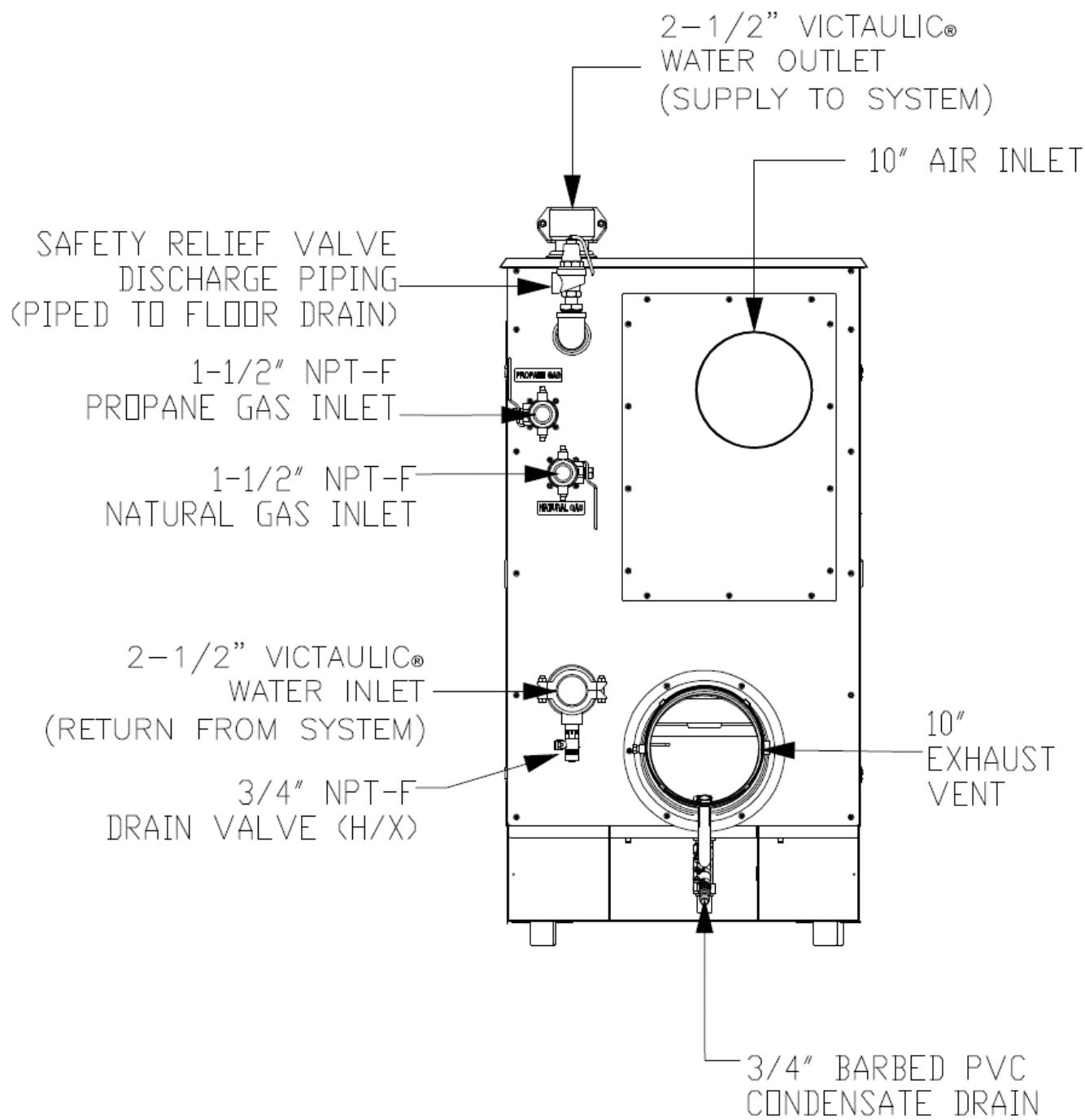
### 3.2 Appliance Connections

The table below summarizes the appliance connections to the P-K MACH® series boilers:

Boiler Model	C-1500H & C-2000H	C-2500	C-3000 & C-4000
Power Requirement	110-120/1/60 VAC		208-240/3/60 VAC <b>-or-</b> 440-480/3/60 VAC
Air Intake Connection	10"		12"
Nominal Exhaust Vent Connection		10"	
Condensate Drain		3/4" Flexible Tubing	
Heat Exchanger Drain		3/4" NPT-F	
Natural Gas Shutoff Valve	1-1/2" NPT-F		2" NPT-F
Propane Gas Shutoff Valve		1-1/2" NPT-F	
HWR Connection	2-1/2" Grooved (Carbon Steel)	3" Grooved (Carbon Steel)	4" Grooved (Carbon Steel)
HWS Connection	2-1/2" Grooved (Carbon Steel)	3" Grooved (Carbon Steel)	4" Grooved (Carbon Steel)

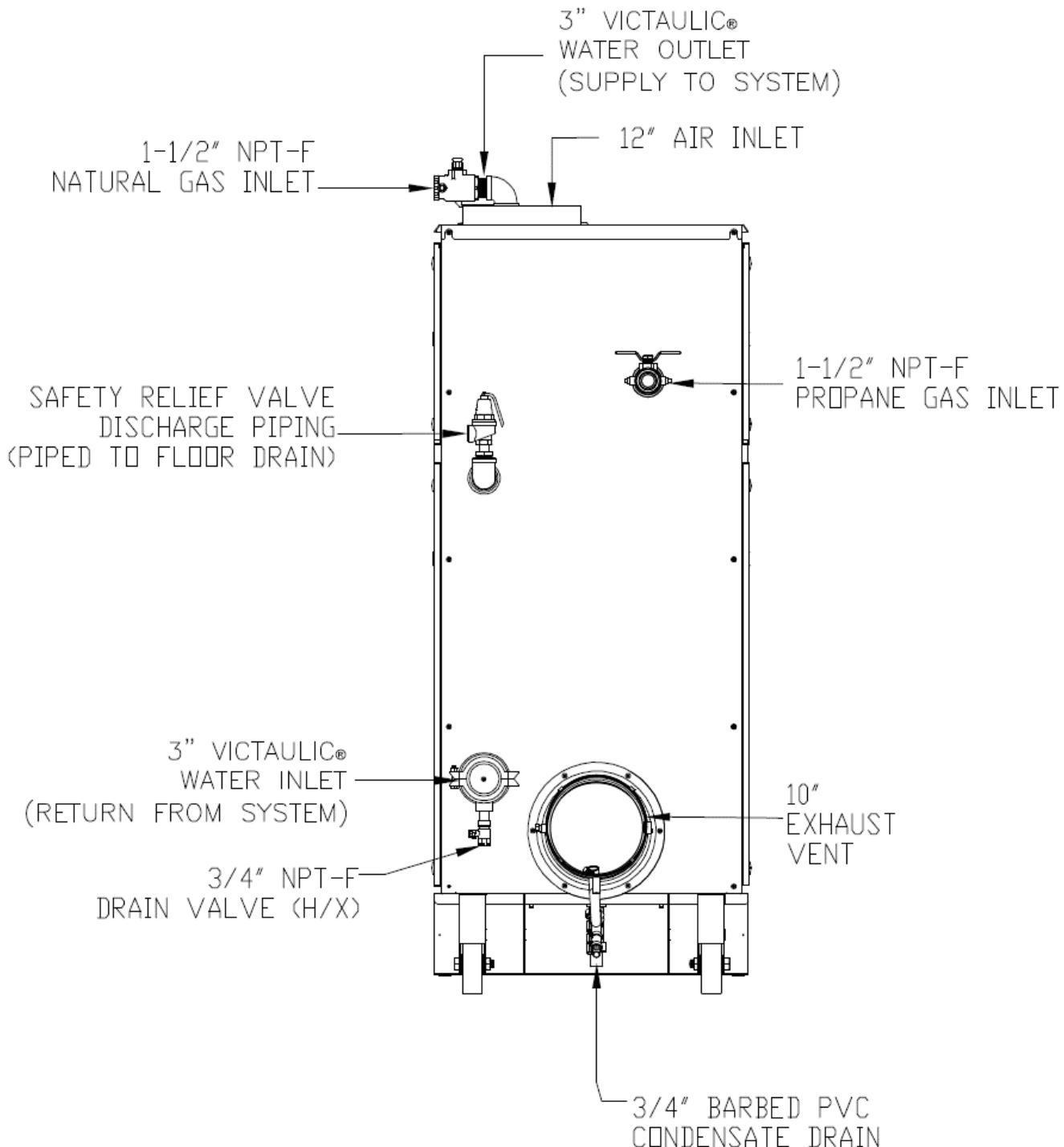
### 3.2.1 Appliance Connections (C-1500H & C-2000H)

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



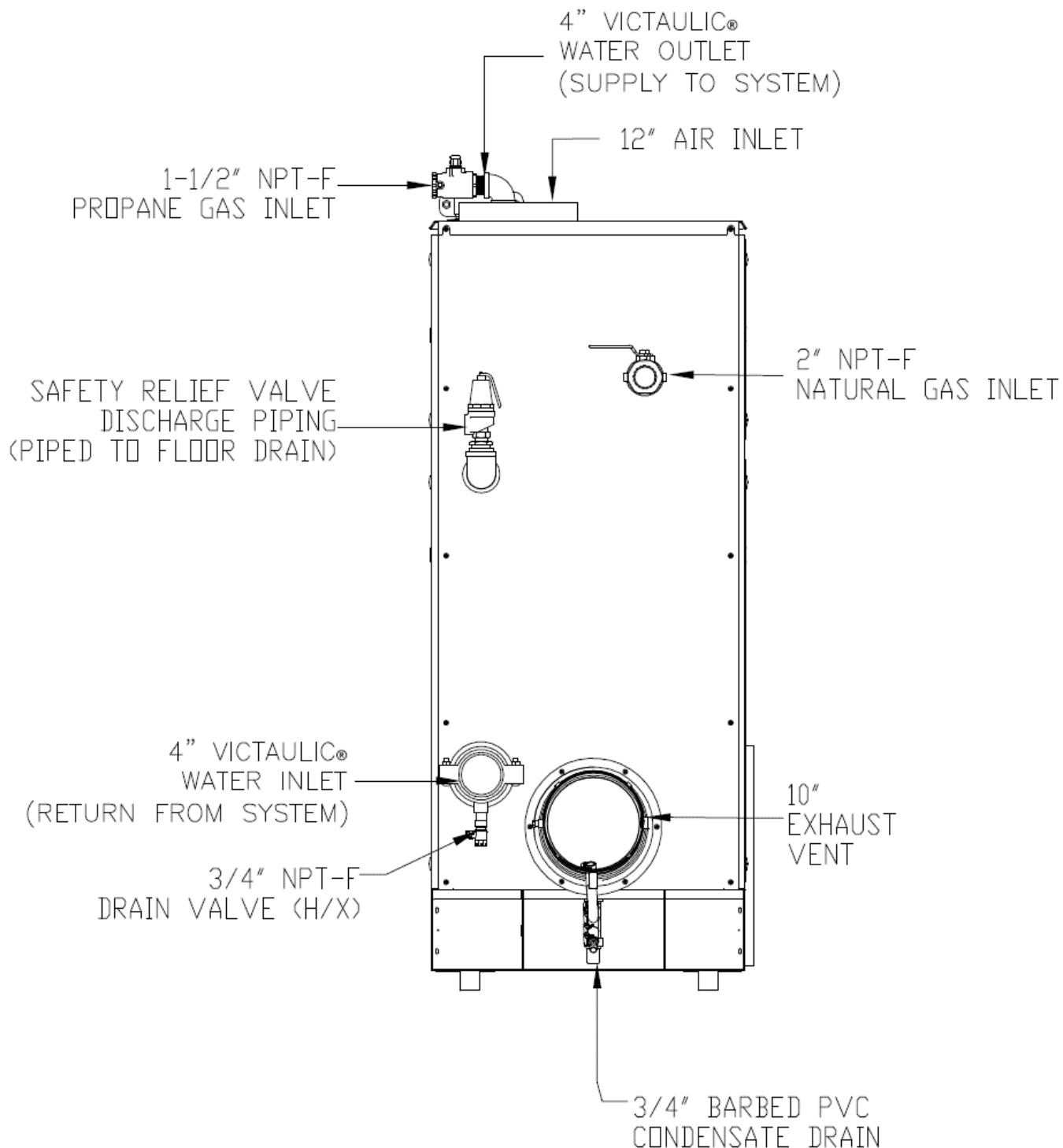
### 3.2.2 Appliance Connections (C-2500 & C-3000)

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



### 3.2.3 Appliance Connections (C-4000)

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



### 3.3 Electrical Connections

#### 3.3.1 Power Requirements (C-1500H, C-2000H & C-2500)

The C-1500H, C-2000H and C-2500 boiler models require 110-120 VAC, **single phase**, 60 hertz electrical service. The MCA and MOCP are indicated on the boiler's rating nameplate. Before starting the boiler, check to ensure that the proper electrical service is connected to the boiler. The total operating amperage is indicated on the rating nameplate and the C-1500H & C-2000H boilers require less than 15 Amps at full load. The C-2500 boiler requires less than 17 Amps at full load. Before starting the boiler, check to ensure that the proper electrical service is connected to the boiler.

An external electrical disconnect and overload protection (not supplied with the boiler) **are required**. Refer to Section [7.1](#) for proper wiring and configuration of the electrical connections. The electrical service to the boiler must be installed and 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 or, in Canada, to the current Canadian Electrical Code, Part I, CSA C22.1 latest edition. Installed conduit must not block any of the boiler's openings and must allow the front door to be opened.

#### 3.3.2 Single Phase Power Supply Connection (C-1500H, C-2000H & C-2500)

The C-1500H, C-2000H and C-2500 models feature three dedicated power terminals on the **High Voltage (TB2)** terminal block for the 110-120VAC, **single phase**, and 60 hertz electrical supply. The image below shows the location of the **Low Voltage (TB1)** and **High Voltage (TB2)** terminal blocks with the front door opened for clarity:

- TB2 Terminal 1 = HOT L1
- TB2 Terminal 2 = **Not Used**
- TB2 Terminal 3 = NEUTRAL N1
- TB2 Terminal 4 = GROUND GND

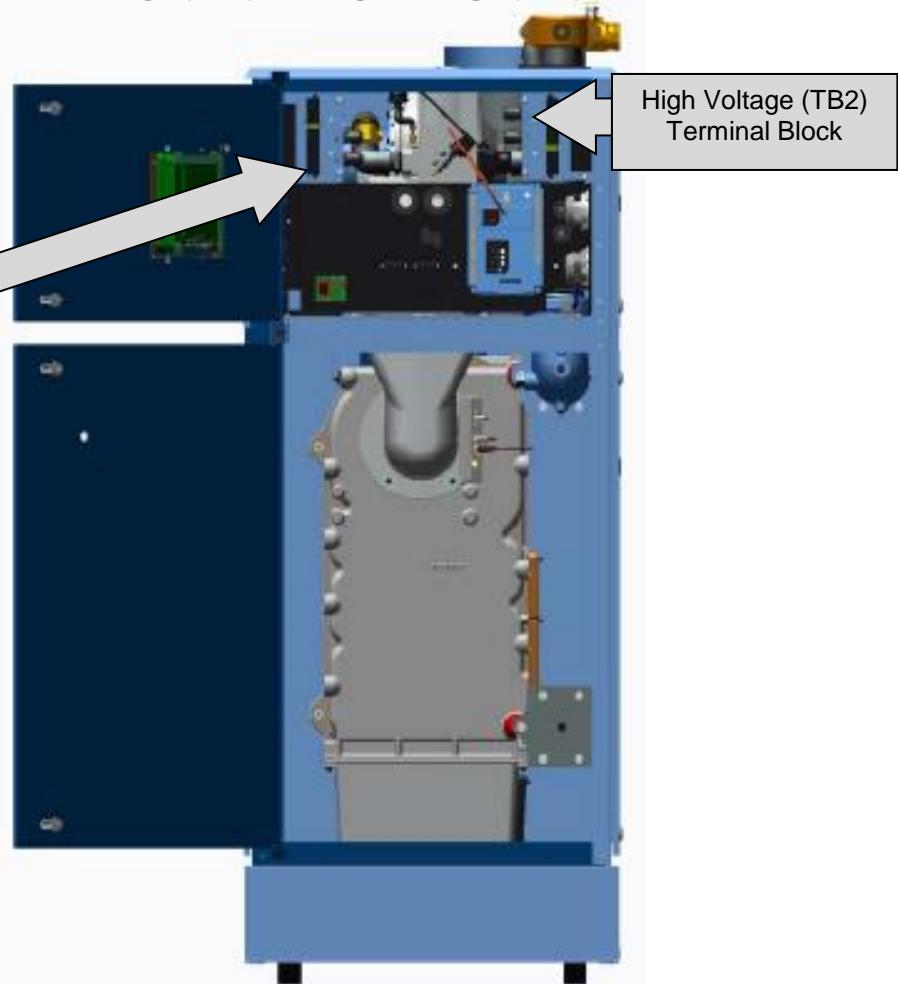
Low Voltage (TB1) Terminal Block

High Voltage (TB2)  
Terminal Block

**NOTE**  
These terminals can accommodate maximum 10AWG wire.

**CAUTION**

Do not over-tighten the terminal screws. Maximum tightening torque = 6 in-lbs!



### 3.3.3 Power Requirements (C-3000 & C-4000)

The C-3000 and C-4000 boilers can be manufactured for 208-240 VAC, three phase, 60 hertz electrical service OR 440-480VAC, three phase, 60 hertz electrical service. The total operating amperage is indicated on the rating nameplate and the C-3000 & C-4000 boiler models require less than 20 Amps at full load. Before starting the boiler, check to ensure that the proper electrical service is connected to the boiler.

**NOTE:** The C-3000 & C-4000 boiler models **MUST** be ordered to the correct voltage! **IT IS NOT POSSIBLE** to convert a C-3000 or C-4000 between the 240V and 480V configurations in the field!

An external electrical disconnect and overload protection (not supplied with the boiler) **are required**. Refer to Section [7.1](#), for proper wiring and configuration of the electrical connections. The electrical service to the boiler must be installed and 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 or, in Canada, to the current Canadian Electrical Code, Part I, CSA C22.1 latest edition. Installed conduit must not block any of the boiler's openings and must allow the front door to be opened.

### 3.3.4 Three Phase Power Supply Connection (C-3000 & C-4000)

#### Main Power Connection Box

Always check the rating nameplate of the C-3000 or C-4000 boiler to determine the required electrical service:

- 208-240VAC, three phase, 60 hertz
- 440-480VAC, three phase, 60 hertz

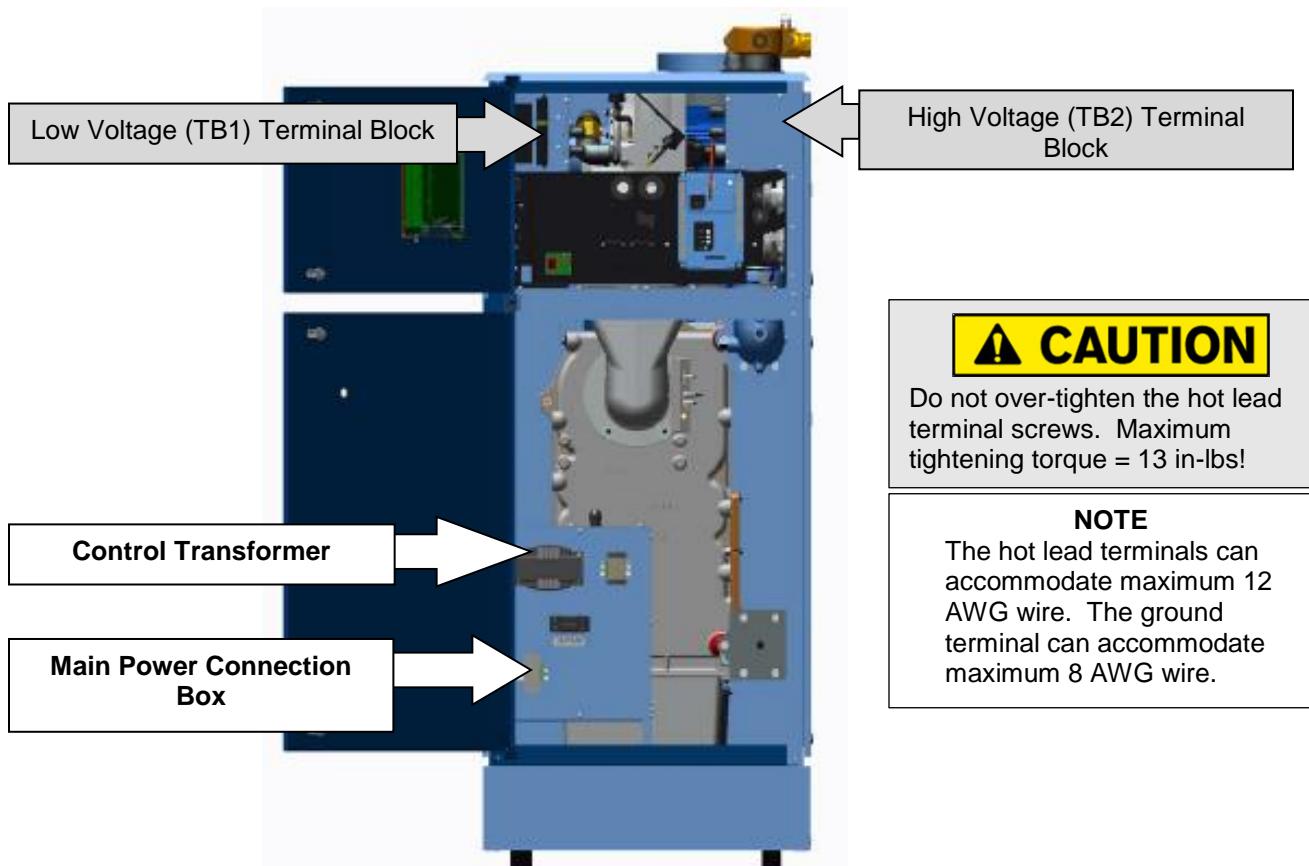
The incoming three phase power for the C-3000 & C-4000 boilers is connected to the over-current safety device (rated for 20 Amps) and the Ground terminal located in the main power connection box. The image on the next page shows the Low Voltage (TB1) and High Voltage (TB2) terminal blocks, plus the **Main Power Connection Box** on the C-3000 & C-4000 with the front door hidden for clarity:

- Terminal 1 = HOT L1
- Terminal 3 = HOT L2
- Terminal 5 = HOT L3
- Terminal G = GROUND

#### Control Transformer

The **Main Power Connection Box** features a **Control Transformer** which steps down two hot leads from the incoming three-phase power in order to supply 110-120VAC single phase power to the NURO® control system. Be aware that C-3000 & C-4000 boilers ordered in the 240V configuration, are pre-wired from the factory for operation with 240 VAC three phase incoming power.

**NOTICE:** If 208 VAC three phase power is supplied to the boiler, the internal control transformer **must be re-wired** for operation at this lower voltage. The wire in terminal X3 on the load side of the internal control transformer must be moved to terminal X4. This supplies 110 VAC power to the NURO® control from the 208 VAC main voltage. Refer to Section [7.1](#), for proper wiring and configuration of the internal control transformer.



### 3.3.5 High Voltage (TB2) Terminal Block

**Start Interlock #1** – The Start Interlock #1 terminals can be used for auxiliary safety devices such as damper limit switches, control valve limit switches, emergency stop buttons, and low water cutoff devices. This circuit is energized with 120VAC, so the contacts on any auxiliary safety devices must be rated for a minimum of 120VAC.

**Start Interlock #2** – The Start Interlock #2 terminals are in series with Start Interlock #1 and provide additional connection points for auxiliary safety devices. This circuit is energized with 120VAC, so the contacts on any auxiliary safety devices must be rated for minimum 120VAC.

#### NOTE

The boiler ships with a factory-installed jumper across Start Interlock #1 and Start Interlock #2 terminals. Remove the jumper(s) if using any auxiliary safety devices.

#### NOTE

Both the Start Interlock #1 and Start Interlock #2 circuits must close within 5 minutes of a call for heat. Failure to close the Start Interlock circuit will cause the boiler to lockout on alarm.

**Auxiliary Input #1** – These terminals are reserved for future use. This circuit is energized with 120VAC.

**Auxiliary Input #2** – These terminals are reserved for future use. This circuit is energized with 120VAC.

**Air Damper Interlock** – The Air Damper Interlock provides dedicated terminals for proof of open end limit switch on a motorized air damper. This circuit is energized with 120VAC, so the contacts on the end limit switch must be rated for minimum 120VAC.

#### NOTE

The boiler ships with a factory-installed jumper across the Air Damper Interlock terminals. Remove the jumper if connecting a motorized air damper with end limit switch.

**Relay A** – User-configurable relay output #1. The normally-open contacts on this relay have a maximum voltage rating of 240VAC and maximum current capacity of 1/2 Amp.

**Relay B** – User-configurable relay output #2. The normally-open contacts on this relay have a maximum voltage rating of 240VAC and maximum current capacity of 1/2 Amp.

## CAUTION

Be sure to check the nameplate on the boiler before connecting the electrical supply.

## NOTICE!

A dedicated earth ground (green wire) is required to avoid nuisance shutdowns. Do not ground through the conduit!

## WARNING

The high voltage (TB2) terminal block on the P-K MACH C-1500H, C-2000H, and C-2500 boilers with NURO controls contains one hot lead (HOT L1), a neutral lead (NEUTRAL) and a ground lead (GROUND) for 110 - 120 VAC, single phase 60Hz electrical supply. This terminal block (TB2) also contains dry-contact relays with a maximum voltage rating of 240VAC and 1/2 Amp maximum current capacity. Incorrect wiring can result in equipment damage, injury, or death.

## WARNING

The high voltage (TB2) terminal block on the MACH C-3000 & C-4000 with NURO controls contains dry-contact relays with a maximum voltage rating of 240VAC and 1/2 Amp maximum current capacity. Incorrect wiring can result in equipment damage, injury, or death.

#### NOTE:

Refer to Section [7.1](#) for proper wiring and configuration of the electrical connections.

Relays A through D can be user-configured through the NURO touch screen interface to control devices such as the Comfort Heat (CH) Pump, Domestic Hot Water (DHW) Pump, Air Damper, System Pump, etc.

**Relay C** – User-configurable relay output #3. The normally-open contacts on this relay have a maximum voltage rating of 240VAC and maximum current capacity of 1/2 Amp.

**Relay D** – User-configurable relay output #4. The normally-open contacts on this relay have a maximum voltage rating of 240VAC and maximum current capacity of 1/2 Amp.

**Master Alarm Relay** – The Master Alarm Relay terminals are normally-open dry contacts that close in the event of an alarm output from the boiler control.

### 3.3.6 Low Voltage (TB1) Terminal Block

**Enable/Disable** – TB1-1 and TB1-2 can be used to remotely enable or disable the boiler. The functionality of these terminals is user-configurable through the NURO controls, but generally closure of the Enable/Disable circuit provides a call for heat to the boiler. Opening this circuit prevents the boiler from running.

The boiler ships with a factory-installed jumper across the Enable/Disable terminals. This circuit is energized with a 24VAC potential, so the contacts on any remote enable devices must be rated for minimum 24VAC.

**4-20mA Analog Input** – TB1-3 and TB1-4 can be used to provide a remote analog 4-20mA control signal to the boiler. This analog signal can be used to change the boiler's operating setpoint or firing rate.

**Spare Analog Input** – TB1-5 and TB1-6 are reserved for future use.

**HDR Temp Sensor** – TB1-7 and TB1-8 can be used to connect a remote header temperature sensor, installed in the primary hydronic system piping, downstream of all the boilers. This temperature sensor must be a 2-wire 12kΩ NTC thermistor. This circuit is energized by the boiler with a 5VDC potential.

**DHW Stat/Sensor** – TB1-9 and TB1-10 can be used to connect either an aquastat or remote DHW temperature sensor installed in a domestic hot water storage tank. If using an aquastat, use a SPST normally-closed, break on rise type with either a fixed or adjustable deadband above and below the setpoint.

Alternatively, if using a temperature sensor, it must be a 2-wire 12kΩ NTC thermistor and be of sufficient length to measure an accurate storage tank temperature. This circuit is energized by the boiler with a 5VDC potential.

**Outdoor Temp Sensor** – TB1-11 and TB1-12 can be used to connect an outdoor air temperature sensor which allows the NURO control to be programmed to run an outdoor air schedule. The outdoor air temperature sensor must be a 2-wire 12kΩ NTC thermistor and should be installed on the North face of the building and shielded from direct sunlight exposure. This circuit is energized by the boiler with a 5VDC potential.

**Night Setback** – TB1-13 and TB1-14 can be used to connect a day/night or occupancy timer. Closure of the Night Setback circuit enables the Night Setback mode which reduces the boiler's operating setpoint. Opening this circuit resumes normal operation. This circuit is energized by the boiler with a 5VDC potential, so the contacts on the day/night timer must be rated for minimum 5VDC.

**4-20mA Analog Output** – TB1-15 and TB1-16 provide a 4-20mA analog output signal which tracks the boiler's firing rate. When operating at full power (maximum firing rate), the boiler will provide a 20mA output. When operating at minimum power (minimum firing rate), the boiler will provide a 4mA output.

**Ground** – TB1-17 provides an equipment (frame) ground connection for input, output, or communication connections. For independently powered control devices, it may be necessary to create a common ground.

**Cascade Shield & Cascade** – TB1-18, TB1-19 and TB1-20 can be used to setup a cascade system with multiple MACH boilers with NURO controls. Terminals TB1-19 and TB1-20 are reserved for the cascade communication between the master and member boilers. Terminal TB1-18 should be used to connect the cascade communication wiring shield between all boilers. The cascade and shielding must be wired from the master boiler to each individual member boiler in a daisy-chain fashion.

**NOTE** Only ground the shield at the master boiler.

**MODBUS COM & MODBUS Shield** – TB1-22, TB1-23, and TB1-24 can be used to integrate the boiler with a Building Management System (BMS), Protocol Converter, or other device capable of RS-485 2-wire MODBUS communication. Terminals TB1-22 and TB1-23 are reserved for MODBUS and terminal TB1-18 provides a connection for the MODBUS communication wire shield.

**NOTE** Only ground the shield at the master boiler.

**ECOM 1, 2 & 3** – TB1-25, TB1-26, and TB1-27 can be used to connect a wireless outdoor air temperature sensor. The wireless receiver should be installed at or near the boiler, and the wireless temperature sensor should be installed on the North face of the building and shielded from direct sunlight exposure.

## 3.4 Combustion Air

### 3.4.1 Air Inlet Requirements – United States

Air inlet requirements for the United States are established by 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 ft<sup>3</sup> per 1,000 Btu/Hr (4.8 m<sup>3</sup>/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 1,000 Btu/Hr (2,200 mm<sup>2</sup>/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 1,000 Btu/Hr (4,400 mm<sup>2</sup>/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 3,000 Btu/Hr (700 mm<sup>2</sup>/kW) of installed appliance input capacity, and not less than the sum of the areas of all vent connectors in the room.

**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. This applies to both sealed combustion and atmospheric room combustion air applications.**

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 (550 mm<sup>2</sup>/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 (550 mm<sup>2</sup>/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 (1,100 mm<sup>2</sup>/kW) of total boiler input is required.

**NOTES:**

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 1/4 inch.
3. Motorized louvers shall be interlocked with the appliance so that they are proven open prior to main burner ignition and operation.

**United States Minimum Area of Ventilation Openings per Boiler (Sq. In)**

P-K MACH® Boiler MODEL	AIR SOURCE					
	INDOOR AIR SUPPLY		OUTDOOR AIR SUPPLY			
	SAME FLOOR	DIFF FLOORS	ONE OPENING	TWO OPENINGS		
				DIRECT	VERT DUCT	HORIZ DUCT
C-1500H	1500	3000	500	375	375	750
C-2000H	2000	4000	667	500	500	1000
C-2500	2500	5000	833	625	625	1250
C-3000	3000	6000	1000	750	750	1500
C-4000	4000	8000	1334	1000	1000	2000

### 3.4.2 Air Inlet Requirements - Canada

Air inlet requirements for the Canadian Provinces are established by CAN/CSA B149.1. 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. (6,500 mm<sup>2</sup>), whichever is greater.

- NOTES:**
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 1/4 inch.
  3. Motorized louvers shall be interlocked with the appliance so that they are proven open prior to main burner ignition and operation.

- 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. (6,500 mm<sup>2</sup>), whichever is greater.
- B. Use the following opening calculation for P-K MACH® 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 mm<sup>2</sup>/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. When combustion air is supplied by natural airflow into a space containing the type of appliance described in **Paragraph B**, the cross sectional area of the opening shall not be 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**.
- D. When a duct is used to meet the requirement for combustion air supply, as described in **Paragraphs A through C**, 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.
- E. When combustion air is supplied by mechanical means, an airflow-sensing device must be installed. It must be wired into the pre-ignition limit/interlock to prevent the burner from starting or to stop an operating burner in case of air supply failure.
- F. 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 E** do not apply.

### Canadian Minimum Area of Combustion and Ventilation Air Openings

P-K MACH® Model #	BTU/Hr	Required Combustion Air Opening		Ventilation Air Opening	
		Input	in <sup>2</sup>	mm <sup>2</sup>	in <sup>2</sup>
C-1500H	1,500,000	50	32,258	10	6,452
C-2000H	2,000,000	67	43,226	10	6,452
C-2500	2,500,000	83	53,548	10	6,452
C-3000	3,000,000	100	64,516	10	6,452
C-4000	4,000,000	134	86,451	13.4	8,645

### 3.4.3 P-K MACH® Combustion Air Requirements

The table below summarizes the combustion air requirements for P-K MACH® boilers:

P-K MACH® Model #	Air Intake Connection	Required SCFM Combustion Air
C-1500	10"	350
C-2000	10"	470
C-2500	12"	580
C-3000	12"	696
C-4000	12"	928

### 3.4.4 Direct Vent / Sealed Combustion Installations

The P-K MACH® series boilers are certified for operation in direct vent / sealed combustion systems, which feature combustion air intake ductwork which sources the combustion air supply from outdoors. The flow of combustion air through this ductwork is maintained by the appliance's combustion blower.

The combustion air intake ductwork can be constructed with PVC, CPVC, single wall galvanized steel, or other suitable materials. The ductwork must be rigid enough to maintain the full required cross sectional area under all operating conditions.

**NOTE:** The combustion air intake ductwork must be sufficiently rigid in order to prevent collapse due to the potential for negative pressures inside the ductwork. If the ductwork collapses, this will restrict the combustion air supply to the appliance which may prohibit operation.

Proper sealing of the combustion air intake ductwork is necessary to prevent infiltration of air from conditioned space. For example, joints in PVC or CPVC piping must be cemented. For galvanized duct, wrap each joint and seam with adhesive aluminum tape or other sealant. Harsco Industrial Patterson-Kelley recommends installing a 1" x 1" or larger bird screen on the exterior termination. Ensure that the screen does not become blocked with snow, ice, insects etc.

The combustion air supply 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 appliance 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 appliance. 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, cause improper combustion and premature appliance failure due to the formation of acids which quickly attack the heat exchanger and the flue piping materials.

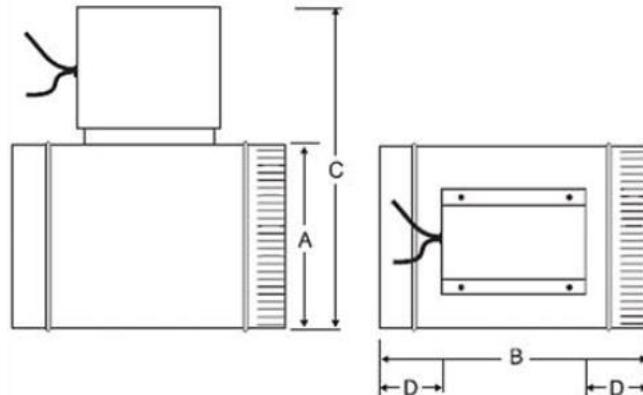
## Sizing the Combustion Air Intake Ductwork

The combustion air flow rate requirements per boiler model are summarized in Section [3.4.3](#). When sizing the combustion air intake ductwork, the pressure drop through this ductwork **MUST NOT** exceed 0.22" W.C. as described in the table below:

P-K MACH® Boiler Model	Flue Vent Category	Maximum Allowable Pressure Drop through Combustion Air Ductwork	Allowable Vent Pressure
C-1500H, C-2000H, C-2500, C-3000 & C-4000	II	0.22" W.C.	-0.01" W.C. to -0.04" W.C.
C-1500H, C-2000H, C-2500, C-3000 & C-4000	IV	0.22" W.C.	+0.01" W.C. to +0.22" W.C.
<b>NOTE:</b> If the combustion air intake ductwork and the exhaust vent terminate on the same wall of the building, they <b>must</b> utilize the same type of termination fitting.			
<b>NOTE:</b> Harsco Industrial Patterson-Kelley recommends including a motorized combustion air damper in each appliance's air intake ductwork. Refer to Section <a href="#">3.4.5</a> for more information.			

### 3.4.5 Motorized Combustion Air Dampers

Harsco Industrial Patterson-Kelley recommends, and most installation codes require, the use of motorized combustion air dampers with end limit switches installed in the combustion air intake ductwork upstream of each appliance. This damper isolates the combustion air supply when the appliance is in standby. Once the appliance receives a call for heat, the motorized combustion air damper opens and the end limit switch must close before the appliance can proceed to ignition. Harsco Industrial Patterson-Kelley offers motorized combustion air dampers with built-in end limits switches for sale, which are summarized in the table below:



**Table of Recommended Motorized Combustion Air Dampers**

Combustion Air Ductwork Size	Normally-Closed Motorized Damper	A	B	C	D
12"	10-0490-6946	12"	12"	15"	4.38"
14"	10-0490-6989	14"	14"	17"	5.5"

These normally-closed motorized combustion air dampers operate on 120 VAC and feature a built in end limit switch which must be wired to the appliances' Air Damper Interlock circuit. Upon a call for heat, the boiler's Air Damper Relay energizes, which drives the damper motor open. Once the damper reaches the fully-open position, the end limit switch makes contact and closes the Air Damper Interlock circuit, allowing the appliance to proceed to ignition. The diagram on the next page shows the wiring necessary to install the normally-closed motorized damper.

## ⚠ WARNING

For correct installation of a vent system, read all of these instructions and refer to the vent manufacturer's instructions.

**Failure to use a proper vent system (types and materials) as described in this manual will void the appliance warranty and may result in rapid deterioration of the venting system, creating a health or life safety hazard.**

**Faulty vent installation can allow toxic fumes to be released into living areas. This may cause property damage, injury, or death**

## ⚠ WARNING

**External power supplies are required for Relay A, Relay B, Relay C and Relay D. Because power is provided from an external source, the power is still present when the appliance is turned off. Check all voltage sources have been disconnected prior to servicing. Failure to do so could result in electrocution, injury, or death.**

## NOTICE!

Relay A, Relay B, Relay C, and Relay D are rated for a maximum voltage of 240VAC and a maximum current capacity of 1/2 Amp. Customer must supply fusing for all current connected to the relays. Connecting a motorized damper which exceeds the voltage or current capacity of the relay could cause permanent damage to the relay.

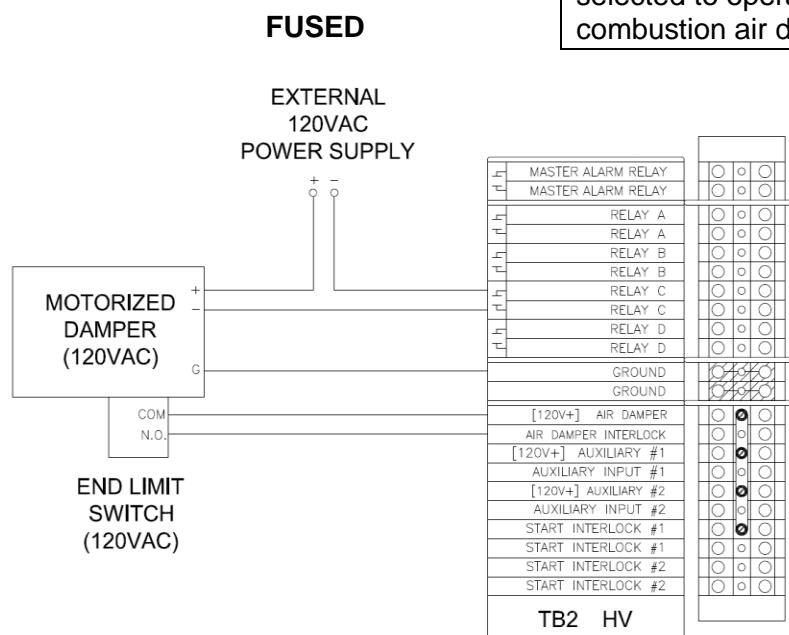
**NOTE:** The power source to drive the damper actuator motor must be provided externally. The appliance DOES NOT provide a power source for this purpose.

**NOTE:** Combustion air dampers other than those listed in the table above may require voltages other than 120VAC. This is acceptable, provided the required voltage does not exceed 240VAC.

**NOTE:** The Air Damper Interlock circuit for the end limit switch is always 120VAC which is sourced from the appliance itself. All end limit switches must be rated for 120VAC.

Motorized combustion air dampers must be powered from an external power supply other than the appliance. The figure below shows a sample installation in which Relay C is user-selected to operate a 120VAC motorized air damper. Relay C is normally-open, so when the appliance is in standby, the combustion air damper remains closed. Once a call for heat is received, Relay C closes the 120VAC circuit (external power supply) which provides power to the damper motor, opening the damper. Once the motorized damper is fully-open, its end limit switch completes the Air Damper Interlock circuit (120VAC) which allows the appliance to proceed to ignition.

**Note:** The NURO® control allows the user to allocate Relay A, B, or C for use with a motorized combustion air damper. The figure above shows Relay C in use for the motorized combustion air damper. Depending on the user-configuration, Relay a, Relay B, or Relay C can be selected to operate the combustion air damper.



### 3.5 Flue Gas / Exhaust Venting

All vent installations shall be in accordance with NFPA 54/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.

The vent material to be used for US and Canada is listed in the Table of Acceptable Materials for Venting Systems located in [2.5.4](#).

For interior clearance requirements, refer to [2.5.5](#). The vent shall 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. Refer to [3.5.2](#) for an illustration of the flue termination. Additionally, the boiler vent shall terminate at least three (3) feet above a forced air inlet located within ten (10) feet.

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 appliances.**

Vertical vents are allowed to be terminated with a variety of ends, including plain straight pipe, elbow, or vent tee. Horizontal vents must be terminated with an elbow or vent tee. Similarly, a bird screen with 1" x 1" openings is recommended for termination. Harsco Industrial, Patterson-Kelley does not recommend using a vent rain cap of any type.

#### 3.5.1 Category II or IV Venting Installation

P-K MACH® boilers are dual certified as **Category II or IV** appliances, as defined in ANSI Z21.13/CSA 4.9, latest edition and are not suitable for use with Type "B" Vents. The vent material to be used for US and Canada is listed in the Table of Acceptable Materials for Venting Systems located in [2.5.4](#).

Vent installations shall be in accordance with NFPA 54/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.

**NOTE:** For **Category II** installations, ensure the flue venting system is designed to maintain a slightly negative exhaust pressure **between -0.01" W.C. and -0.04" W.C.**

**NOTE:** For **Category IV** installations, ensure the flue venting system is designed to maintain a slightly positive exhaust pressure which **MUST BE** in the following ranges:

- **+0.01" W.C. and +0.22" W.C. (Direct Vent / Sealed Combustion)**
- **+0.01" W.C. and +0.4" W.C. (Exhaust Only)**

## Vent Sizing

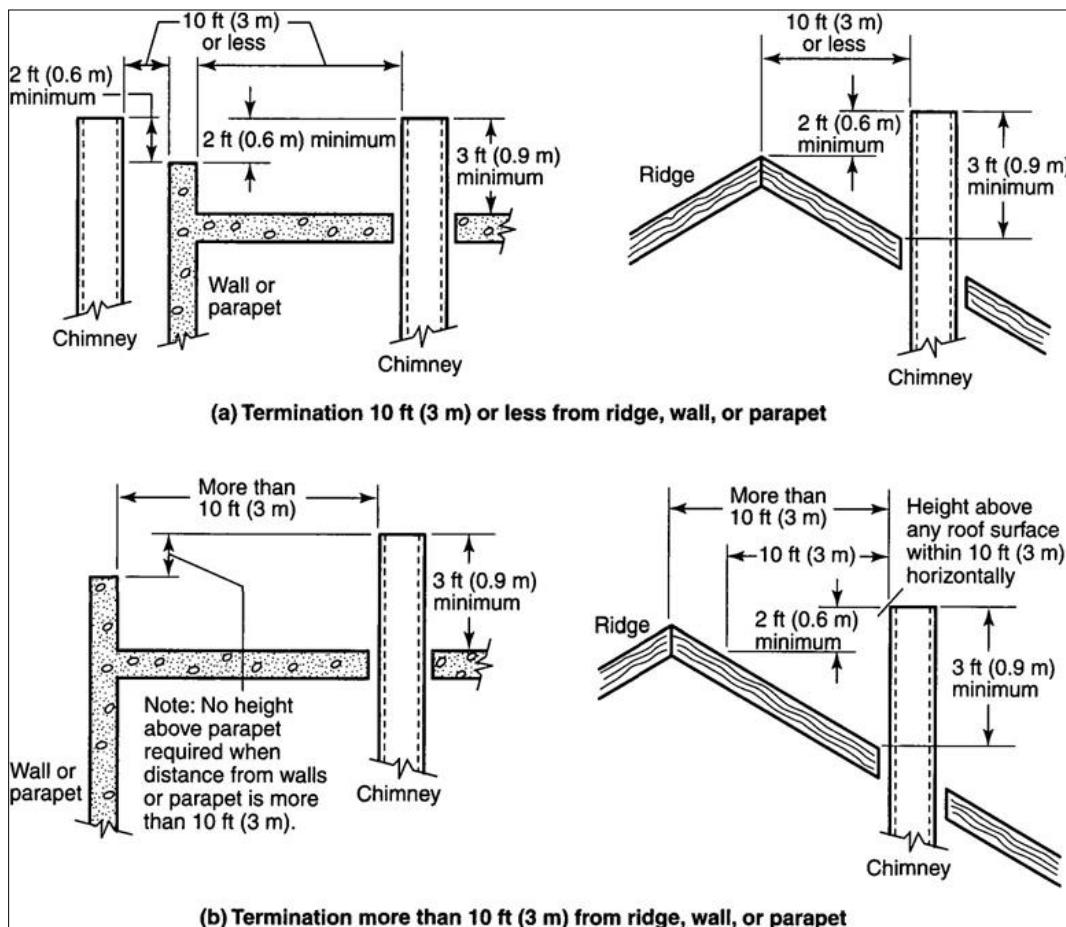
The vent must be sized in accordance with the ASHRAE Systems and Equipment handbook, Chapter 30 or according to the vent manufacturer's recommendations. When using manufactured venting systems, consult your vent supplier for correct sizing and structural support requirements. See the table below table for vent design parameters.

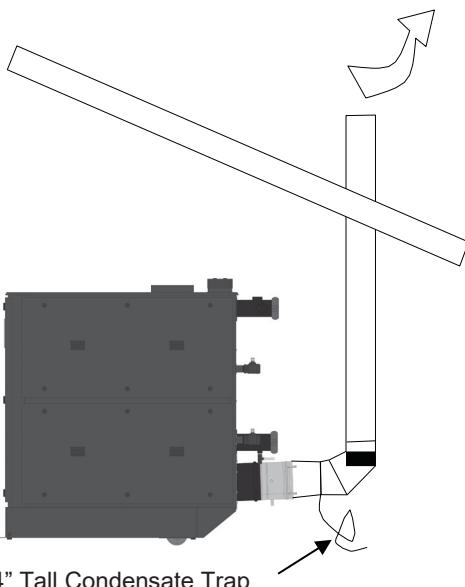
P-K MACH® Boiler Model	Draft	Stack Temperature	CO <sub>2</sub> Natural Gas	CO <sub>2</sub> Propane Gas
C-1500H, C-2000H, C-2500, C-3000, C-4000	Category II -0.01" to -0.04" W.C.	220 °F (gross)	9.2%	10.4%
C-1500H, C-2000H, C-2500, C-3000, C-4000	Category IV (Sealed Combustion) +0.01" to +0.22" W.C.	220 °F (gross)	9.2%	10.4%
C-1500H, C-2000H, C-2500, C-3000, C-4000	Category IV (Exhaust Only) +0.01" to +0.4" W.C.	220 °F (gross)	9.2%	10.4%

### 3.5.2 Vent Termination

For interior clearance requirements, refer to [2.5.5](#). The vent shall 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. This is illustrated in the following diagram.

Additionally, the boiler vent shall terminate at least 3 ft. above a forced air inlet located within 10 ft.





The image to the left represents a simplified vent installation. A condensate trap loop (minimum 4" height) **must** be installed in the flue vent system prior to the boiler's flue connection.

### 3.5.3 Venting for Multiple Boilers

While the vent design parameters outlined in [3.4](#) and [3.5](#) still apply, achieving those same parameters in a combined vent system adds a significant degree of complexity. Therefore, venting systems for multiple appliances shall be designed by experienced and knowledgeable venting professionals. The venting system shall be designed to prevent backflow of exhaust gas through idle appliances. For combined breeching installations, please follow recommendations of a qualified venting engineer/manufacturer.

Harsco Industrial, Patterson-Kelley recommends that common venting systems be designed for a maximum continuous exhaust pressure of **-0.04" W.C.** when measured in the common vent. Locking inline dampers are recommended on the exhaust connection of each individual appliance in order to control the exhaust back pressure within the appliance and upstream of this damper. The -0.04" W.C. in the common flue will also help make sure the exhaust gases from an online appliance does not backflow through offline appliance(s). In addition, Harsco Industrial, Patterson-Kelley also recommends the use of motorized combustion air dampers in the combustion air intake ductwork of each individual appliance. When an appliance is offline, its combustion air damper will remain closed which will also help prevent the backflow of flue gases from online appliances. Please refer to Section [3.4.5](#) for more information.

If the common venting system uses a draft inducer fan or damper device, this **MUST** be interlocked with the appliances. In the event this draft inducer device fails, the interlock circuits to the appliances must be opened in order to prevent operation. Failure to do so could result in appliance operation under excessive back pressure conditions which could result in damage to the appliance and lead to serious injury or death.

**WARNING**

The design of any common venting system **MUST** prevent backflow of combustion gases through offline boilers or water heaters. Failure to do so could result in damage to the appliance and lead to serious injury or death.

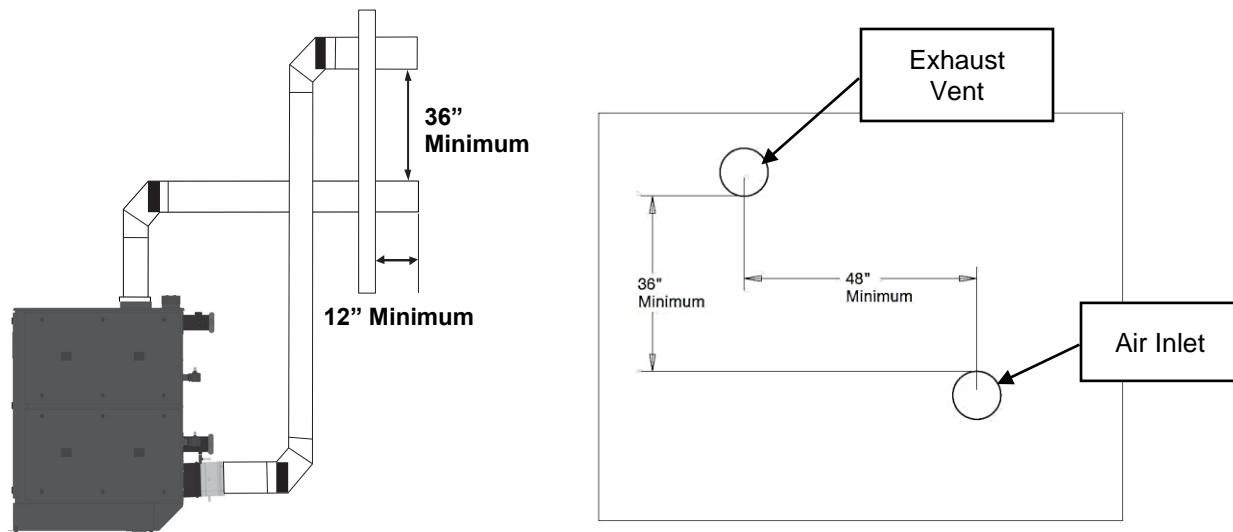
**WARNING**

### 3.5.4 Sealed Combustion/Direct Vent Systems

These boilers are also certified for operation with a sealed combustion air and pressurized venting system. Such a system employs a sealed combustion air intake duct leading from outdoors and a sealed exhaust vent terminating outdoors. Air flow through the system is maintained by the combustion air fan. Allowable configurations of vent and air intake terminations are illustrated below.

**NOTE**

Drains have been omitted for clarity. The exhaust vent must be at least 3 feet above the air intake. The air intake and exhaust vent must extend 6" to 12" from the exterior wall and be offset by at least 48" as shown. The inlet air duct loss should not exceed 0.22" W.C.



The combined pressure drop of the air supply duct and exhaust vent must not exceed 0.44" W.C. This pressure drop includes both the inlet and exhaust duct friction loss. This boiler may be installed without termination fittings if both the exhaust and air intake are on the same wall of the building. Allowable termination fittings are either 90° elbows or tees. This boiler may be installed with sidewall vent using room air, see Section [3.4.1](#).

### 3.5.5 Inlet Duct Connection to Boiler

Connect the air supply duct to the inlet air collar on the boiler. Fasten the air inlet duct to the collar with sheet metal screws at 90° angles and seal with aluminum tape or sealant.

### 3.5.6 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. The installation of a 1" x 1" birdscreen on the intake termination is recommended. Ensure that the screen does not become blocked with snow, ice, insects, etc.

### 3.5.7 Category II Installations

The P-K MACH® boilers are dual-certified for either Category II or Category IV operation. Category II appliances operate with a non-positive vent static pressure and with a vent temperature that may cause excessive condensate production in the vent. There are several requirements for reliable operation of the boilers under Category II conditions:

1. A stainless steel vent adapter is required to mate the boiler exhaust connection and the vent pipe. See the table below for the applicable part numbers.
2. A normally-closed motorized damper is required on the boiler's air intake. See the table below for the applicable part numbers.
3. The draft, measured inside the vent at the rear of the boiler, **must not exceed -0.04" W.C.** Excessive negative draft will cause nuisance trips such as flame failures.
4. The vent system must be properly drained of condensate before returning to the boiler. See [3.7.7](#) for information on installing condensate drains in the exhaust vent.

**Table of Required Stainless Steel Vent Adapters and Category II Motorized Dampers**

Boiler Size	Nom. vent Size	Stainless Vent Adapter	Vent adapter size	Boiler Combustion Air inlet	Combustion air N.C. Motorized Damper	Size
C-1500H	10"	2640000133	10"	10"	1004906945	10"
C-2000H	10"	2640000133	10"	10"	1004906945	10"
C-2500	10"	2640000133	10"	12"	1004906946	12"
C-3000	10"	2640000133	10"	12"	1004906946	12"
C-4000	10"	2640000133	10"	12"	1004906989	14"

A normally-closed motorized combustion air damper with end limit switch is required for Category II vent installations and is optional for Category IV vent installations. 120VAC motorized dampers with end limit switches are available for purchase from Harsco Industrial, Patterson-Kelley. Other damper motor voltages are acceptable, provided they do not exceed 240VAC. The Air Damper Interlock circuit for the end limit switch is always 120VAC which is sourced from the boiler itself. All end limit switches must be rated for a minimum 120VAC.

### 3.5.8 Category IV Installations

If the vent installation is designed for Category IV conditions only (condensing – positive pressure) as it is defined in ANSI Z21.13/CSA 4.9, latest edition. The installations shall be in accordance with NFPA 54/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.



**Do not use a barometric damper** if operating with a positive stack pressure (Category IV). Harmful flue gases may leak into the room which can cause serious injury or death.

### 3.5.9 Stainless Steel Venting

The following materials are used by venting manufacturers to produce listed venting systems.

- AL29-4C Stainless Steel Vent Systems listed and labeled to UL1738 *Venting Systems for Gas-Burning Appliances, Categories II, III, and IV*
- 316L Stainless Steel where certified and warranted by the vent manufacturer for venting of Category II, III or IV appliances

These prefabricated venting systems must be installed according to the manufacturer's installation instructions. Special care should be taken to ensure that any and all integral gasketing is properly assembled and creates a gas and water tight seal. Systems that require silicone caulking for gasketing should only be installed with silicone caulk that is recommended by the vent manufacturer, or if none is recommended, only high temperature, waterproof, silicone caulk should be used. Support of venting system must be according to the manufacturer's instructions. The boiler collar shall not be used to support the weight of the vent.

### 3.5.10 CPVC Vent System Installation

Install CPVC vent systems in accordance with this manual and the SMACNA *Thermoplastic Duct Construction Manual*. Install manufactured vent systems in accordance with the manufacturer's listing and instructions. A customer supplied adapter is required to be installed between the boiler and the CPVC venting.

#### Operating Parameters:

- Maximum Water Temperature Set Point 180°F
- Flue Gas Limit 200°F

#### Installation Parameters:

- Cement and primer must conform to ASTM F493
- Three feet of venting closest to the boiler must not be enclosed
- The vent shall not be insulated

#### CPVC Support Spacing (Feet)

Vent Size	Sch. 40	Sch. 80
4	4	4-1/2
6	4-1/2	5
8	5	5-1/2
10	5-1/2	6
12	6	6-1/2

### 3.6 Removing an Existing Boiler

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 appliance 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 to the National Fuel Gas Code, ANSI Z223.1 and CSA B149 Installation Code. When resizing any portion of the common venting system, the common vent system should be resized to approach the minimum size as determined using the appropriate tables in part 11 of the National Fuel Gas Code, ANSI Z223.1/NFPA 54 and/or CAN/CSA B149.1 Natural Gas and Propane Installation Code.

**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!

**NOTICE!**

See Pipe Capacity for Natural Gas & Propane Gas charts on the following pages for required pipe size, based on overall length of pipe from the meter plus equivalent length of all fittings. Approximate sizing may be based on 1 cubic foot of natural gas per 1,000 Btu/Hr input, i.e., 3,000,000 Btu/Hr requires about 3,000 cubic feet per hour.

## 3.7 Piping

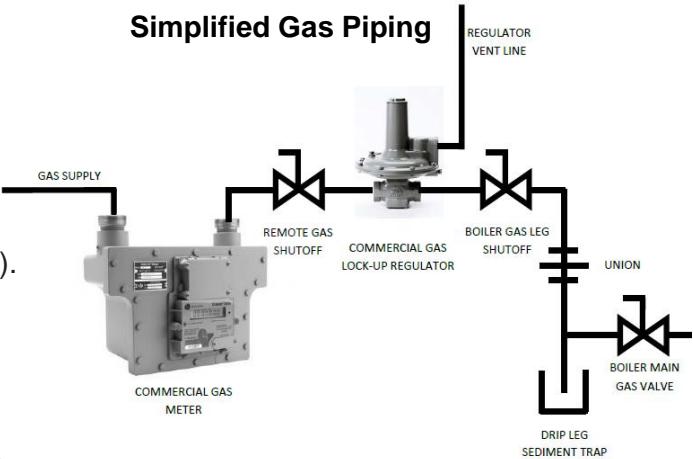
### 3.7.1 Gas Piping Overview

Before making the gas hook-up, make sure the boiler is being supplied with the type of fuel shown on the boiler nameplate. If installing a dual fuel model, refer to section [4.3.1](#) to see the correct connection for each gas type.

The boiler shall be installed such that the gas ignition system components are protected from water (dripping, spraying, rain, etc.) during appliance operation and service (circulator replacement, control adjustment, etc.).

The boiler is factory fire-tested and adjusted for proper combustion. The gas train components are certified to handle a maximum inlet pressure of 14" W.C. (1/2 psig). Typical gas pressure supply for natural gas is 7" W.C. (11" W.C. for propane). If the available gas pressure exceeds 14" W.C., a suitable additional intermediate gas pressure regulator of the "lock up" type must be provided to reduce the pressure to less than 14" W.C. Refer to the appliance's label for the minimum inlet gas pressure.

**Simplified Gas Piping**



**Note:** When using a vented lock-up gas pressure regulator, the vent piping should be increased by one pipe size for every 10 equivalent feet of length. Never connect vent piping that is small in size than the gas regulator's vent port connection.

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

Appliance Size (BTU/Hr)	Natural Gas Requirement (CFH)	Propane Gas Requirement (CFH)
1,500,000	1500	600
2,000,000	2000	800
2,500,000	2500	1000
3,000,000	3000	1200
4,000,000	4000	1600

### 3.7.2 Natural Gas Piping

The table below should be used to size the natural gas piping to the appliance. The approximate energy content of natural gas is 1,000 BTU / cu. Ft:

**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" W.C. Equivalent Length of Pipe (in feet)						
		90° Ell (Feet)	Tee (Feet)	20	40	60	80	100	150	200
2	2.067	5.17	10.3	2750	-	-	-	-	-	-
2- 1/2	2.469	6.16	12.3	4350	3000	2400	2050	1850	1500	-
3	3.068	7.67	15.3	7700	5300	4300	3700	3250	2650	2280
4	4.026	10.1	20.2	15800	10900	8800	7500	6700	5500	4600

### 3.7.3 Propane Gas Piping

The table below should be used to size the propane gas piping to the appliance. The approximate energy content of propane gas is 2,500 BTU / cu. Ft:

**Pipe Capacity for Propane Gas**

Nominal Iron Pipe Size (Inches)	Internal Diameter (Inches)	Equivalent Pipe Length		Maximum Capacity in MBH Propane Gas Pressure Drop of 0.5" W.C. Equivalent Length of Pipe (in feet)						
		90° Ell (Feet)	Tee (Feet)	10	20	40	80	150	300	
1- 1/2	1.610	4.02	8.04	2850	1960	-	-	-	-	-
2	2.067	5.17	10.3	5490	3770	2590	1780	-	-	-
2- 1/2	2.469	6.16	12.3	8740	6010	4130	2840	2020	-	-

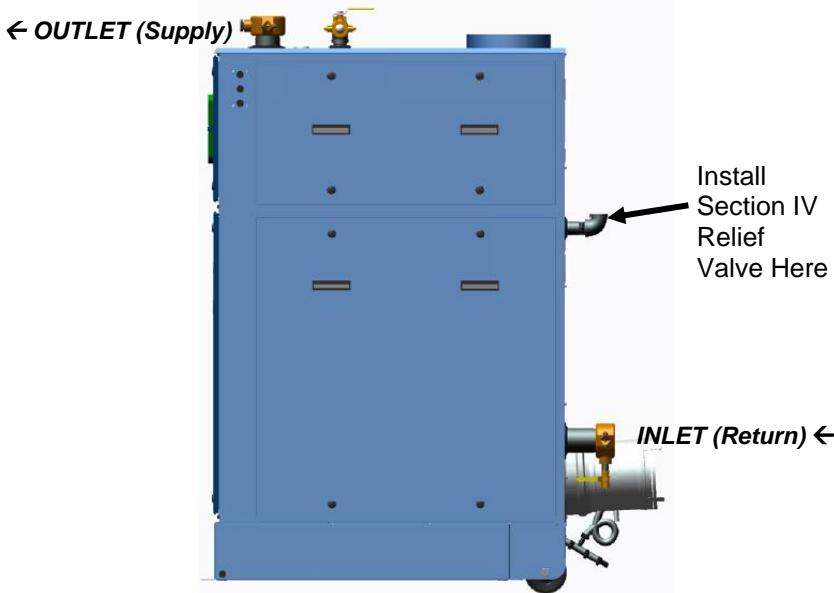
### 3.7.4 Pressure Testing the Gas Piping

The appliance and all gas piping connections should be pressure-tested and must be checked for leaks before being placed into service. The appliance **must be disconnected** at the manual shut-off valve (located at the end of the supplied gas train) from the gas supply piping during any pressure testing of the system at pressures in excess of 0.0723 psig (2" W.C.). Perform the pressure test with compressed air or inert gas if possible.

Some leak test methods, including the use of soap and water, may cause corrosion of the carbon steel gas pipe fittings. If using soap and water or a similar leak test method, make sure to clean off all moisture from the gas pipe fittings prior to placing the appliance into service.

### 3.7.5 Boiler Water Piping

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.



### 3.7.6 Boiler Inlet and Outlet Connections

All water connections should be in compliance with national, state, and local code requirements. Adapters from Victaulic to NPT are available from Harsco Industrial, Patterson-Kelley. The bottom rear connection to the boiler is the INLET and must be used for the return from the system. The top rear connection to the boiler is the OUTLET and must be connected as the supply to the system. All water piping must be installed such that no stresses are transmitted to the boiler. The boiler **shall not** be used as a pipe anchor.

### 3.7.7 Boiler Water Piping (for Installer)

#### 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 for maximum efficiency and long life of the boiler. Refer to [Appendix D – Best Practices For New & Retrofit Systems](#) for more information on best piping practices.

#### Relief Valve Piping

Each boiler is supplied with a pressure-relief valve sized in accordance with ASME requirements. The relief valve discharge must be piped to an acceptable drain at a safe point of discharge. Reducing couplings or other restrictions are not permitted in the discharge line.

The C-1500H, C-2000H, C-2500, C-3000, and C-4000 boilers require an ASME Section IV relief valve to be installed on the dedicated safety relief valve connection. The spindle of the relief valve must be vertical. The ASME Section IV relief valves are available for purchase from Harsco Industrial, Patterson-Kelley.

#### NOTICE!

The C-1500H & C-2000H boilers are furnished with 2-1/2" grooved connections and Victaulic couplings.

The C-2500 and C-3000 boilers are furnished with 3" grooved connections and Victaulic couplings.

The C-4000 boiler is furnished with 4" grooved connections and Victaulic couplings.

These couplings must be used with the EPDM Victaulic seals. Isolating valves must be installed in both the inlet and outlet water connections.

#### NOTICE!

The Condensate Trap must be piped to a drain in accordance with all national, state and local codes. If installed outdoors and the local requires freeze protection, it must be field heat traced.

### Low Water Cut-Off

The boiler is furnished with a probe-type low water cut-off; no field piping is required. If the water level in the boiler drops below the probe, the boiler will shut down and LOCKOUT LOW WATER LEVEL will be displayed on the control panel. The low water cutoff circuit will automatically reset when the low water condition clears; however, the boiler controls will retain the lockout condition until the reset button on the display is depressed. Installation of external limit controls may be required by certain codes or in certain installations. Review applicable local codes for details.

**NOTICE!** Some local jurisdictions may require an auxiliary low water cut-off device installed in the external piping. The auxiliary low water cutoff device only prevents operation when the water level in the appliance is insufficient. It does not detect low water conditions in other parts of the system. Installation of automatic air vents in the "high points" of the piping or additional low water safety devices should be considered to protect the system.

### Drain Valve and Piping

The P-K MACH® boilers feature a  $\frac{3}{4}$ " drain connection. Prior to draining the boiler, electrical power and gas supply must be turned off to the boiler, and the boiler must be isolated from the system at the supply and return connections.

**NOTICE!** The  $\frac{3}{4}$ " manual drain is for draining the water inside the heat exchanger only, not the entire hydronic or domestic system. Draining the entire system through the boiler or water heater's drain valve will deposit sediment and debris from the system inside the heat exchanger. This will result in poor heat transfer and premature failure. Refer to [Appendix D – Best Practices For New & Retrofit Systems](#) for more information on best piping practices.

### Condensate Drain

The condensate is acidic (pH between 3.0 and 5.0) and may be corrosive to some building drain systems. A condensate neutralization system may be required and is available from Harsco Industrial, Patterson-Kelley. If the condensate drainage system is exposed to freezing temperatures, it must be field heat traced. The boiler could generate up to one gallon of condensate per 100,000 BTU input. For example, a C-4000 boiler at full fire can produce 40 gallons per hour of condensate. Disposal of condensate must comply with all state and local codes.

### Piping with Refrigeration Systems

When installed in a two-pipe system that provides both chilled and hot water, the control system should be configured so as to limit the time rate of change of temperature at the boiler. Consult your authorized Harsco Industrial, Patterson-Kelley boiler representative for application guidance.

### 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.

### 3.8 Water Quality

The P-K MACH® boiler's heat exchanger is made a cast Aluminum alloy. The heat exchanger requires proper water conditions to remain efficient and function properly. Information of proper water treatment can be found on our website [www.harscopk.com](http://www.harscopk.com) type in search: "water quality". For information, please refer to Harsco Industrial, Patterson-Kelley Multi-Metal Systems Water Quality Standards as it appears in [Appendix C – Water Quality Standards Quality Standards for Hydronic Boilers in Multi-Metal Systems](#) as this applies to the warranty of your heat exchanger. Under no circumstances should Soften Water be used in boiler.

**NOTICE!** The chemical manufacturer for use must certify glycol or other treatment chemicals added to the system in multi-metal systems that include an aluminum heat exchanger.

Under no circumstances should petroleum-based cleaning or sealing compounds be used in the boiler system.

Under no circumstances should the hydronic system be flushed while the appliance is attached to the system since the debris or corrosion products may accumulate in the appliance and obstruct the appliance's 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. Following chemical cleaning, the system should be thoroughly rinsed to remove cleaning agents prior to reconnecting the boiler to the system.

### 3.9 Pre-Start Checklist

**⚠ WARNING**

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

Operating a boiler that has failed a safety check could result in injury.

Bypassing safety mechanisms will result in unsafe boiler operation which could result in injury or death.

**⚠ WARNING**

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

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

- Inspect the gas train, blower, ignition electrode, and boiler in general to be sure there was no damage during shipment or installation.
- Flue gas from the boiler is properly vented.
- Gas connection has been made, pressure tested for leakage and the line purged of air. Make sure all required vents have been installed.
- Water connections are complete and the boiler and system have been filled and purged of air.
- The boiler is connected to the correct electrical power source listed on the nameplate, a disconnect having adequate overload protection is required.
- Combustion air openings are not obstructed in any way and have adequate capacity.
- The boiler is placed the proper distance from any combustible walls.
- Relief valves have been piped to an acceptable drain at a safe point of discharge.
- Condensate piping is properly connected.
- Verify system water quality is within specifications.

## 3.10 Safety Checks

The following checks of safety systems must be made before putting the boiler into normal operation. Before firing the boiler refer to Section 5 for information on the use of the controls, lighting, and shut-down procedures.

### 3.10.1 Ignition Safety System Test

Test the ignition system safety shutdown as follows:

1. Cycle the boiler on by generating a heat request. (The method for this will depend on your boiler configuration.)
2. During the pre-purge cycle (before ignition), smoothly close the downstream manual isolation valve (inside the boiler cabinet) to reduce the gas flow.
3. Closing the manual isolation valve will prevent a successful ignition, and the NURO will display either:

109: “**Ignition Failed**”

110: “**Ignition Failure Occurred**”

These alarms indicate an ignition failure and the lockout will remain until the control is reset. After completing this test, turn the boiler off, open the downstream manual isolation valve, then turn the boiler back on.

### 3.10.2 Low Water Cut-Out Test

The boiler is furnished with a probe-type low water cut-out. The probe is installed near the boiler’s outlet in order to detect the presence of water at the highest possible location in the boiler and is connected to the low water cut-out circuit board by a single wire. The low water cut-out circuit board is located inside the boiler’s front door, toward the top of the control panel and is identified with a yellow label.

In order to test the low water cut-out, press and hold the red “Push to Test” button for at least 5 seconds. A manual lockout reset error displaying 10010: “**Low Water Limit**” on the NURO touchscreen should occur. The red LED indicator on the Low Water cut-off will no longer be illuminated.

**Optional Test Method:** First turn the boiler off, and then turn off the boiler’s circulating pump. Isolate the boiler from the system. Drain the water level below the low water cut-off probe. Turn the boiler back on. It should not operate, and a manual lockout reset error displaying 10010: “**Low Water Limit**” on the NURO touchscreen should occur. The red LED indicator on the Low Water cut-off will no longer be illuminated.

Return the system to normal operation by refilling with water, restarting the boiler’s circulating pump, and then turning the boiler back on.

### 3.10.3 Manual Reset High Temperature Limit Test

The boiler is furnished with a manual reset high temperature limit which features a probe installed near the boiler’s outlet in order to measure the outgoing supply water temperature. This probe is connected to the manual reset high temperature limit by a thin, metal capillary tube. The manual reset high temperature limit is located inside the boiler’s front door, toward the top of the control panel and is identified with a yellow label.

**CAUTION**

The user should become thoroughly familiar with the operation of the boiler and controls before attempting to make any adjustments.

**CAUTION**

Changing parameters requires an understanding of the parameters and the functionality of the boiler. The boiler may not function properly if parameters are changed from the factory values.

Test the manual reset high temperature limit control as follows:

1. Cycle the boiler on by generating a heat request.
2. Allow the boiler to proceed through ignition until main flame is established.
3. Using a flathead screwdriver, turn down the setting on the manual reset high temperature limit to its lowest value. Turning the screwdriver counter-clockwise decreases the temperature setting.
4. When the outgoing supply water temperature exceeds the setting on the manual reset high temperature limit, the main burner will shut off.

The NURO touchscreen will display 10009: “**High Temperature Limit**”. Return the system to normal operation by readjusting the setting on the manual reset high temperature limit to its default setting, press the reset button on the manual reset high temperature limit, and finally touch any prompts from the NURO control.

### 3.10.4 Gas Pressure Switch Tests

#### Low Gas Pressure Switch

The boiler is furnished with a low gas pressure switch, installed near the boiler’s main gas shutoff/control valve. The operation of this switch must be checked as follows:

1. Close the main gas cock (external to the boiler).
2. Cycle the boiler on by generating a heat request.
3. Allow the boiler to proceed through prepurge and attempt ignition.

When the main gas shutoff/control valve opens to attempt ignition, the low gas pressure switch will trip, causing the NURO touchscreen to display 10012: “**Low Gas Limit**”. Even after re-opening the main gas cock, 10012: “**Low Gas Limit**” will remain on the NURO display until the boiler is manually reset by pressing “Reset Control”.

**NOTE**

Make sure to re-open the main gas cock (external to the boiler) after a successful test.

#### High Gas Pressure Switch

The boiler is furnished with a high gas pressure switch, installed near the boiler’s main gas shutoff/control valve. The operation of this switch must be checked as follows:

1. Before starting the boiler, close the downstream gas cock located inside the boiler’s enclosure.
2. Cycle the boiler on by generating a heat request.
3. Allow the boiler to proceed through prepurge and attempt ignition.

When the main gas shutoff/control valve opens to attempt ignition, the high gas pressure switch will trip, causing the NURO touchscreen to display 10011: “**High Gas Limit**”. Even after re-opening the downstream gas cock inside the boiler, 10011: “**High Gas Limit**” will remain on the NURO display until the boiler is manually reset by pressing “Reset Control”.

**NOTE**

Make sure to re-open the downstream gas cock (inside the boiler) after a successful test.

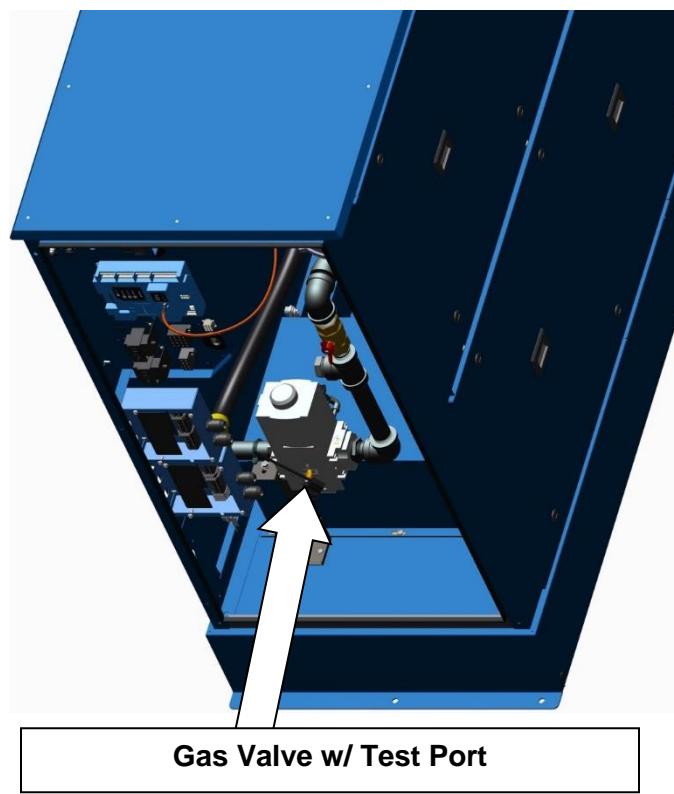
## 3.11 Fuel/Air Adjustments

The P-K MACH® boilers are equipped with a gas/air ratio control valve and a gas safety shut off control valve, combined into one valve assembly. The valve functions in series with the variable speed combustion blower to supply the correct gas/air mixture for optimum firing performance and efficiency. The combustion blower speed is controlled automatically by the boiler controller. The blower speed determines the amount of air flow and the amount of suction/negative pressure at the gas valves. The gas valve adjusts gas flow to maintain the proper delivery pressure at the outlet of the valve.

### 3.11.1 Gas Pressure Adjustment

See rating plate for the minimum and maximum gas pressure of the boiler. The supply pressure during main burner operation must be greater than the minimum indicated on the rating plate. Nominal gas supply pressure is 7" W.C. for natural gas. The gas pressure must not exceed 14" W.C. which is the maximum allowable pressure on the gas train components. Each boiler is furnished with a manual shut-off valve which has an integrated test port. This port is located on the upstream side of the valve body for measuring supply pressure.

The air flow is pre-set at the factory prior to shipment. Gas flow is dependent primarily on fan speed not upstream gas pressure. The automatic gas valve may have to be adjusted to obtain proper combustion readings for specific local conditions. A combustion analyzer must be used. Combustion must be set in accordance with the Recommended Combustion Settings for P-K MACH Boilers in Section [3.11.2](#).



### 3.11.2 Manual Control Mode for High and Low Fire Adjustment

To adjust/tune combustion, use the NURO's "Manual Control Firing Rate" mode. To access this mode, touch the "Info" button in the lower left corner of the screen, and then press "Service" in the lower left. Next, touch "Press to Activate Manual Control" which will open the "Manual Control Firing Rate" mode.

This test mode should be used when adjusting or tuning the gas safety shut off/control valve.

**NOTE:** Proper water flow should be established before performing any combustion adjustments to ensure the boiler doesn't short-cycle or overheat.

Once in "Manual Control Firing Rate" mode, a heat request is required. Once the appliance cycles on and is running in "Manual Control Firing Rate", use the UP and DOWN arrows or the slider to force the boiler to operate at low fire, high fire, or anywhere in-between. To prevent the appliance from cycling off prematurely during adjustment, ensure that any load devices (air handlers, control valves, radiators, air handling units, etc.) are in operation and are able to shed/dump the heat created by the boiler.

#### Recommended Combustion Settings for P-K MACH® Boilers

Fuel	Nominal Gas Pressure	High Fire Setting		Low Fire Setting	
		% O <sub>2</sub>	% CO <sub>2</sub>	% O <sub>2</sub>	% CO <sub>2</sub>
Natural Gas	7" W.C.	5.0 ± 0.3	9.1 ± 0.2	5.1 ± 0.3	9.0 ± 0.2
Propane Gas	11" W.C.	4.8 ± 0.2	10.4 ± 0.3	5.0 ± 0.2	10.3 ± 0.3

The P-K MACH® boilers are equipped with a combination gas/air control and gas safety shut off control valve. The "zero governor" gas valve responds to the variable speed combustion blower in order to supply the correct air/gas ratio for optimum performance and efficiency.

**NOTICE!** For high altitude adjustments (greater than 2,000 feet above sea level), see [Appendix B – Boiler Altitude Derate Schedule](#) at the end of this manual.

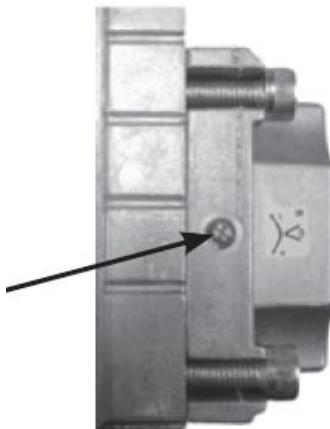
### 3.11.3 Adjusting High Fire

**NOTE: ALWAYS** adjust high fire combustion first!

Start the boiler and observe proper operating parameters for the system. Access the “Manual Control Firing Rate”, as described above, and increase the firing rate to 100%. Check combustion readings using the combustion analyzer. If the combustion readings are not in accordance with Section [3.11.2](#), adjust as follows:

**Required Tools:** Flat head screwdriver/no 2.5 allen wrench, Combustion analyzer and water tube manometer.

1. Using a slotted screw driver, set the maximum restrictor (high fire screw) on the outlet/shutter flange of the combination gas safety shut off / control valve by turning clockwise or counterclockwise to achieve the desired CO<sub>2</sub> or O<sub>2</sub> level. To increase the O<sub>2</sub> level, adjust towards the “-“ symbol to decrease gas flow. To decrease the O<sub>2</sub> level, adjust towards the “+“ symbol to increase gas flow.
2. There will be a slight time delay between the adjustment and the response of the CO<sub>2</sub>/O<sub>2</sub> measuring instrument. Clockwise rotation decreases gas flow. Counterclockwise rotation increases gas flow.



### 3.11.4 Adjusting Low Fire

**Required Tools:** 2.5 mm hex wrench and combustion analyzer.

Start the boiler and observe proper operating parameters for the system. Set boiler to the “Manual Control Firing Rate” mode, as described above, and decrease the firing rate to 1%. Once the boiler has reached low fire operation, check combustion readings using the combustion analyzer. If combustion readings are not in accordance with the above table, adjust as follows:

1. Using a 2 mm hex wrench, adjust the pressure regulator offset adjustment (pictured above) to achieve the desired CO<sub>2</sub> /O<sub>2</sub> level. To increase the O<sub>2</sub> level, adjust towards the “-“ symbol to decrease gas flow. To decrease the O<sub>2</sub> level, adjust towards the “+“ symbol to increase gas flow.
2. Adjustments to the offset pressure regulator should not exceed ¼ turn at a time before allowing the readings to respond and stabilize.



Following all gas valve adjustments, check for proper light-off and verify correct fuel/air mix and combustion quality throughout the entire firing rate (from low to high fire).

### 3.11.5 Checking Flame Signal

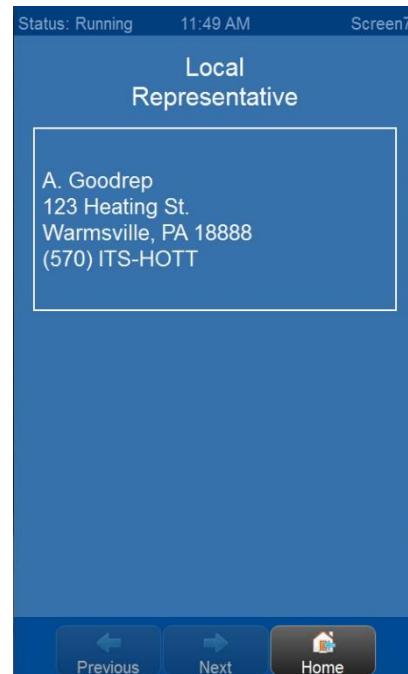
Touch the “Info” button in the lower left corner of the NURO display to load the “Information” menu which shows real-time read-only boiler values such as temperatures, relay states, etc. Scroll down the “Information” menu to find the “Flame Signal” value. This value displays the strength of the combustion flame (units = V) as measured by the ignition electrode/ionization probe. When the boiler is in standby, prepurge, or postpurge the flame signal should read 0V. During main flame, a strong flame signal should read between 20-50V.

## 3.12 Initial NURO Control Setup and Adjustment

This manual covers basic NURO control setup and adjustment. For a walkthrough of the complete control setup, please refer to the *NURO Boiler Controller: Advanced User's Guide*, Part Number is 1004905979 which is helpful for more complex installations. For more complex boiler or water heater applications and more information on the parameters, please refer to the NURO Advanced User's Guide.

### 3.12.1 Startup

When the boiler or water heater is powered on, the NURO touchscreen will display an initial Startup Screen then the **Local Representative** screen. This shows the name, address and phone number of the local HARSCO Industrial representative.



### 3.12.2 Home Screen

After a brief time, the **Local Representative** information screen will timeout displaying the **Home Screen**. The **Home Screen** shows a snapshot of the boiler or water heater's current operating conditions:

- Outlet (Supply) Temperature
- Inlet (Return) Temperature
- Exhaust Temperature
- Firing Rate, etc.

Pressing the “**Info**” button in the lower left corner will load the **Information** screen.

For the setup wizard, press the “**Settings**” button in the lower right corner to load the “**Settings**” or “**Main Menu**” screen.

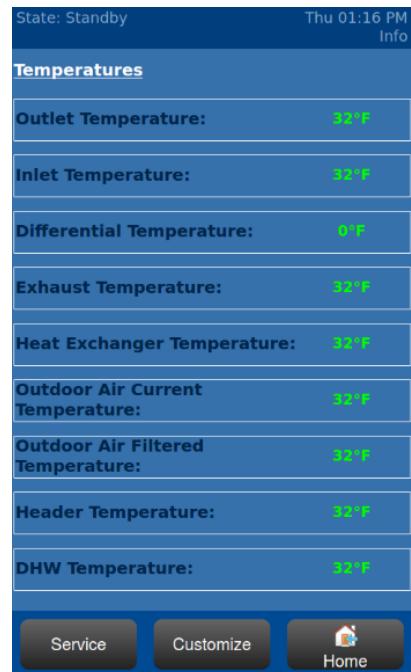


### 3.12.3 Information Screen

The Information Screen contains real-time read-only values such as temperatures, relay states, etc. Scroll through the Information Screen by sliding your finger up or down. This screen is helpful to determine the operating characteristics.

#### NOTE

For more information on any value, please refer to the NURO Boiler Controller: Advanced User's Guide, Part Number is 1004905979.

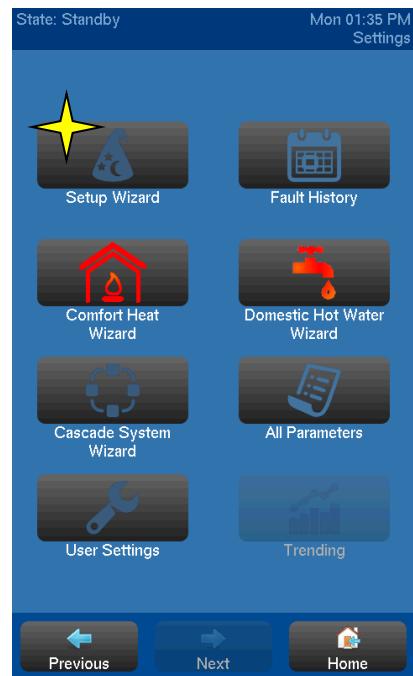


### 3.12.4 Setup Wizard

The Setup Wizard is recommended for all boilers and water heaters because it guides the user through setup for multiple applications (Standalone Comfort Heat, Standalone Domestic Hot Water, and/or Cascade operation). The Setup Wizard will guide the user through the parameter setup for all the relevant applications based on responses to a series of questions. To access the Setup Wizard, press <SETUP WIZARD> from the “SETTINGS” menu.

While navigating the Setup Wizard, press the desired buttons in the center content area. The selected choice will be indicated with a yellow light as seen below. To proceed to the next Setup Wizard screen, press <NEXT> at the bottom of the screen. The NURO® control also allows the user to back-track at any time by pressing <PREVIOUS> in the bottom-left corner of the screen.

The Setup Wizard allows the user to assign functionality to the user-configurable Relays A through D. This allows the user to assign functions like “Boiler Pump”, “System Pump”, “Flame Detected”, and “Air Damper” to the relays.



**NOTE:** The relay assignments **must** agree with the wiring to/from the appliance. For example, if Relay A is user-configured to enable/disable the Boiler Pump, the control wires to operate the boiler pump must be properly wired to the Relay a terminals in the High Voltage (TB2) terminal block.

### 3.13 Typical Boiler Operating Conditions

Model Number	Input Rating (BTU/Hr)	Voltage	Phase	Total Amperage	Gas Flow Rate (CFH)		
					Natural Gas (1030 Btu/ft^3)	LP Gas (2500 Btu/ft^3)	Output Capacity (Btu/Hr)
C-1500H	1,500,000	110-120	Single	Less than 15	1456	600	1,440,000
C-2000H	2,000,000	110-120	Single	Less than 15	1942	800	1,920,000
C-2500	2,500,000	110-120	Single	Less than 17	2427	1000	2,375,000
C-3000	3,000,000	208-240	Three	Less than 20	2913	1200	2,850,000
		440-480	Three	Less than 20			
C-4000	4,000,000	208-240	Three	Less than 20	3689	1600	3,800,000
		440-480	Three	Less than 20			

## 4 Dual Fuel Boiler Operation



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

### 4.1 Overview

The P-K MACH® dual fuel boilers with NURO® controls feature two independent gas trains. One gas train is designed exclusively for operation with Natural Gas and the other gas train is designed exclusively for operation with Propane Gas. Refer to the labels on the dual fuel boiler for the proper location of the Natural Gas and Propane Gas trains. Also, Section [4.3](#) and [4.4](#) show the specific locations of the gas trains for each boiler model.



**WARNING** Failure to observe the NATURAL GAS and PROPANE GAS labels on the boiler and this manual could result in equipment damage, injury, and/or death.

In addition, the P-K MACH® dual fuel boilers with NURO® controls feature a fuel selector switch inside the boiler's enclosure. To access the fuel selector switch, open the front door while the boiler is in "Standby". Refer to Sections [4.3.2](#) and [4.4.3](#) show the specific locations of the fuel selector switch for each boiler model.

### 4.2 Changing Fuel Types

Before changing fuel types, force the boiler into "Standby" through the NURO® touchscreen user interface. Refer to the boiler's manual or the NURO® Advanced Users' Guide for more information. Once the boiler is in standby, follow the steps below:

1. Force the boiler into "Standby" through the NURO® touchscreen user interface.
2. Close the gas valve/cock for the fuel that will no longer be used.
3. Open the gas valve/cock for the desired fuel type.
4. Toggle the fuel selector switch to the desired fuel type: Natural Gas = "NG" & Propane = "LP".
5. Return the boiler to its normal (automatic) mode through the NURO® touchscreen user interface.



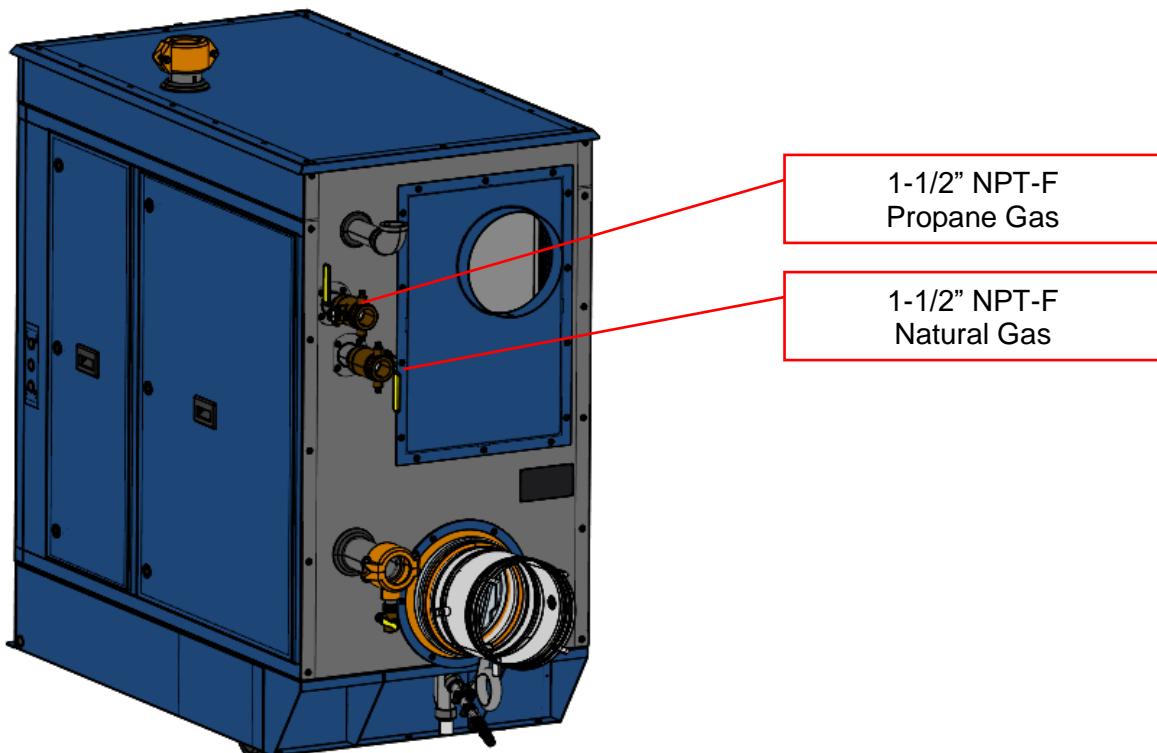
**WARNING** If operating with Natural Gas, ensure the Propane Gas valve/cock is **CLOSED**. If operating with Propane Gas, ensure the Natural Gas valve/cock is **CLOSED**. Failure to do so could result in equipment damage, injury, and/or death.

The operating principle of the fuel selector switch is identical between all the dual fuel boiler models with NURO® controls. Refer to Sections [4.3.1](#) through [4.4.3](#) for model-specific information on the location of the gas trains, the fuel selector switch and the dual fuel wiring diagrams.

## 4.3 P-K MACH C1500GG & C2000GG

### 4.3.1 Natural Gas Train and Propane Gas Train Locations

The dual fuel MACH C1500GG & C2000GG feature two 1-1/2" gas valves/cock on the rear surface as shown below:

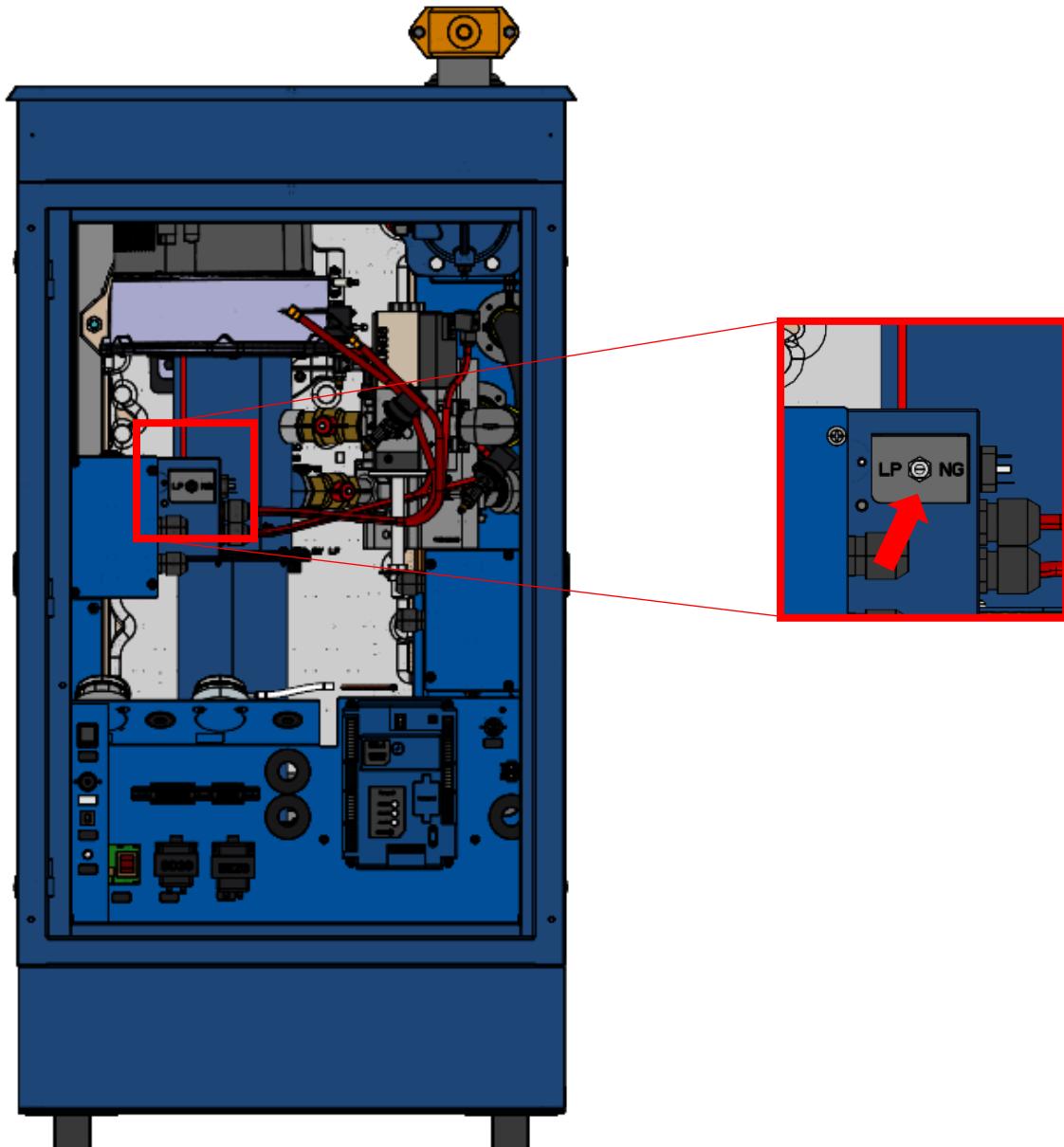


#### **WARNING**

If operating with Natural Gas, ensure the Propane Gas valve/cock is CLOSED. If operating with Propane Gas, ensure the Natural Gas valve/cock is CLOSED. Failure to do so could result in equipment damage, injury, and/or death.

#### 4.3.2 Fuel Selector Switch Location

The image below shows the location of the Propane Gas (LP) / Natural Gas (NG) selector switch for the P-K MACH® C1500GG and C2000GG models. To access this selector switch, open the front door and look toward the middle of the inner cabinet, above the control panel assembly.



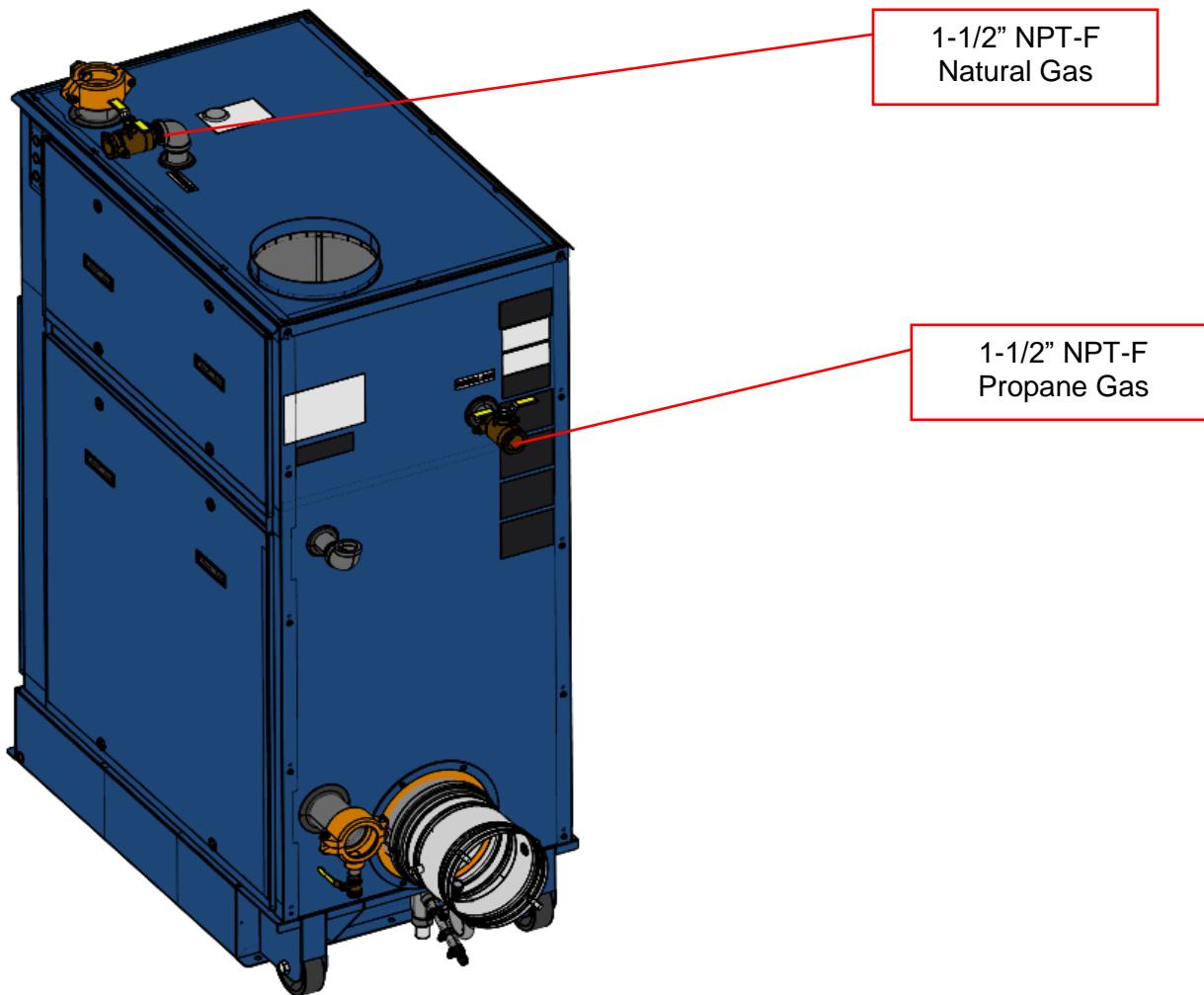
**WARNING**

If operating with Natural Gas, ensure the Propane Gas valve/cock is CLOSED. If operating with Propane Gas, ensure the Natural Gas valve/cock is CLOSED. Failure to do so could result in equipment damage, injury, and/or death.

## 4.4 P-K MACH C2500GG, C3000GG & C4000GG

### 4.4.1 Natural Gas Train and Propane Gas Train Locations (C2500GG & C3000GG)

The dual fuel MACH C2500GG & C3000GG feature two 1-1/2" gas valves/cock on the rear and top surfaces as shown below:

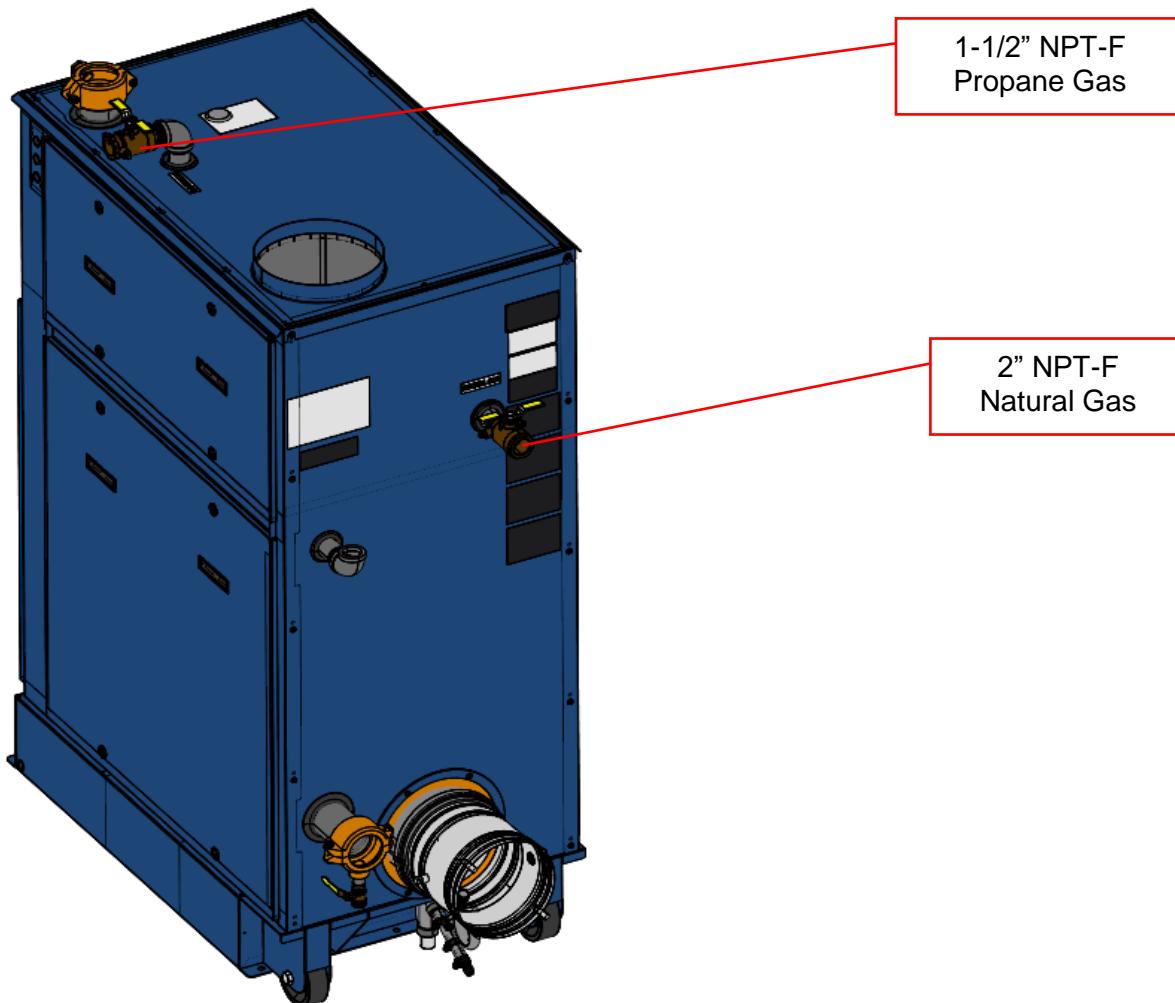


#### **WARNING**

If operating with Natural Gas, ensure the Propane Gas valve/cock is CLOSED. If operating with Propane Gas, ensure the Natural Gas valve/cock is CLOSED. Failure to do so could result in equipment damage, injury, and/or death.

#### 4.4.2 Natural Gas Train and Propane Gas Train Locations (C4000GG)

The dual fuel MACH C4000GG features a 2" gas valve/cock on the rear surface for Natural Gas and a 1-1/2" gas valve/cock on the top surface for Propane Gas as shown below:

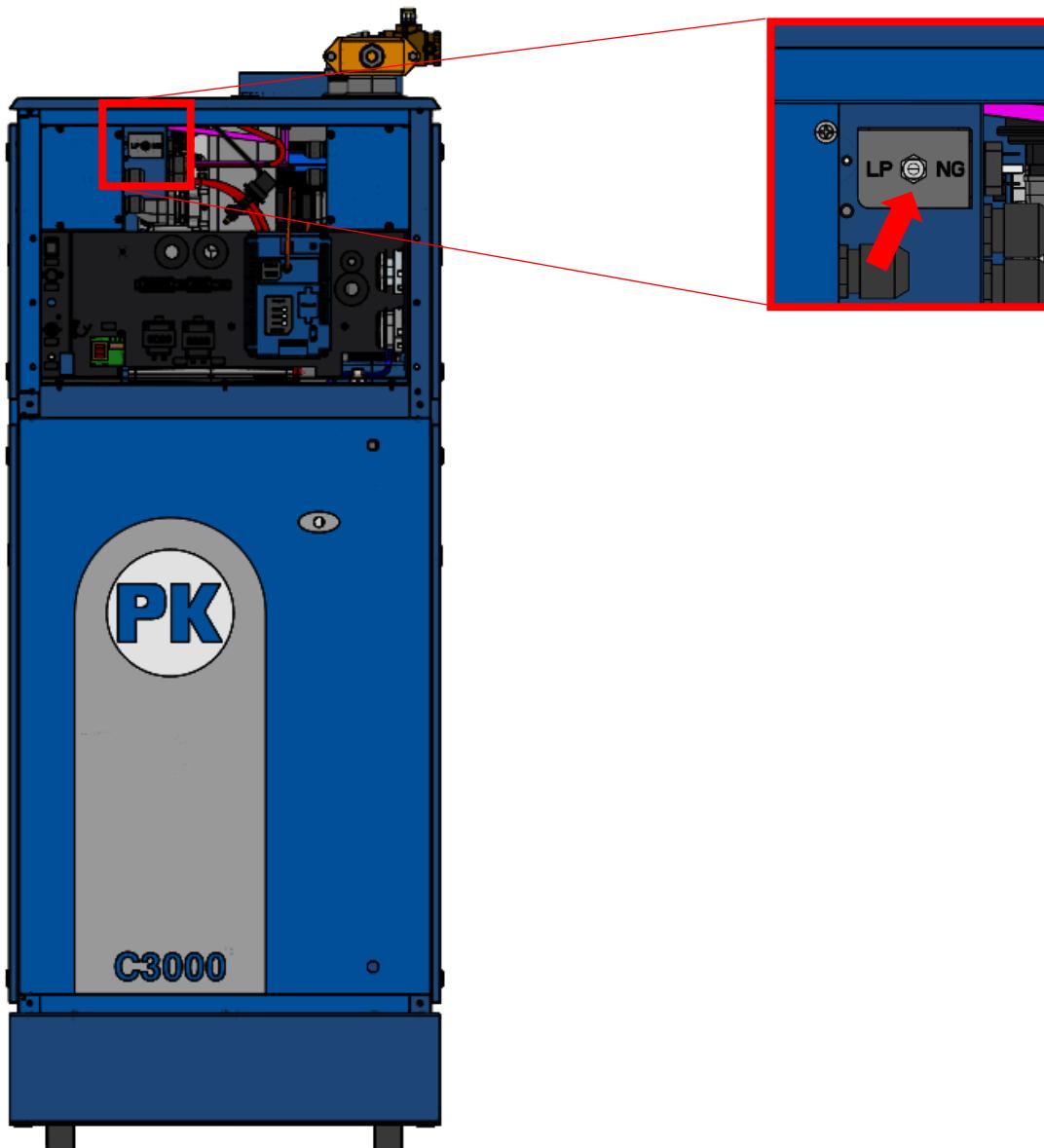


**⚠ WARNING**

If operating with Natural Gas, ensure the Propane Gas valve/cock is CLOSED.  
If operating with Propane Gas, ensure the Natural Gas valve/cock is CLOSED. Failure to do so could result in equipment damage, injury, and/or death.

#### 4.4.3 Fuel Selector Switch Location

The image below shows the location of the Propane Gas (LP) / Natural Gas (NG) selector switch for the P-K MACH® C2500GG, C3000GG and C4000GG models. To access this selector switch, open the upper front door and look toward the top left of the inner cabinet, above the control panel assembly.

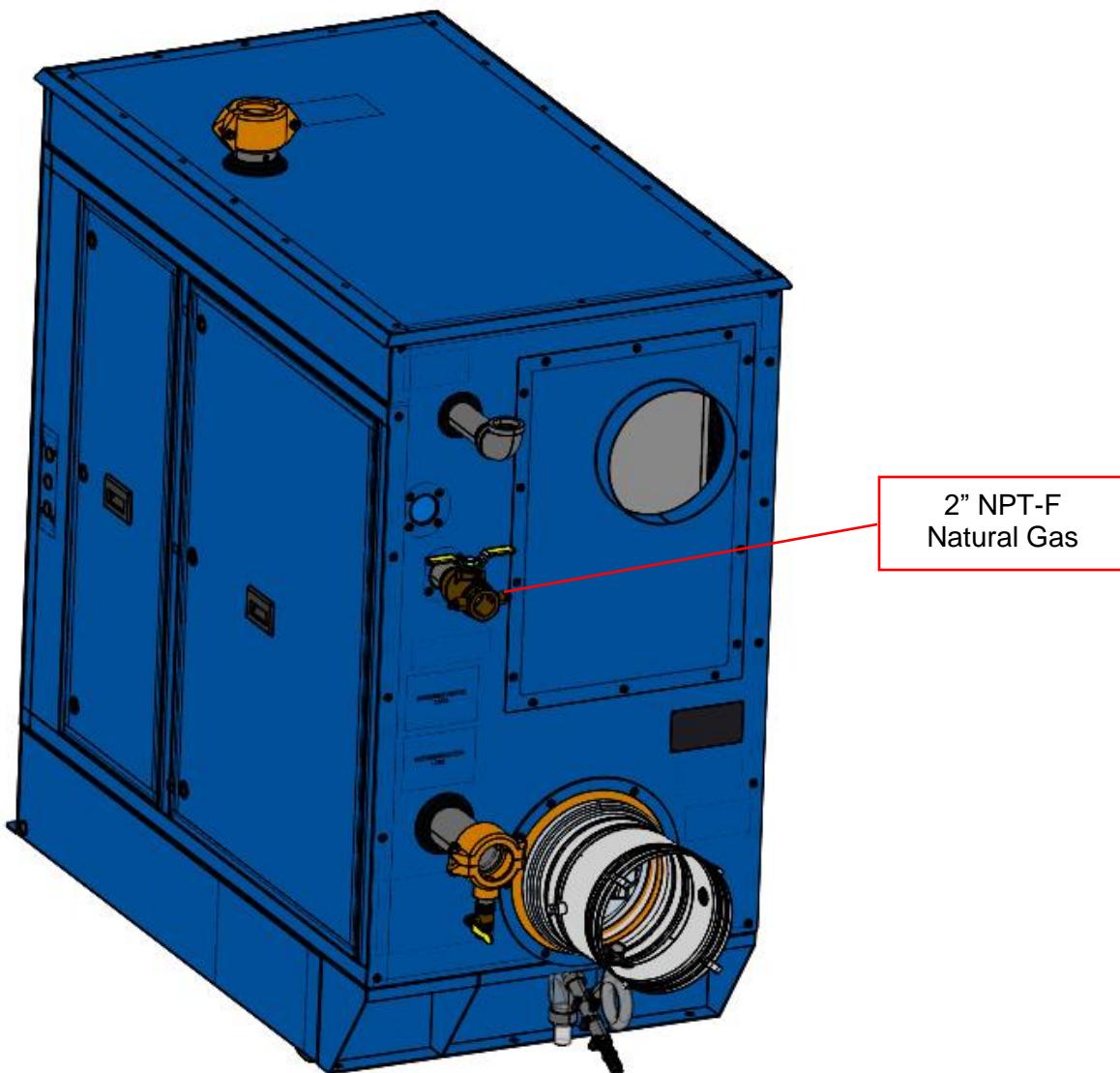


**⚠️ WARNING**

If operating with Natural Gas, ensure the Propane Gas valve/cock is CLOSED.  
If operating with Propane Gas, ensure the Natural Gas valve/cock is CLOSED. Failure to do so could result in equipment damage, injury, and/or death.

## 4.5 P-K MACH C1500T & C2000T

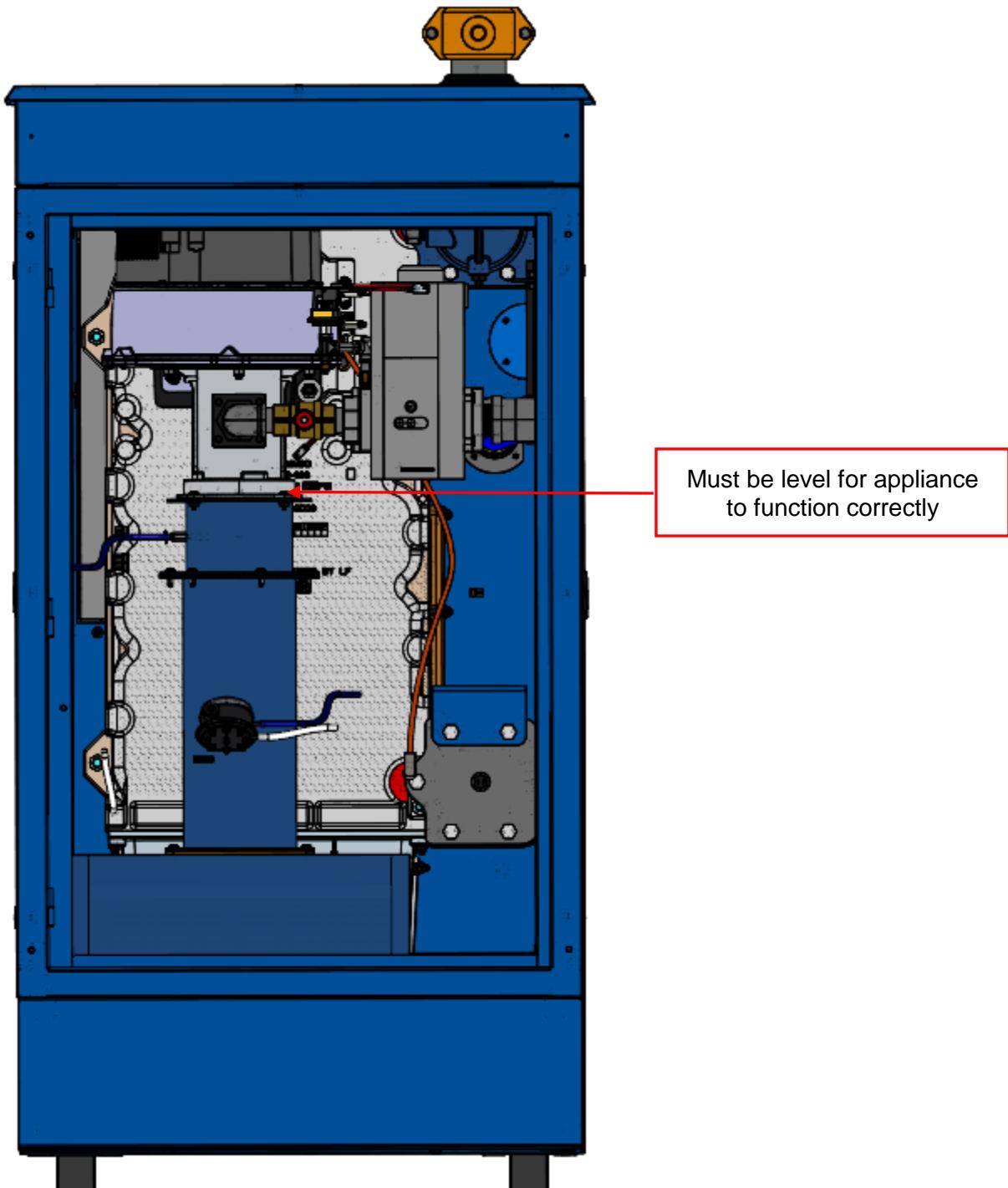
### 4.5.1 Natural Gas Train Location



#### **⚠ WARNING**

The boiler must be level within 0.25° in order to function properly. Failure to heed this warning could result in personal injury or death.

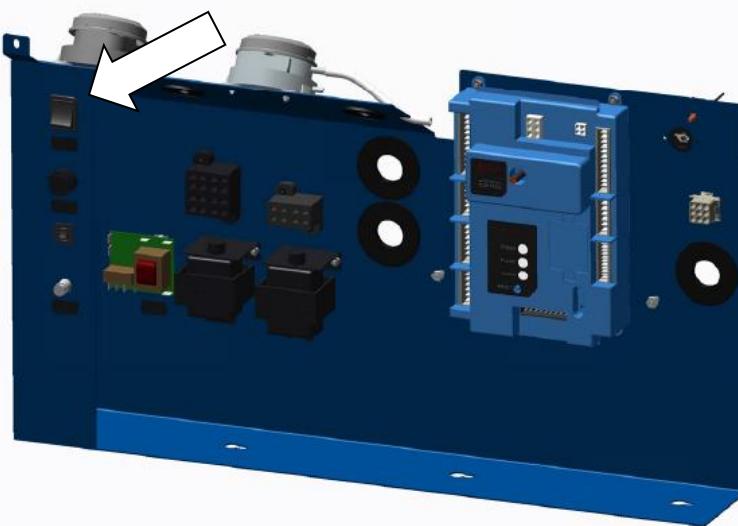
#### 4.5.2 High Turndown C1500T & C2000T



## 5 Operations

### 5.1 NURO Control Panel

Once the boiler has been installed in compliance with this manual, it is necessary to open the front door of the boiler in order to access the power (on/off) switch located in the upper left hand corner of the NURO control panels. The C-1500H & C-2000H NURO control panel is below:



The C-2500, C-3000 & C-4000 NURO control panel is below:



#### 5.1.1 NURO Touch Screen Interface

Once the boiler is switched to the “ON” position, the P-K MACH® boiler can be programmed and operated with the NURO touch screen interface located on the front door as shown to the right. A clear plastic cover protects the touch screen which can be opened by pinching the clasp and swinging open to the left.

**⚠ 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. Failure to do so could result in electrocution, injury, or death.

**⚠ 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.



### 5.1.2 Factory Tests

Safe lighting and other performance criteria were met with the gas manifold and control assembly provided on this boiler when the boiler underwent factory tests specified in ANSI Z21.13/CSA 4.9, latest edition. (See "Factory Firetest" label).

## 5.2 Normal Lighting and Shut-down Procedures

### 5.2.1 Normal Lighting Procedures

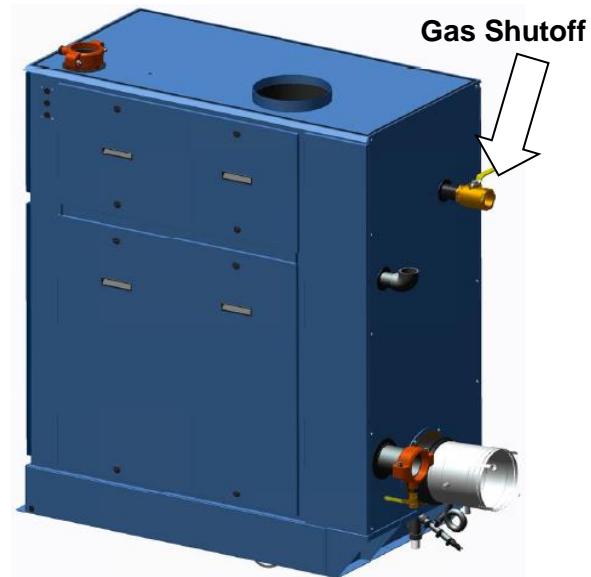
1. Make sure the system is filled with water and water is circulating in the system. Turn on electrical supply and open the gas supply valves to the boiler.
2. Turn the on/off switch to the “On” position. If an error is indicated, refer to the NURO Advanced User’s Guide to troubleshoot the problem and take necessary corrective action before proceeding.
3. Set the desired high temperature limit and operating temperature. The NURO controller will now begin the automatic firing sequence.

### 5.2.2 Normal Shut Down Procedures

1. Allow the boiler to turn off on its own once the temperature satisfies, or remove the call for heat to the boiler.
2. Once the boiler completes a successful “Post-Purge” and “Post-Pump”, it will return to “Standby”.
3. Once in standby, turn the on/off switch to the “Off” position.
4. Close all manual gas valves to right.
5. Turn off the electrical disconnect to the boiler.

## 5.3 Emergency Shut-Off

In case of emergency, shut off the gas supply at a valve external to the boiler. See illustration on the right for valve locations. The upper shut off valve is for Propane Gas and the lower valve for Natural Gas.



## 6 Maintenance

### 6.1 Preventative Maintenance

**NOTICE!** Proper maintenance schedule and record keeping is critical for optimum performance and to maintain the Harsco Industrial, Patterson-Kelley warranty.

**NOTE:** The combustion blower motor is permanently lubricated and does not require periodic lubrication.

#### 6.1.1 Daily Preventative Maintenance

Observe operating temperature and general conditions. Make sure that the flow of combustion and intake air to the appliance is not obstructed. Determine the cause of any service codes or lockouts on the NURO® touchscreen display. Observe any 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 immediate area around the boiler or water heater is free and clear of any combustible materials, including flammable vapors and liquids.

#### 6.1.2 Weekly Preventative Maintenance

Observe the conditions of the main flame. A normal high fire flame is mostly orange with a blue halo. A normal low fire flame will glow reddish-orange. However, do not attempt to adjust the flame "by eye".

Correct air adjustment is essential to the efficient operation of this appliance. Ensure that the flow of combustion and ventilation air is not obstructed. If an adjustment in the combustion appears necessary, the flue gas composition should be checked with a carbon dioxide (CO<sub>2</sub>) or oxygen (O<sub>2</sub>) analyzer and compared to the values stated in the Combustion Setup and Adjustment combustion settings table in Section [3.11.2](#). If an adjustment to the combustion is necessary, call a qualified and knowledgeable installer or service agency that has been trained on the Harsco Industrial, Patterson-Kelley appliance.

**⚠ WARNING**

Lockout/tagout procedure must be employed when servicing this unit. Failure to do so could result in electrocution, injury, or death.

**⚠ 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 and ensure all connections are tight. Use a leak detector to check for leaks before and after servicing any component of the gas piping. Failure to do so could result in injury or death.

**⚠ WARNING**

Use care when servicing boiler to prevent the accumulation of gas in or around the combustion chamber. Pockets of accumulated gas are subject to combustion and/or explosion which could result in injury or death.

**⚠ WARNING**

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

**⚠ WARNING**

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

### 6.1.3 Monthly Preventative Maintenance

1. Press the “Info” button on the NURO® touchscreen to load the Information Screen and scroll down to view the flame signal measured in Volts. Typical flame signals should read between 20-50V. If the flame signal is below 10V, the UV scanner may need to be replaced.
2. Test the low water level cut-off. Refer to [3.10.2](#) (if applicable).
3. Test the manual reset high-temp limit. Refer to [3.10.3](#).
4. Test the low gas pressure switch. Refer to [3.10.4](#).
5. Test operating temperature controls by reducing or increasing temperature settings as necessary to check burner operation.
6. Check the combustion chamber drain piping for leaks or obstructions.

**NOTICE!** Installation and service must be performed by a qualified installer or service agency that has been trained on the appliance.

### 6.1.4 Semi-Annually

In addition to the recommended monthly service:

1. Clean burner of any accumulated dust or lint. Refer to Section [6.2](#).
2. Inspect burner for any signs of deterioration or corrosion. Replace immediately if deterioration or corrosion is evident.
3. Check the pH level of the system fluid. Verify the pH is in accordance with [Appendix C – Water Quality Standards Quality Standards for Hydronic Boilers in Multi-Metal Systems](#)
4. Inspect and clean the condensate system and check for leaks. If a condensate neutralization kit is present, open the lid and inspect the limestone rocks. If they are absent or have been significantly worn away, replace them with new limestone rocks. Use high-calcium (or pure) limestone.

### 6.1.5 Annually

In addition to the recommended monthly and semi-annual service:

1. Inspect and clean the inlet screen of any accumulated dust or lint.
2. Check burner and clean off any soot or foreign material that may have accumulated. Refer to Section [6.2](#). Check for corrosion of the burner and its parts. If there is evidence of deterioration or corrosion, replace immediately. Inspect combustion chamber when the burner is removed for inspection. Note any signs of deterioration. Clean as necessary.
3. Inspect and clean heat exchanger. Remove the various covers to inspect the flue gas passageways. Clean the combustion side casting pins by flushing with clean water and blowing dry with compressed air. Do not use any cleaning agents or solvents. Do not use soap. A soft nylon brush may be used in accessible areas. Be sure to inspect condensate collection pan that is the lowest part of the heat exchanger.
4. Replace the ignition electrode and gasket.
5. Drain and flush the water side of the heat exchanger as required (separate from system flush) using clean water only.

6. Inspect and clean the condensate system and check for leaks. If a condensate neutralization kit is present, open the lid and inspect the limestone rocks. If they are absent or have been significantly worn away, replace them with new limestone rocks. Use high-calcium (or pure) limestone.
7. Examine the venting system. Refer to the vent manufacturer's instructions for requirements in addition to those listed below.
  - a. Check all joints and pipe connections for tightness.
  - b. Check pipe for corrosion or deterioration. If any piping needs replacing, do so immediately.
  - c. Inspect and clean any screens in the vent terminal.
8. Qualified service personnel should thoroughly inspect the heating system and correct any problems prior to re-starting the boiler.
9. Qualified service personnel should thoroughly inspect the heating system and correct any problems prior to re-starting the boiler.
10. Perform combustion analysis and readjust as necessary according to the Section [3.11](#) combustion settings table. It is recommended that a copy of this report is filed for future reference.
11. Perform a leak test of the gas valves in accordance with the manufacturer's instructions.

## 6.2 Cleaning the Burner & Combustion Chamber

Harsco Industrial, Patterson-Kelley recommends cleaning burner and combustion chamber once annually:

### 6.2.1 MACH C-1500H & C-2000H

1. Lockout/tagout gas supply to the boiler.
2. Lockout/tagout electrical power to the boiler.
3. Disconnect the condensate neutralization tank piping in order to install a temporary drain hose into the condensate drain. Run the open end of this hose to a nearby floor drain.
4. Open the front and right side doors of the boiler.
5. Protect the electrical and control components from exposure to water with towels, a nylon tarp, or plastic wrap.
6. Remove the wires/cables from the ignition electrode and flame/ionization rod.
7. Remove the power and signal cables from the combustion blower.
8. Locate the angled burner hood casting located directly in front of the burner hole. Refer to Section [7.3](#) for an illustration of these components.
9. Remove the four M12 flanged nuts connecting the angled burner hood casting to the four burner studs.
10. Remove the six M8 screws connecting the combustion blower flange to the air/gas mixer head flange.
11. Gently remove the combustion blower and angled burner hood casting out the front door.
12. Gently remove the burner gasket and set aside. If the gasket is torn or damaged, discard this gasket.

13. Carefully remove the burner from the boiler and clean with pressurized water.

**NOTE**

Do not attempt to wash the burner while installed in the boiler. When cleaning the burner, use a mild detergent such as Simple Green® to help loosen built-up debris trapped in the burner mesh.

14. Now that the burner is removed, the burner hole is open providing access to the combustion chamber.
15. Use a pressurized water hose with control nozzle. Begin by spraying just a few seconds of water into the combustion chamber and then close off the nozzle.
16. Walk around to the rear of the boiler and ensure the wash water is draining into the temporary drain hose off the condensate drain. Adjust the temporary drain hose if needed to help drain the wash water from the boiler.
17. After inspecting the temporary drain hose, continue washing the internal combustion chamber with pressurized water for several minutes. Spray as much of the internal surface area as possible.

**⚠ CAUTION**

Be very careful when cleaning to avoid spraying any of the electrical or control components.

18. After several minutes of washing, turn off hose and allow all the wash water to drain from the boiler.
19. Move to the right hand side of the boiler, and remove one of the rectangular fireside inspection covers in the middle of the boiler by loosening the six M6 nuts.
20. If there is a noticeable accumulation of debris on the fireside of the heat exchanger behind the inspection cover, it may be necessary to wash the fireside for several additional minutes. Reseal the inspection cover and continue washing through the burner hole.
21. If the accumulation of debris on the fireside of the heat exchanger requires additional cleaning, use a serrated cleaning tool which is available from Harsco Industrial, Patterson-Kelley.
22. Reconnect the condensate tubing to the condensate neutralization tank.
23. **CAREFULLY** insert burner into the burner hole. Support the burner so it remains horizontal while inserting.
24. Once the burner is installed, reinstall the gasket over the burner's flange.

**NOTE**

If the original gasket is torn or damaged, replace with a new gasket!

25. Reinstall the angled burner hood casting and tighten the M12 flanged nuts.
26. Once secured to the burner flange, reconnect the combustion blower flange to the air/gas mixer head flange with the six M8 screws. Ensure the O-ring between the combustion blower flange and air/gas mixer head is intact.
27. Reinstall the ignition electrode assembly (if previously removed).
28. Reinstall the flame/ionization rod assembly (if previously removed).
29. Reinstall the wires/cables to the ignition electrode and flame/ionization rod.

30. Double check the tightness of all bolted joints.

### 6.2.2 MACH C-2500, C-3000 & C-4000

1. Lockout/tagout gas supply to the boiler.
2. Lockout/tagout electrical power to the boiler.
3. Disconnect the condensate neutralization tank piping in order to install a temporary drain hose into the condensate drain. Run the open end of this hose to a nearby floor drain.
4. Open the front and right side doors of the boiler.
5. Protect the electrical and control components from exposure to water with towels, a nylon tarp, or plastic wrap.
6. Remove the wires/cables from the ignition electrode and flame/ionization rod.
7. Locate the right angle burner hood casting located directly in the front of the boiler connected to the burner hole. Refer to Section [7.3](#) for an illustration of these components.
8. Remove the eight 3/8"-16 bolts and flat washers connecting the right angle burner hood casting to the air plenum casting.
9. Remove four M12 flanged nuts connecting right angle burner hood casting to the four burner studs.
10. Gently remove the right angle burner hood casting out the front door.
11. Gently remove the burner gasket and set aside. If the gasket is torn or damaged, discard this gasket.
12. Carefully remove the burner from the boiler and clean with pressurized water.

#### NOTE

Do not attempt to wash the burner while installed in the boiler. When cleaning the burner, use a mild detergent such as Simple Green to help loosen built-up debris trapped in the burner mesh.

13. Now that the burner is removed, the burner hole is open which provides access to the combustion chamber.
14. Use a pressurized water hose with control nozzle. Begin by spraying just a few seconds of water into the combustion chamber and then close off the nozzle.
15. Walk around to the rear of the boiler and ensure the wash water is draining into the temporary drain hose off the condensate drain. Adjust the temporary drain hose if needed to help drain the wash water from the boiler.
16. After inspecting the temporary drain hose, continue washing the internal combustion chamber with pressurized water for several minutes. Spray as much of the internal surface area as possible.

#### CAUTION

Be very careful when cleaning to avoid spraying any of the electrical or control components.

17. After several minutes of washing, turn off the hose and allow all the wash water to drain from the boiler.

18. Move to the right hand side of the boiler, and remove one of the rectangular fireside inspection covers in the middle of the boiler by loosening the six M6 nuts.
19. If there is a noticeable accumulation of debris on the fireside of the heat exchanger behind the inspection cover, it may be necessary to wash the fireside for several additional minutes. Reseal the inspection cover and continue washing through the burner hole.
20. If the accumulation of debris on the fireside of the heat exchanger requires additional cleaning, serrated cleaning tool which is available from Harsco Industrial, Patterson-Kelley.
21. Reconnect the condensate tubing to the condensate neutralization tank.
22. **CAREFULLY** insert the burner into the burner hole. Support the burner so it remains horizontal while inserting.
23. Once the burner is installed, reinstall the gasket over the burner's flange.

**NOTE**

If the original gasket is torn or damaged, replace with a new gasket!

24. Reinstall the right angle burner hood casting and tighten the M12 flanged nuts.
25. Once secured to the burner flange, bolt the right angle burner hood casting to the air plenum casting with the 3/8"-16 bolts. Ensure the gasket between the burner transition piece and blower transition piece is in place.
26. Reinstall the ignition electrode assembly (if previously removed).
27. Reinstall the flame/ionization rod assembly (if previously removed).
28. Reinstall the wires/cables to the ignition electrode and flame/ionization rod.
29. Double check the tightness of all bolted joints.

### 6.3 Maintenance and Inspection Schedule

This schedule applies when the boiler is in constant use. The section is divided into critical Semi-Annual and Annual Maintenance followed by scheduled routine maintenance.

### 6.4 After Repairs or Maintenance

Following any major repairs or preventative maintenance, follow the steps below before returning the boiler to service.

1. Follow [3.9](#) and all safety checks in [3.10](#).
2. Check the gas pressure, refer to [3.11.1](#) to ensure proper operation of the boiler.
3. Perform combustion check (Refer to [3.10.4](#)) and adjust air/gas mixture at high fire & low fire if the O<sub>2</sub>% or CO<sub>2</sub>% are out of range.

**NOTE**

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

## 6.5 Sequence of Operations

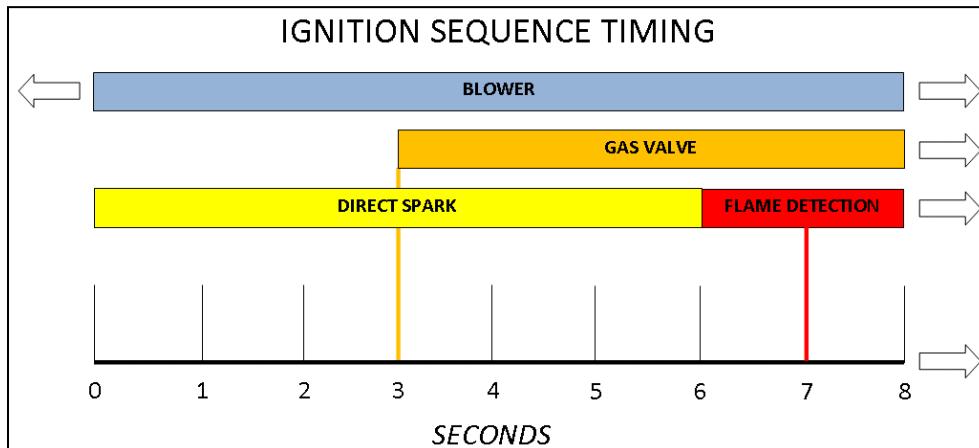
1. When the Boiler On/Off switch is turned on, power is provided through over-current protection (fuse and/or circuit breaker) to the boiler control and the combustion blower.
2. When the outlet water temperature drops below “**CH SETPOINT**” minus “**CH DIFFERENTIAL ON**”, a heat request is generated.
3. Provided all limits are made and the remote enable signal (if installed) is active, the boiler will attempt to start.
4. The NURO control checks to make sure air pressure switch is open indicating there is no airflow through the boiler. The combustion blower is then driven towards the pre-start fan speed. When the air pressure switch closes, the “**PRE PURGE TIME**” timer is started. Once the “**PRE PURGE TIME**” timer expires, the blower is driven to the ignition speed.
5. A trial for ignition begins and the sequence of events is illustrated graphically below. A valid flame signal must be detected within 4 seconds after the gas valves open (elapsed time 7 seconds).
6. After a successful ignition, the fan is driven to low fire and the “**CH LOW FIRE HOLD TIME**” timer is started. Once the “**LOW FIRE HOLD TIME**” timer expires, the boiler is released to modulation.

**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. Attempting to operate a boiler without diagnosing the cause of failure can result in unsafe operation, increasing the risk of injury. Never attempt to bypass a safety limit device.

**NOTICE!**

Once the boiler begins the ignition sequence, the firing sequence will continue until main flame is reached regardless of heat request. The sequence can be interrupted by turning the power switch off.



7. The NURO Control modulates the firing rate between low and high fire to maintain the desired outlet water temperature.
8. The burner will continue firing until the outlet water temperature exceeds “**CH SETPOINT**” plus “**CH DIFFERENTIAL OFF**”. At this temperature, the gas valves are closed combustion air fan continues to run until the “**POST PURGE TIME**” timer has expired.
9. When the outlet water temperature is reduced by the load on the system, a heat request is generated. The operating sequence will recycle to Step 3.

## 6.6 Troubleshooting

The NURO control will display graphical and/or text based error descriptions to announce any problems with the boiler. There are two types of lockouts: manual reset lockouts which require the operator to physically press the on-screen or device's reset button, and automatic reset lockouts which will self-reset when the error condition clears. For a comprehensive list of errors and potential resolutions, please refer to the NURO Advanced User's Guide.

Should the unit fail to operate, call a qualified service technician to troubleshoot the problem and implement corrective actions.

### 6.6.1 Loss of Power

In the event of a power failure, the NURO touch screen will go dark and the entire boiler will de-energize. The signal relays used to command auxiliary devices connected to the boiler (air dampers, pumps, etc.) will also lose power, so these devices will deactivate. When power is restored, the sequence of operation will resume at Step 3 (Section [6.5](#)). If any error/lockout errors were present at the time of the power failure, the NURO control will retain that error/lockout when power is restored.

### 6.6.2 Loss of Water Level

The low water switch opens when there is an insufficient water level in the boiler. The NURO control will display 10010: "**Low Water Limit**", close the gas valve, and lock the boiler out. When the water level is corrected and the on-screen reset button is pressed, the boiler will reset and resume the sequence of operation at Step 3 (Section [6.5](#)).

### 6.6.3 Low Gas Pressure

The low gas pressure switch opens when there is (or has been) insufficient gas pressure available for proper operation of the boiler. If an external gas-supply shut-off valve is closed for any reason, a low gas condition will result. The NURO control will display 10012: "**Low Gas Limit**", close the gas valve, and lock the boiler out. When proper gas pressure is restored, and the on-screen reset button is pressed, the boiler will reset and resume the sequence of operation at Step 3 (Section [6.5](#)) High Gas Pressure

The high gas pressure switch opens when there is (or has been) excessive gas pressure for the proper operation of the boiler. The NURO control will display 10011: "**High Gas Limit**", close the gas valve, and lock the boiler out. When proper gas pressure is restored, and the on-screen reset button is pressed, the boiler will reset and resume the sequence of operation at Step 3 (Section [6.5](#)).

### 6.6.4 High Water Temperature

When the boiler water has exceeded both the operating temperature limit and the manual reset high-temperature limit, the NURO control will display 10009: "**High Temperature Limit**", close the gas valve, and lock the boiler out. When the water temperature falls below the high-limit temperature setting, the boiler will remain locked out until the water high-temperature limit switch is manually reset and the on-screen reset button is pressed. Once reset, the control will resume the sequence of operation at Step 3 (Section [6.5](#)).

### 6.6.5 Low Air

If the NURO control displays either 65: "**Interrupted Airflow Switch OFF**" or 66: "**Interrupted Airflow Switch ON**", this indicates improper airflow through the boiler. First, verify proper standby blower operation – when the boiler is in "**Standby**", the blower should also be in standby.

Next, check for obstructions of the combustion air intake and/or exhaust (flue) piping. Next, check the hoses leading to the air switches are not kinked or obstructed. An error related to the air switch does not necessarily mean that the air switch is defective.

When 66: “**Interrupted Airflow Switch ON**” is displayed, check that the air switch is open when the blower is offline. Ensure there is no air flow through the boiler when the blower is offline. An excessive negative draft in the flue piping can cause air flow through the offline boiler which may be strong enough to maintain closure of the air switch.

When 65: “**Interrupted Airflow Switch OFF**” is displayed, check that the air switch is closed when the blower is running. If the air switch does not close within 5 minutes during purge, the boiler locks out. Check that the burner is clean (Section [5.2](#)) and that there are no obstructions to airflow in the intake or exhaust ducts.

#### 6.6.6 Flame Failure

In the event of a flame failure, the NURO control may display one of the following error messages:

- 106: “**Flame Lost in Main Flame Establish Period**”
- 107: “**Flame Lost Early in Run**”
- 108: “**Flame Lost in Run**”
- 109: “**Ignition Failed**”
- 110: “**Ignition Failure Occurred**”

When 109: “**Ignition Failed**” or 110: “**Ignition Failure Occurred**” is displayed, the boiler did not light during the trial for ignition. Check that the ignition electrode, ignition wire, and gas valve are functioning properly. Check that the direct spark ignition is visible through the flame observation port during the trial for ignition.

When 106: “**Flame Lost in Main Flame Establish Period**”, 107: “**Flame Lost Early in Run**”, or 108: “**Flame Lost in Run**” is displayed, the boiler lost the flame signal during operation. Check that combustion is adjusted properly, the gas pressure is correct, and the ignition electrode, ignition wire, and the gas valves are functioning properly.

#### 6.6.7 Flame Error

In the event of a flame error (premature or late flame signal), the NURO control will display 105: “**Flame Detected Out of Sequence**”. This may be caused by a failed/leaky gas valve or a flame rod or ionization rod malfunction. If gas valve leakage is suspected, the unit must be isolated by turning off the main gas supply line. Lockout/tagout the boiler until qualified and knowledgeable service personnel are available to evaluate and repair or replace the failed parts. Check that the incoming gas pressures have not exceeded 14” W.C. (1/2 psig).

#### 6.6.8 Flue Problem

When the normally-closed high exhaust back pressure switch opens, the NURO control will display 10013: “**High Back Pressure Limit**”. This may be caused by an obstruction in the flue piping, an obstruction in the combustion air intake, or a blocked condensate system. When the blockage is removed, the boiler will automatically restart. If no blockage is found, it may be necessary to replace the high exhaust back pressure switch.

## 7 Parts/Technical Support

Spare parts and replacement parts can be ordered from Harsco Industrial, Patterson-Kelley by calling toll free **(877) 728-5351**. Reach us by fax at **(570) 476-7247**.

Refer to the parts list shown on the assembly drawings provided in this manual.

Technical information is also available by calling or visit the Harsco Industrial, Patterson-Kelley website, [www.harscopk.com](http://www.harscopk.com).

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

Typical schematic drawings are shown on the following pages. Drawings specific to your particular boiler can also be supplied by your local Harsco Industrial, Patterson-Kelley representative.

### **WARNING**

Use of Non-Factory Authorized replacement parts are not recommended for this equipment. All control components are engineered for safety and are designed to work in unison with each of the other components. Use of non-factory authorized replacement parts jeopardizes the functionality of the safety features as well as the performance of the boiler.

### 7.1 Terminal Block Assignments

#### 7.1.1 Terminal Block Assignments – Power Box (C-3000 & C-4000 Only)

The power box is located in the front of the boiler, at the lower left corner. This power box houses the control transformer, fuses, the power box terminal strip circuit breakers, and the blower motor relay.

The three phase circuit breaker is mounted on DIN rail and allows for direct connection of the three power leads. The terminals on the circuit breaker can accommodate maximum 10AWG wire. There is an additional terminal on the DIN rail for a ground connection. Refer to the Ratings Nameplate on the back surface of the boiler to verify the required electrical supply prior to connection.

Figure 7.1.1a Power Box Wiring Diagram (240V Configuration Shown)

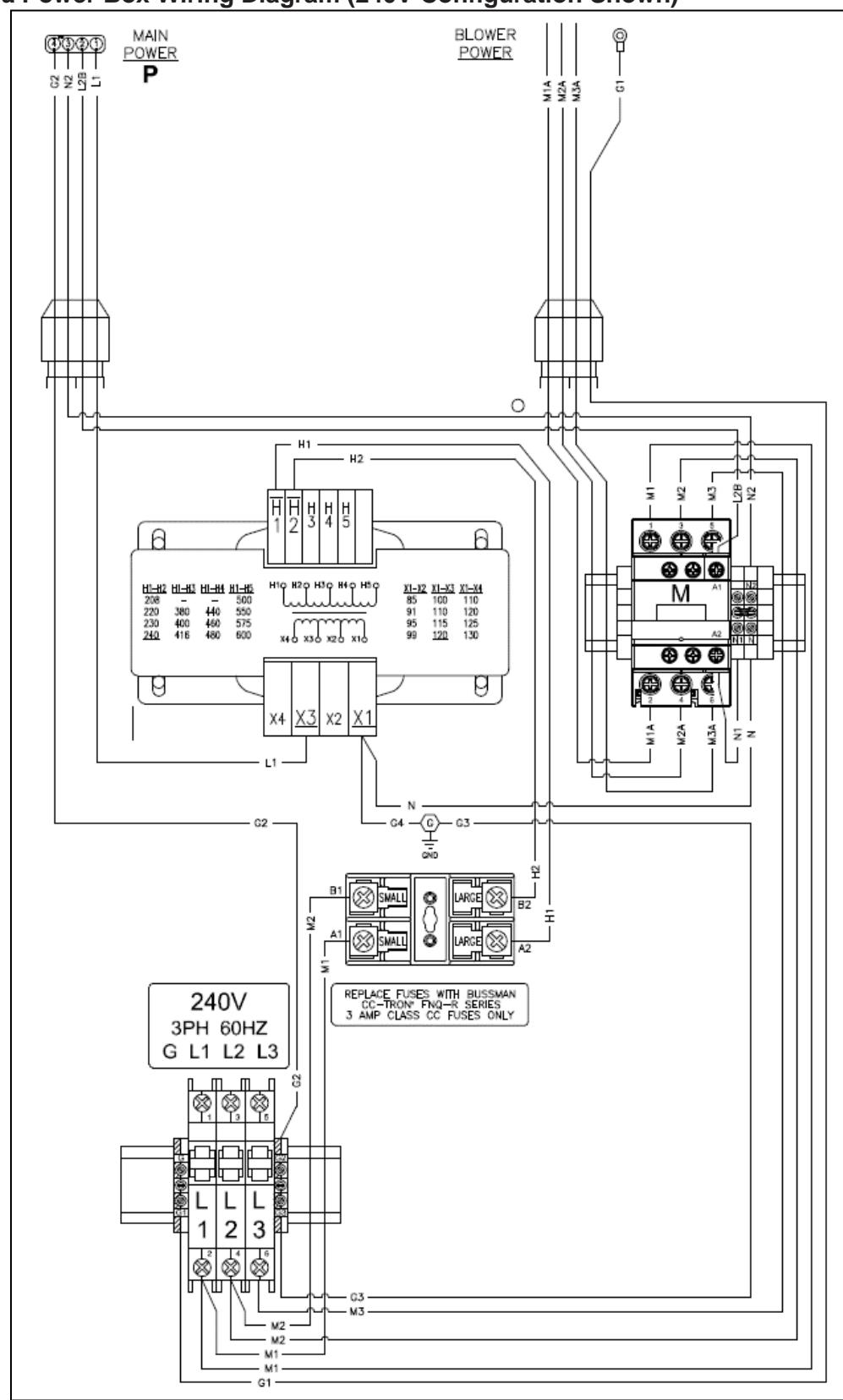
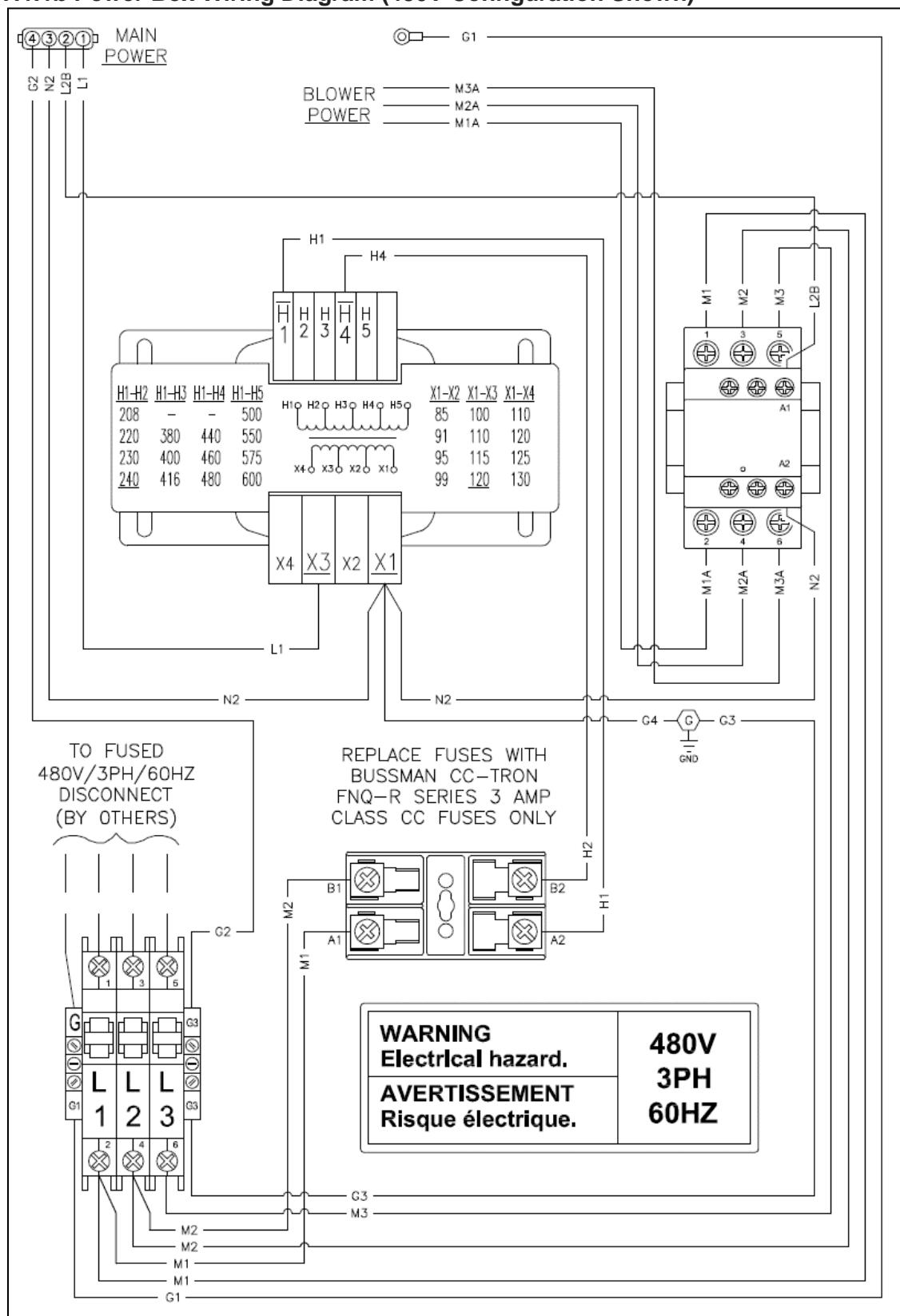


Figure 7.1.1b Power Box Wiring Diagram (480V Configuration Shown)



### 7.1.2 Terminal Block Assignments — Low Voltage (TB1) Terminal Block

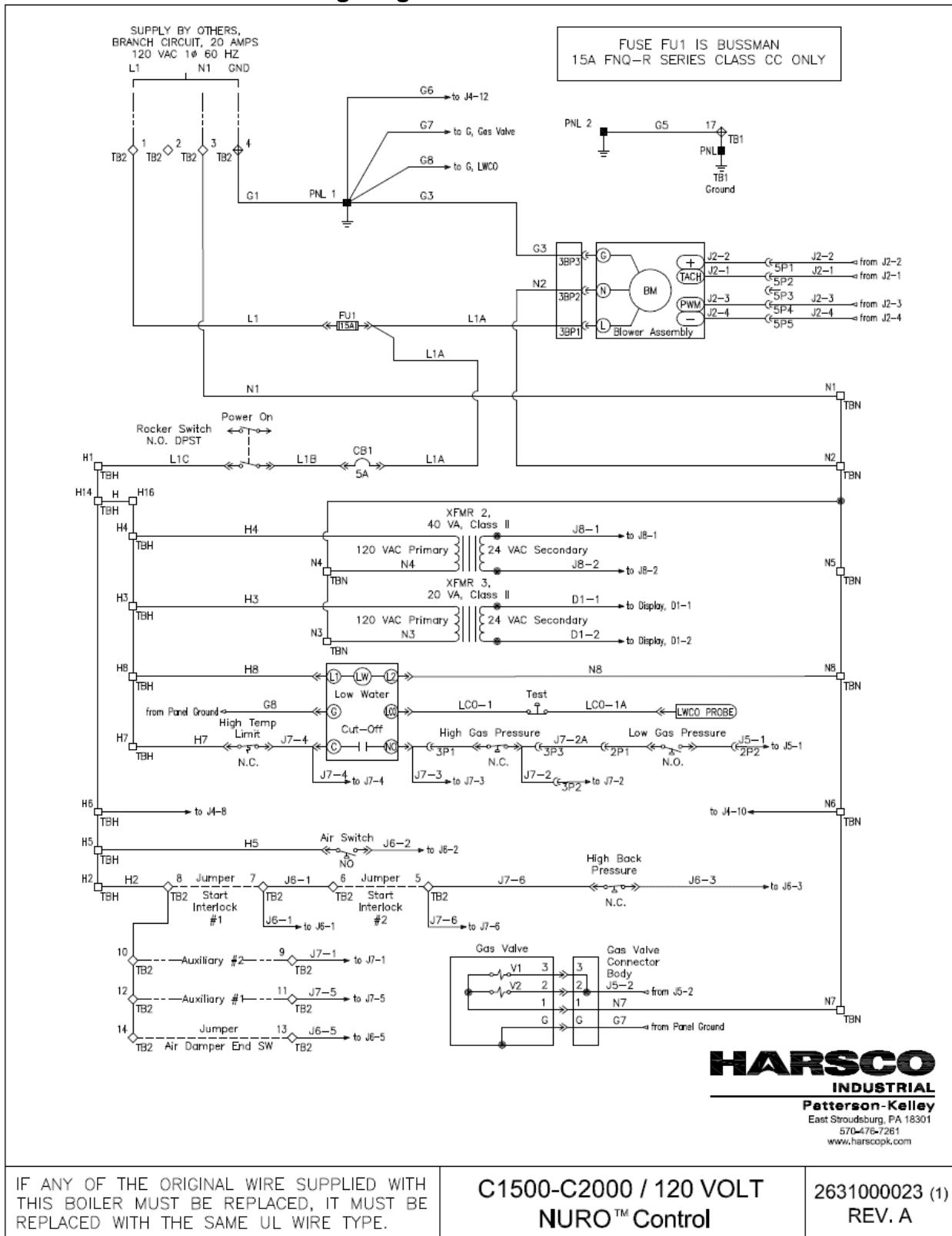
Terminal Number	Label	Description
27	ECOM 3	Wireless Outdoor Air Receiver
26	ECOM 2	
25	ECOM 1	
24	MODBUS SHIELD	2-Wire MODBUS RS485 & Shield Terminal
23	MODBUS COM B	
22	MODBUS COM A	
21	MODBUS/CASCADE REF	Reference Terminal (Application Dependent)
20	CASCADE B TO B	2-Wire Cascade & Shield Terminal
19	CASCADE A TO A	
18	CASCADE SHIELD	
17	GROUND	Ground Terminal for I/O Devices
16	ANALOG OUTPUT [-]	4-20mA Analog Output Tracks Boiler Firing Rate 100% Firing Rate = 20mA, 1% Firing Rate = 4mA
15	4-20mA ANALOG OUTPUT [+]	
14	NIGHT SETBACK	Contact Closure Enables Night Setback Operation Open Circuit Disables Night Setback Operation
13	NIGHT SETBACK	
12	OUTDOOR TEMP SENSOR	Outdoor Air Temperature Sensor for ODA Reset Configurable for 10kΩ or 12kΩ Sensor
11	OUTDOOR TEMP SENSOR	
10	DHW STAT / SENSOR	DHW Enable Circuit Configurable for SPST Break-on-rise Aquastat, or 10kΩ or 12kΩ Tank Sensor
9	DHW STAT / SENSOR	
8	HDR TEMP SENSOR	Hydronic Supply Header Temperature Sensor Configurable for 10kΩ or 12kΩ Sensor
7	HDR TEMP SENSOR	
6	SPARE ANALOG INPUT	Reserved for Future Use
5	SPARE ANALOG INPUT	
4	ANALOG INPUT [-]	4-20mA Analog Input Configurable for Setpoint or Firing Rate Control
3	4-20mA ANALOG INPUT [+]	
2	ENABLE / DISABLE	Contact Closure Enables Comfort Heat Operation Open Circuit Disables Comfort Heat Operation
1	ENABLE / DISABLE	

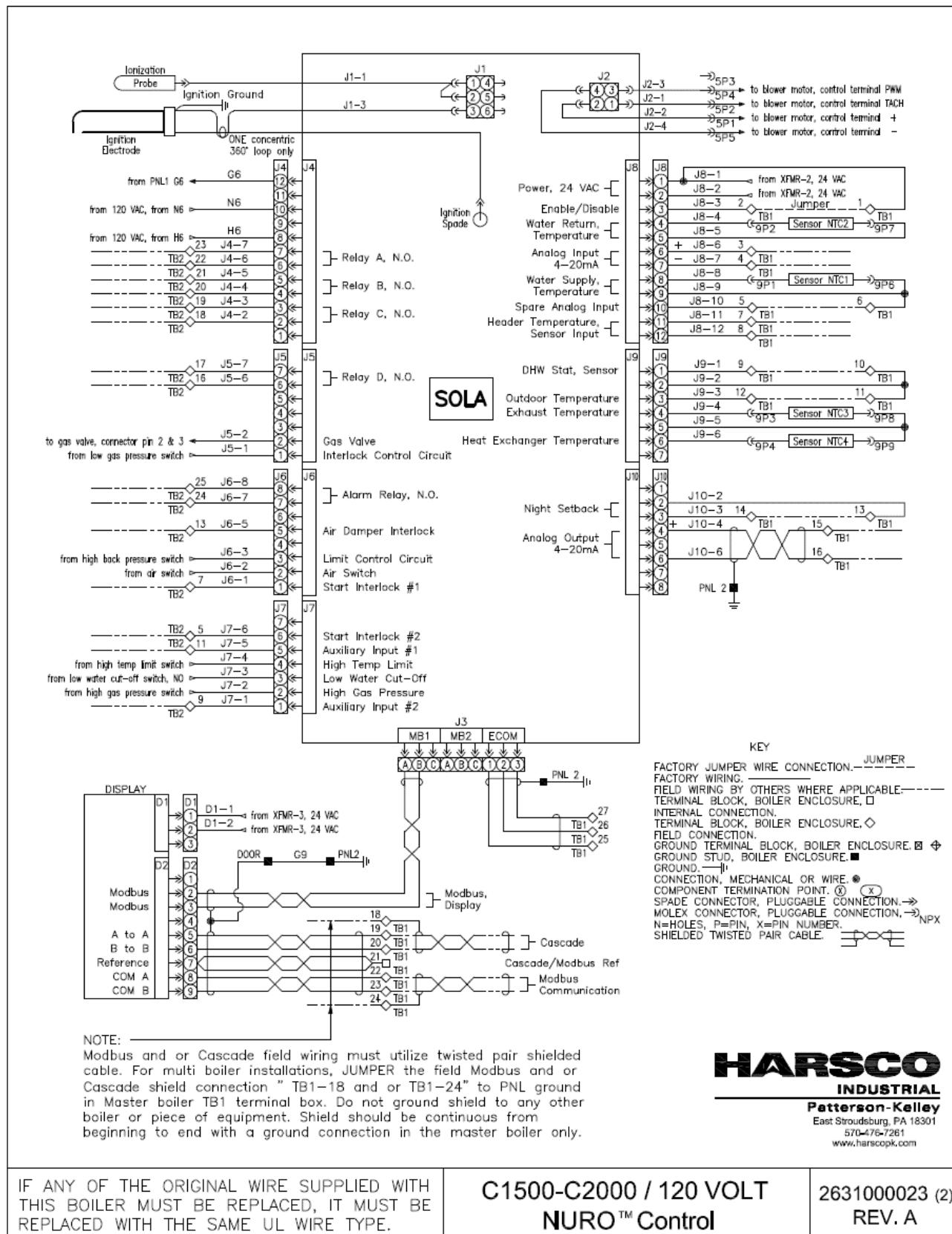
### 7.1.3 Terminal Block Assignments — High Voltage (TB2) Terminal Block

Terminal Number	C-1500H C-2000H C-2500 Label	C-3000 C-4000 Label	Description
25	MASTER ALARM RELAY		Normally-Open Dry Contact, Close on Alarm (240VAC Max Voltage & 1/2Amp Max Current)
24	MASTER ALARM RELAY		
23	RELAY A		User-Configurable Normally-Open Dry Contact A (240VAC Max Voltage & 1/2Amp Max Current)
22	RELAY A		
21	RELAY B		User-Configurable Normally-Open Dry Contact B (240VAC Max Voltage & 1/2Amp Max Current)
20	RELAY B		
19	RELAY C		User-Configurable Normally-Open Dry Contact C (240VAC Max Voltage & 1/2Amp Max Current)
18	RELAY C		
17	RELAY D		User-Configurable Normally-Open Dry Contact D (240VAC Max Voltage & 1/2Amp Max Current)
16	RELAY D		
<b>N/A</b>	GROUND		Ground Terminals for I/O Devices
15	GROUND		
14	[120V+] AIR DAMPER		120VAC Pilot-Duty for Air Damper Limit Switch
13	AIR DAMPER INTERLOCK		Contact Closure When Air Damper Proven Open
12	[120V+] AUXILIARY #1		Reserved for Future Use
11	AUXILIARY INPUT #1		
10	[120V+] AUXILIARY #2		Reserved for Future Use
9	AUXILIARY INPUT #2		
8	START INTERLOCK #1		External Interlock Circuit #1
7	START INTERLOCK #1		
6	START INTERLOCK #2		External Interlock Circuit #2 (In Series w/ #1)
5	START INTERLOCK #2		
4	GROUND G1	<b>Unused</b>	G1 for 110-120VAC, Single phase, 60Hz
3	NEUTRAL N1	<b>Unused</b>	N1 for 110-120VAC, Single phase, 60Hz
2	<b>Unused</b>	<b>Unused</b>	
1	HOT L1	<b>Unused</b>	L1 for 110-120VAC, Single phase, 60Hz

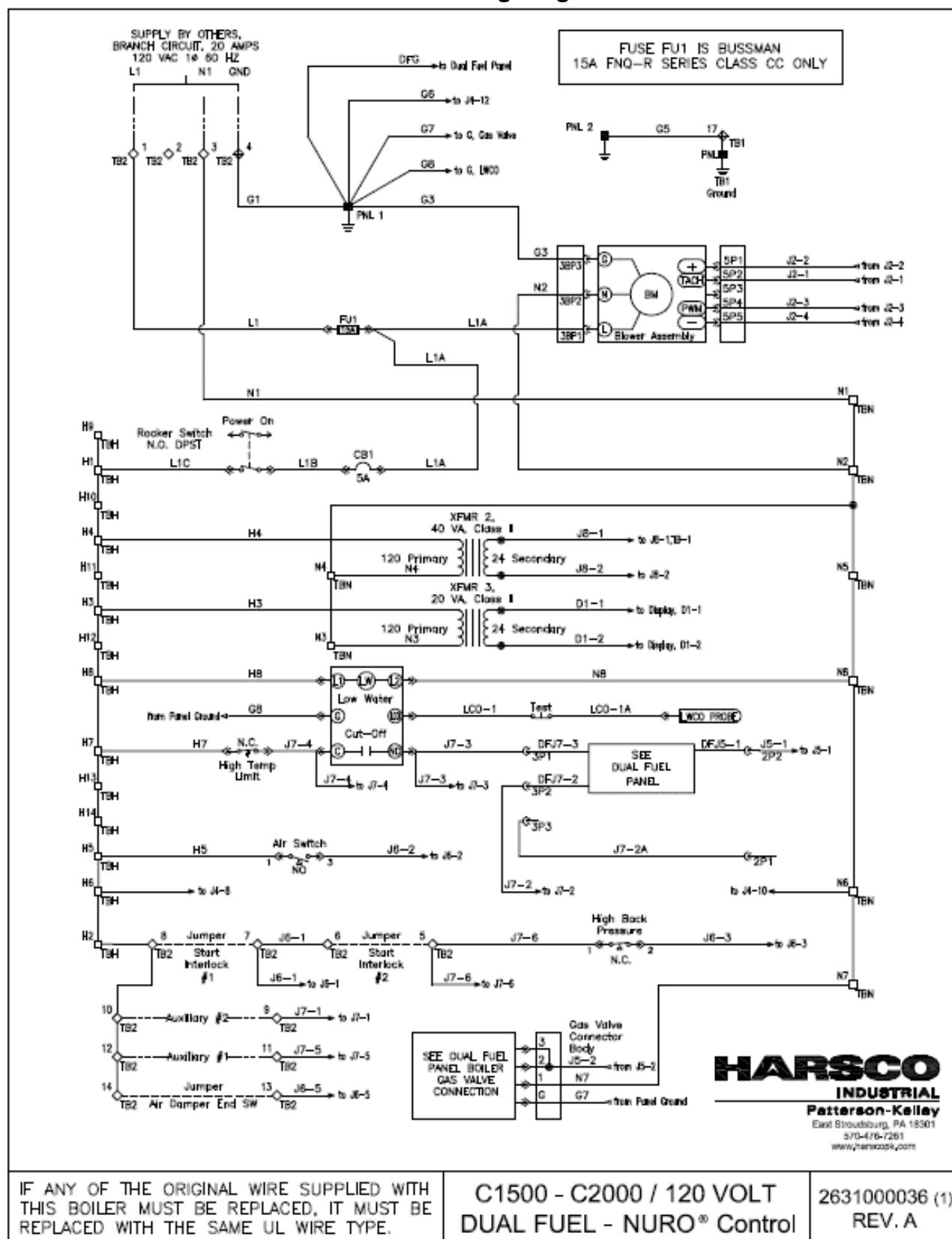
## 7.2 Wiring Diagrams

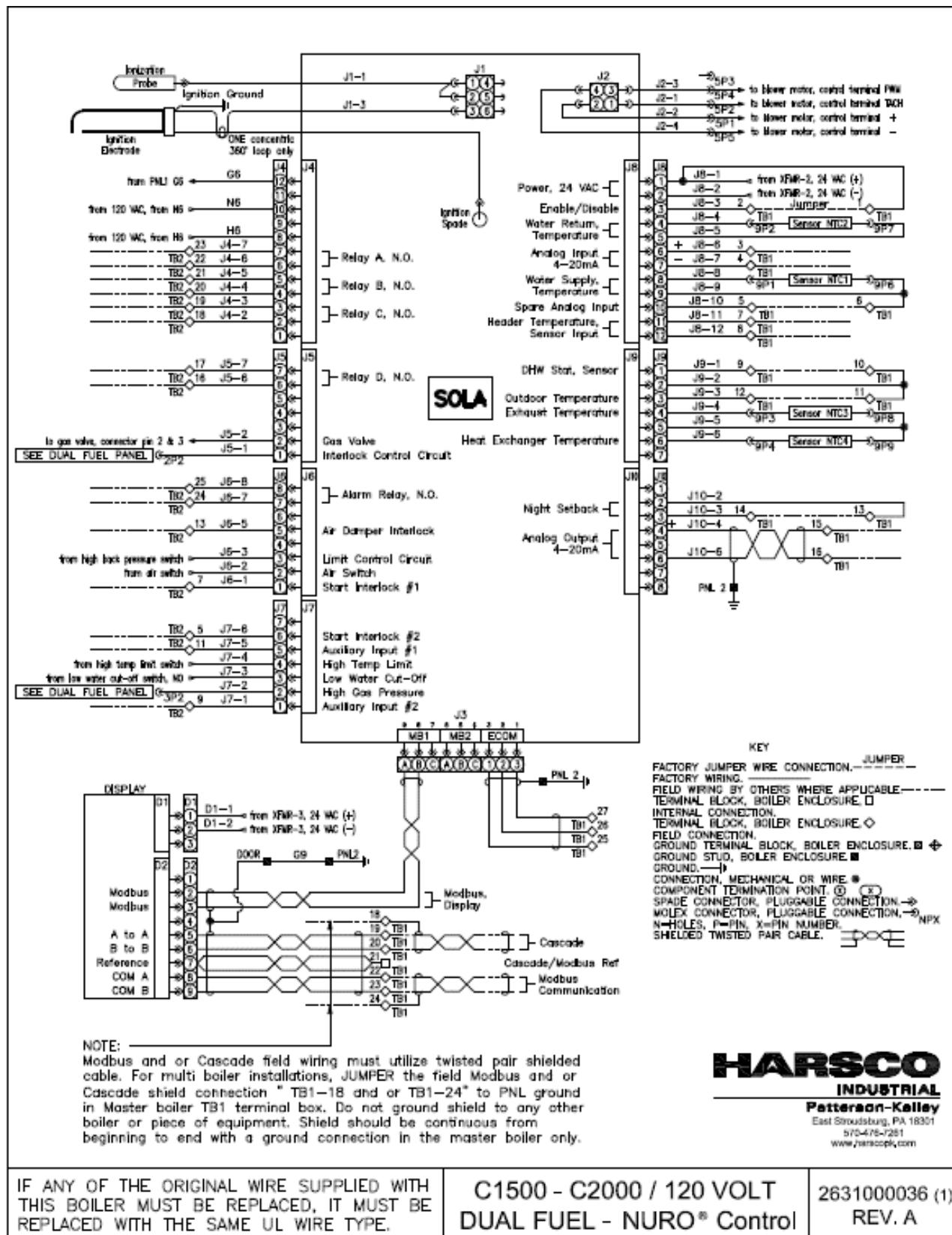
### 7.2.1 C-1500H & C-2000H Wiring Diagram

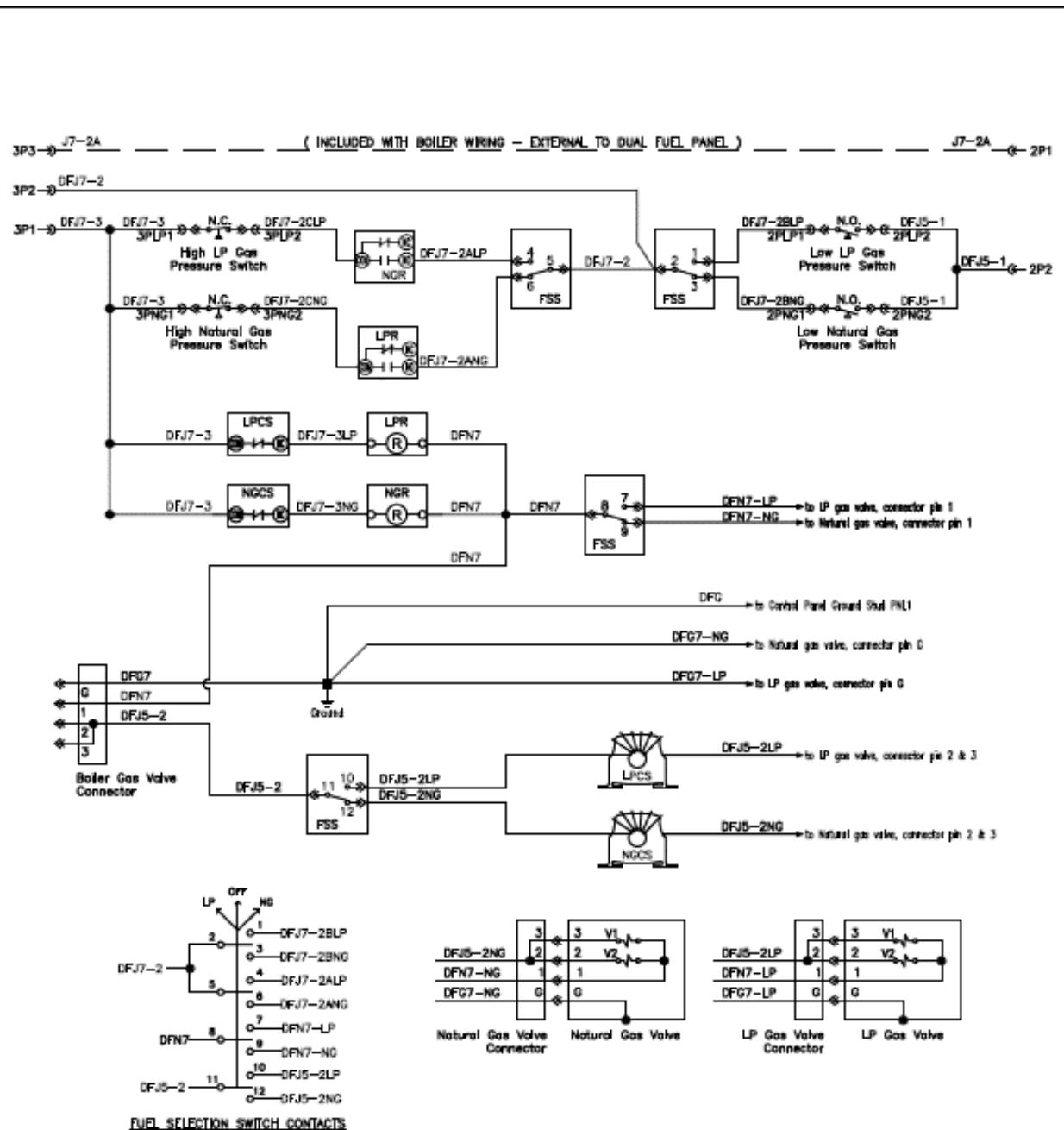




## 7.2.2 C-1500GG & C-2000GG Dual Fuel Wiring Diagram







## DUAL FUEL PANEL

IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

C1500 - C2000 / 120 VOLT  
DUAL FUEL - NURO® Control

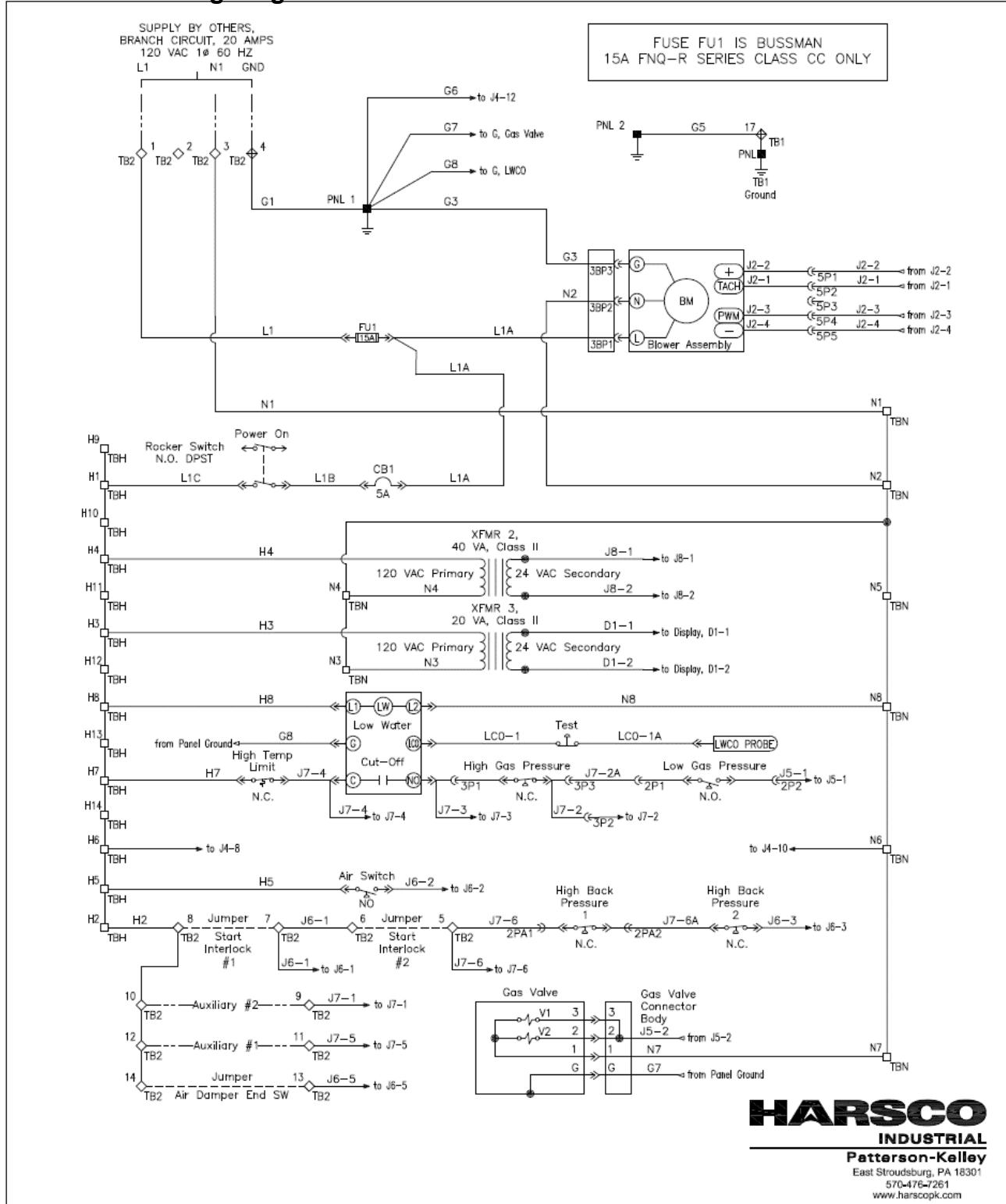
2621000026 40

2631000036

REV A

REV. A

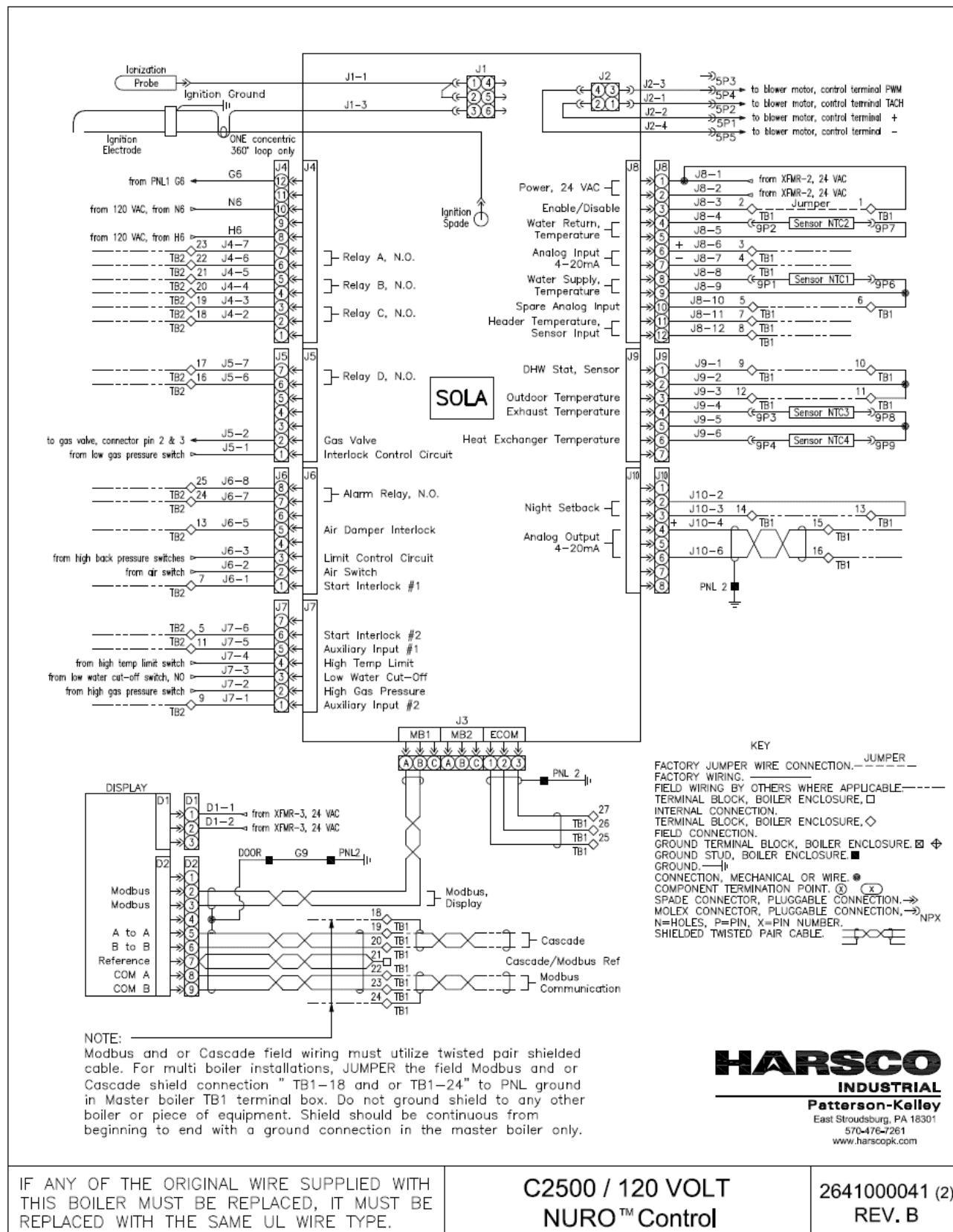
### 7.2.3 C-2500 Wiring Diagram



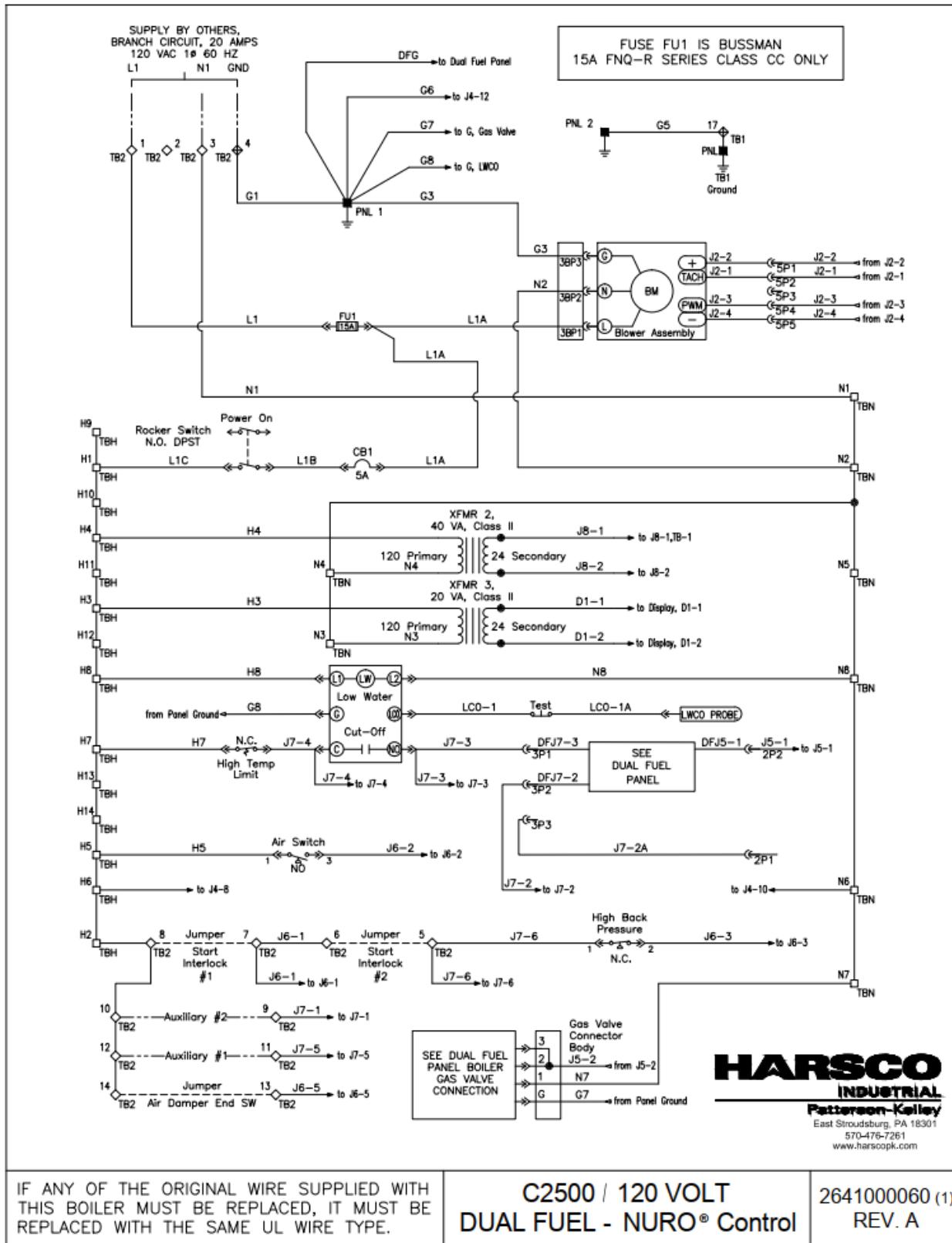
IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

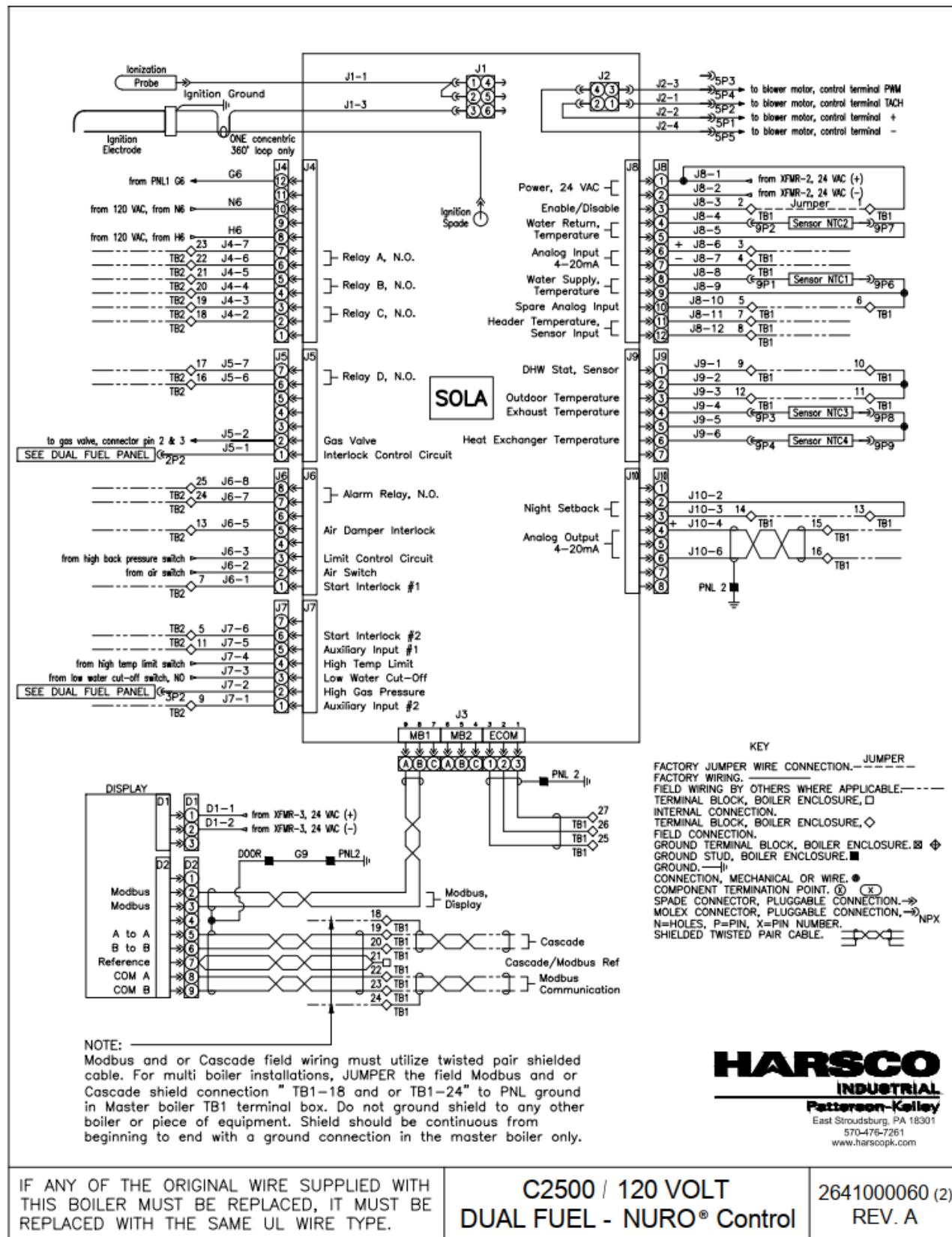
C2500 / 120 VOLT  
NURO™ Control

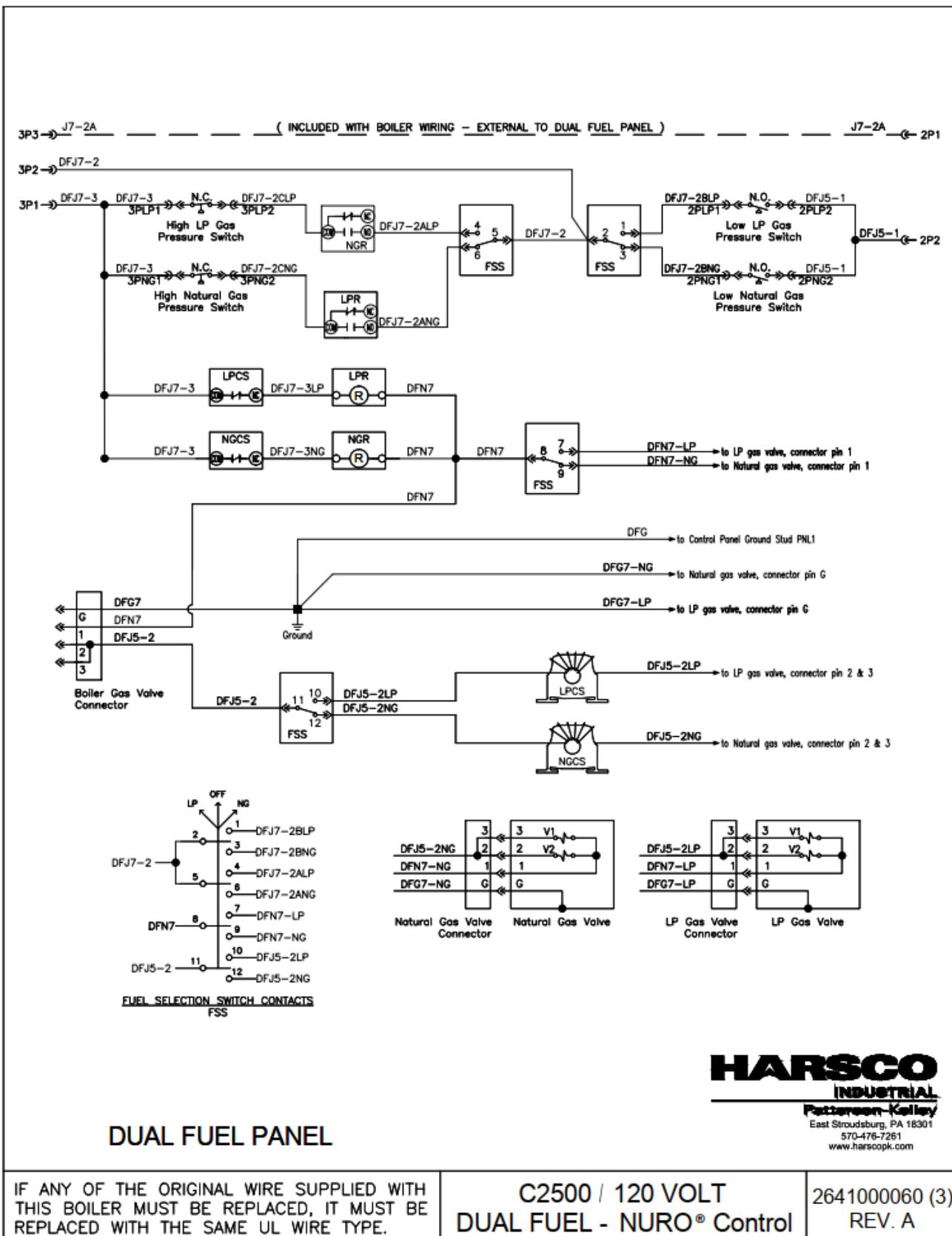
2641000041 (1)  
REV. B



## 7.2.4 C-2500 Dual Fuel Wiring Diagram







### 7.2.5 Control Transformer – Power Box (C-3000 & C-4000 Only)



Figure 7.2.4a C-3000 & C-4000: 208 VAC, three phase, 60 hertz:

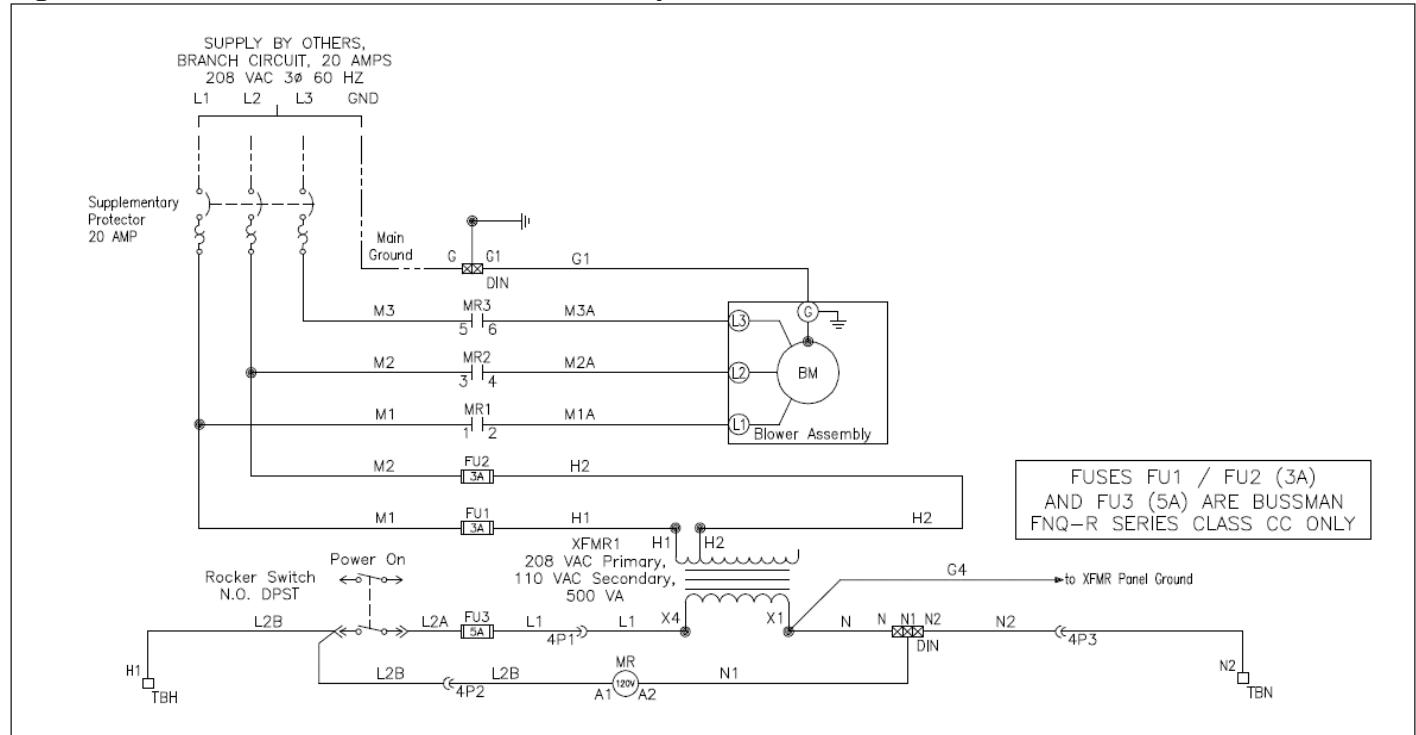


Figure 7.2.4b C-3000 & C-4000: 220-240 VAC, Three Phase, 60 hertz:

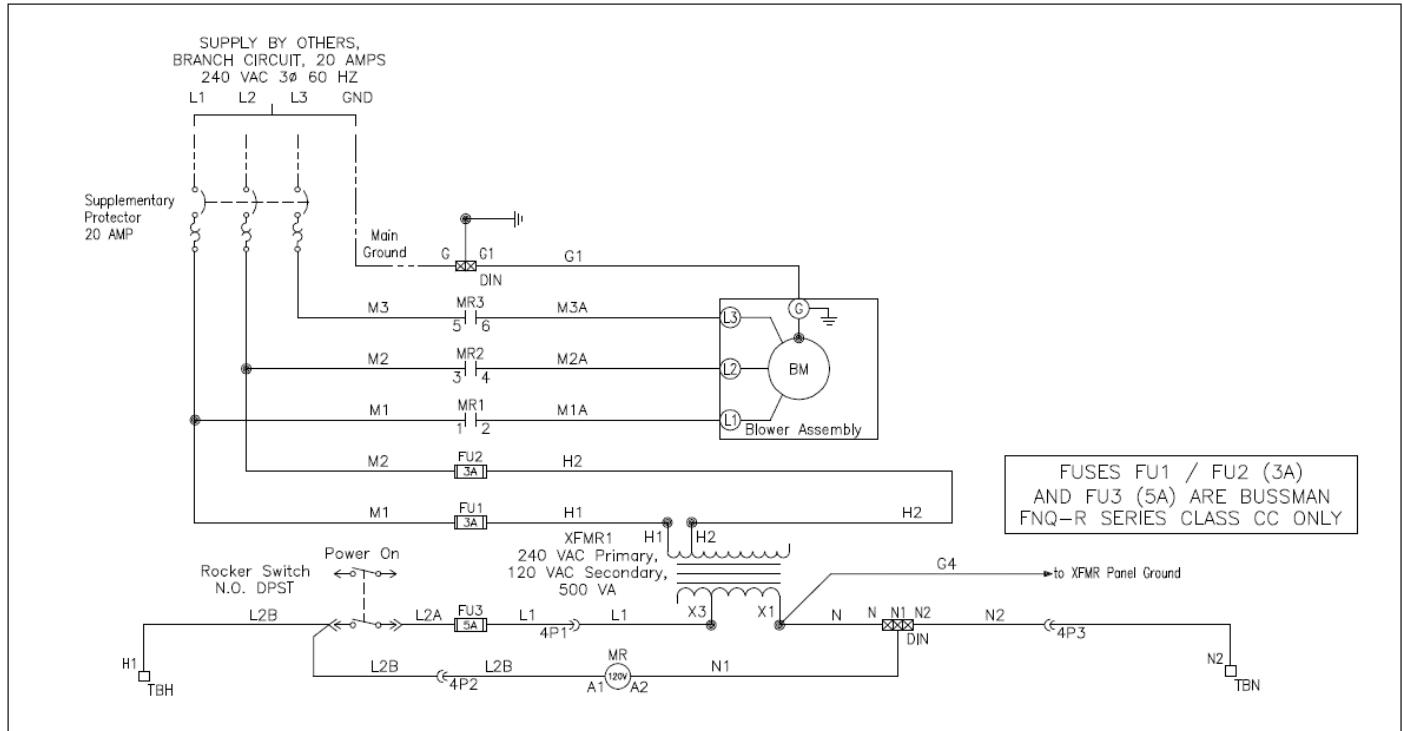
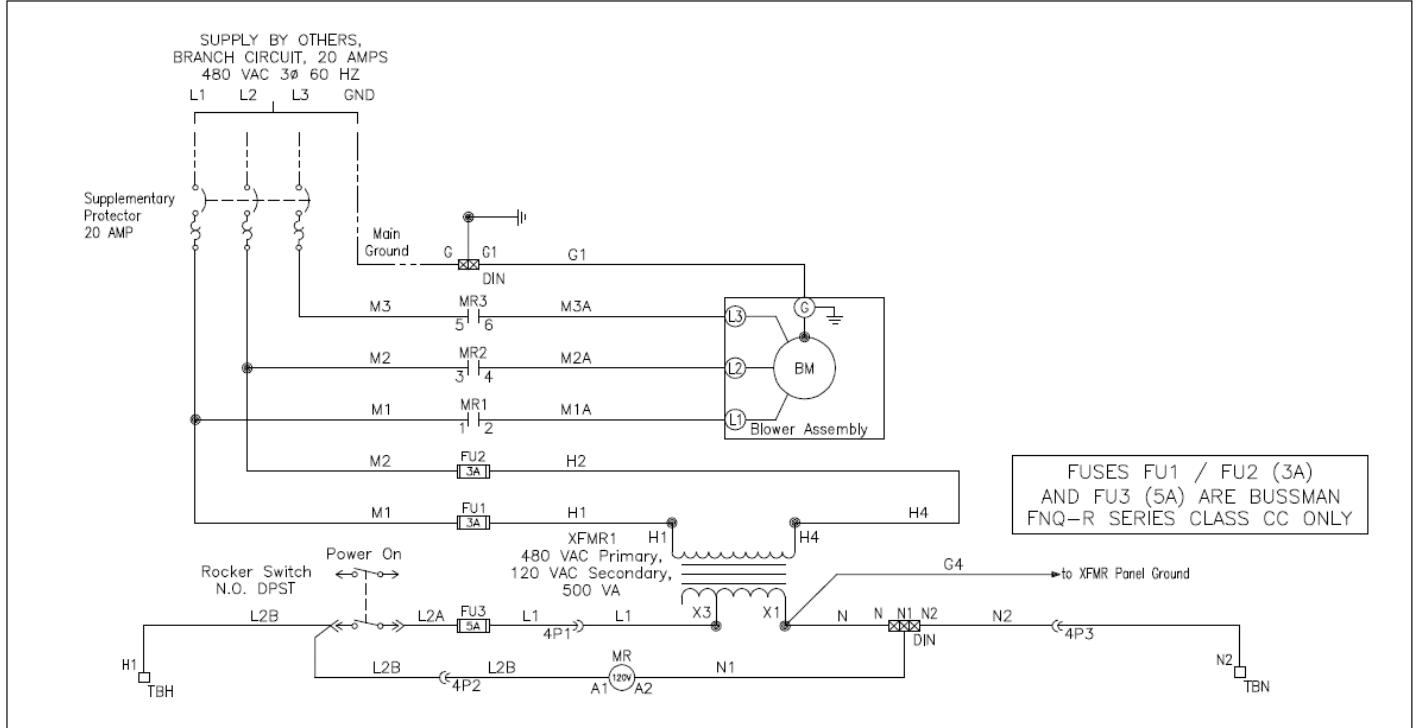
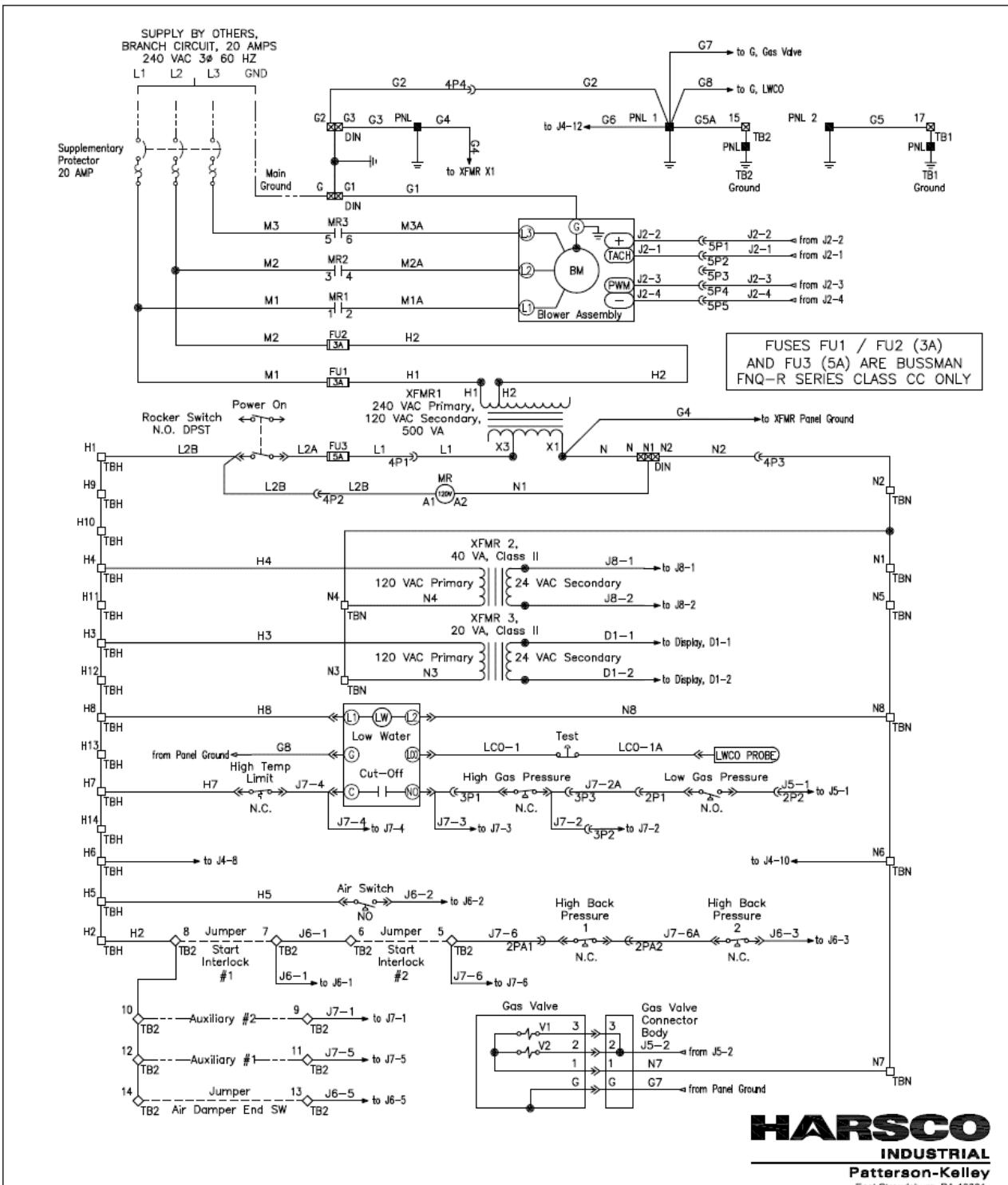


Figure 7.2.4c C-3000 & C-4000: 440-480 VAC, Three Phase, 60 hertz:



## 7.2.6 C-3000 & C-4000 240V Wiring Diagram



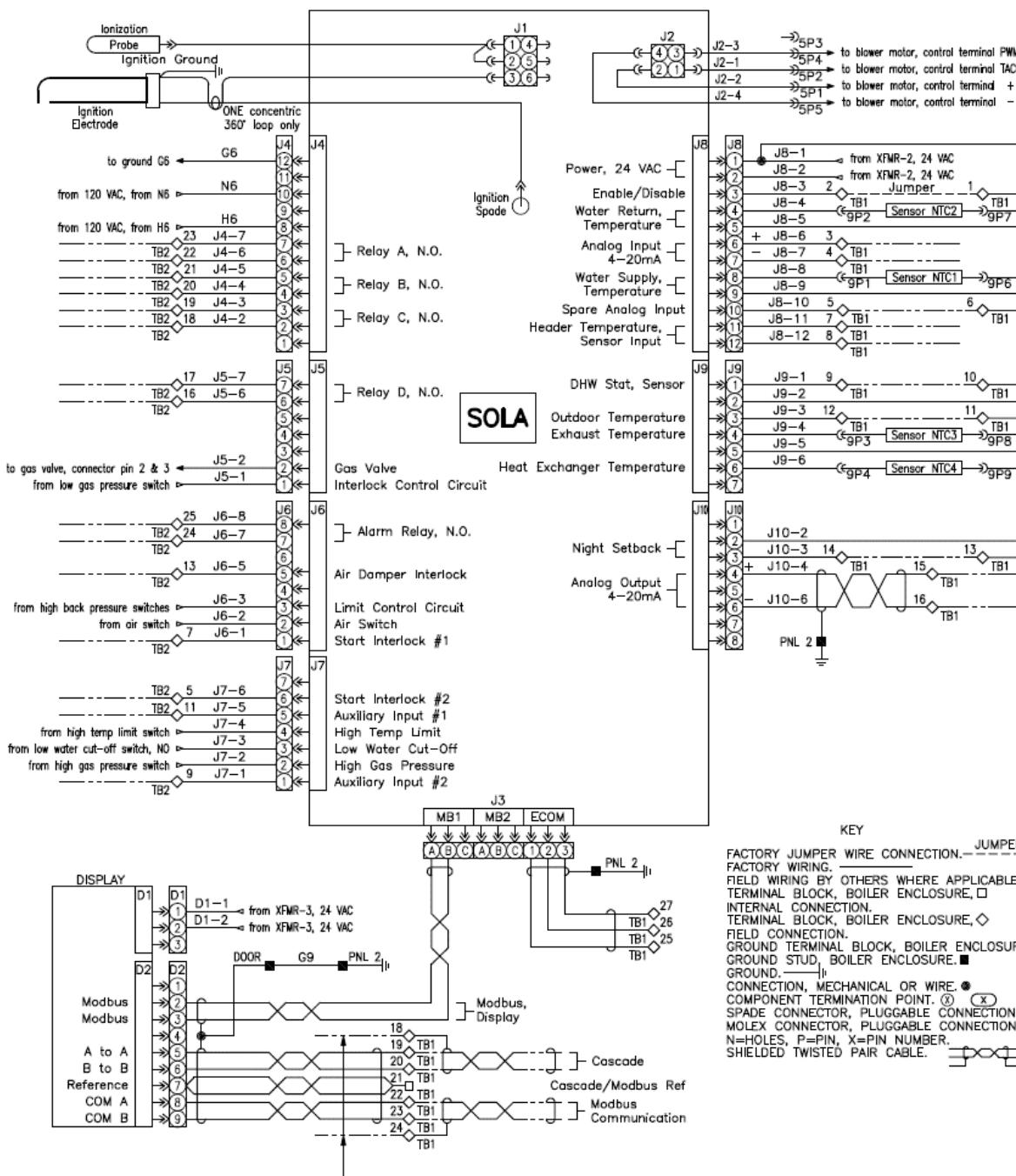
**HARSCO**  
INDUSTRIAL

Patterson-Kelley  
East Stroudsburg, PA 18301  
570-476-7261  
www.harscopk.com

IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

C3000 - C4000 / 240 VOLT  
NURO™ Control

2641000042 (1)  
REV. B



**NOTE:**  
Modbus and or Cascade field wiring must utilize twisted pair shielded cable. For multi boiler installations, JUMPER the field Modbus and or Cascade shield connection " TB1-18 and or TB1-24" to PNL ground in Master boiler TB1 terminal box. Do not ground shield to any other boiler or piece of equipment. Shield should be continuous from beginning to end with a ground connection in the master boiler only.

IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

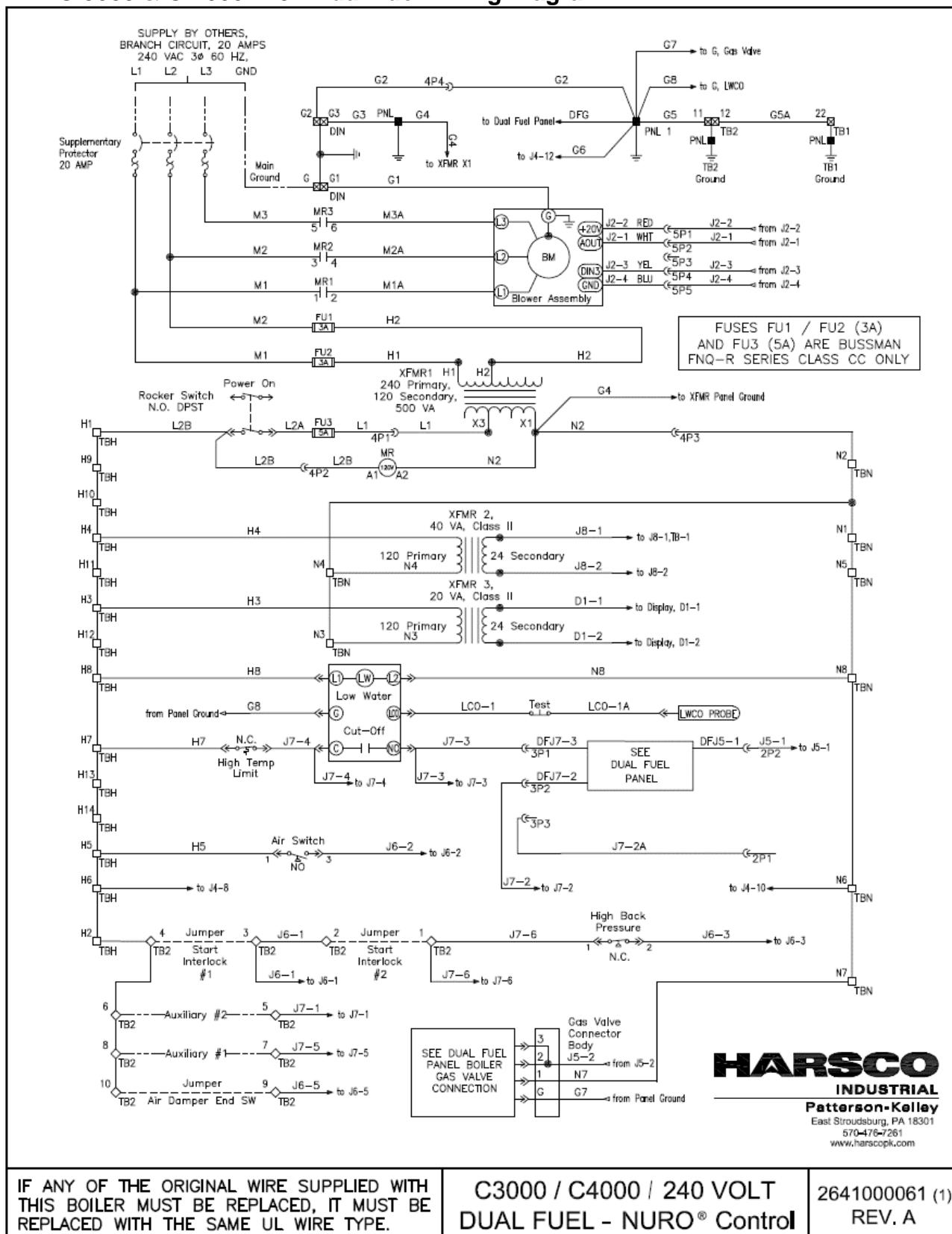
C3000 - C4000 / 240 VOLT  
NURO™ Control

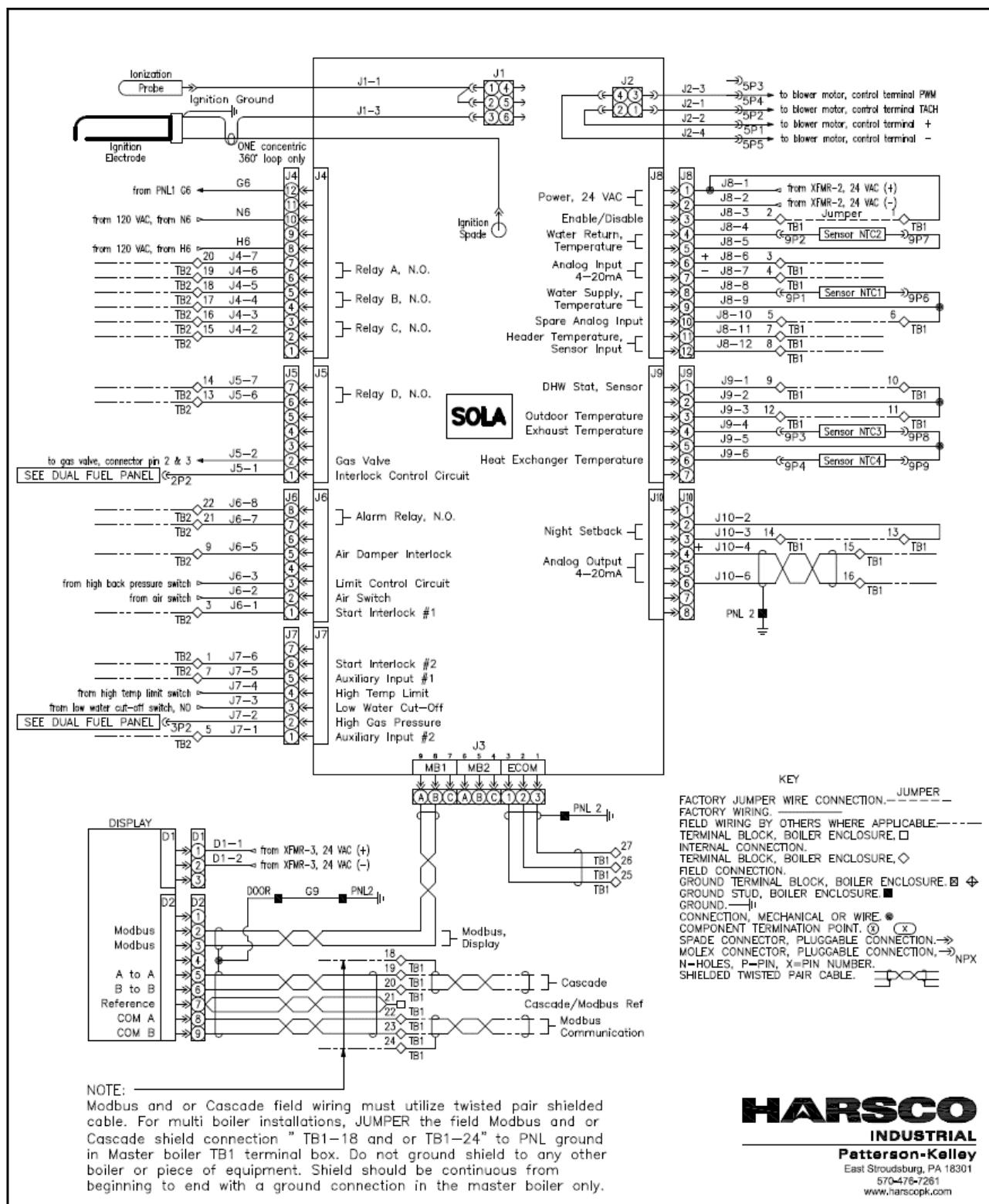
2641000042 (2)  
REV. B

**KEY**

FACTORY JUMPER WIRE CONNECTION.— JUMPER  
FACTORY WIRING.— FIELD WIRING BY OTHERS WHERE APPLICABLE  
TERMINAL BLOCK, BOILER ENCLOSURE, □  
INTERNAL CONNECTION.  
TERMINAL BLOCK, BOILER ENCLOSURE, ◇  
FIELD CONNECTION.  
GROUND TERMINAL BLOCK, BOILER ENCLOSURE. ■  
GROUND STUD, BOILER ENCLOSURE. ■  
GND GROUND.— GROUND  
CONNECTION, MECHANICAL OR WIRE. ●  
COMPONENT TERMINATION POINT. (●) (X)  
SPADE CONNECTOR, PLUGGABLE CONNECTION.—>  
MOLEX CONNECTOR, PLUGGABLE CONNECTION.—>  
N=HOLES, P=PIN, X=PIN NUMBER. NPX  
SHIELDED TWISTED PAIR CABLE. ┌─┐

## 7.2.7 C-3000 & C-4000 240V Dual Fuel Wiring Diagram

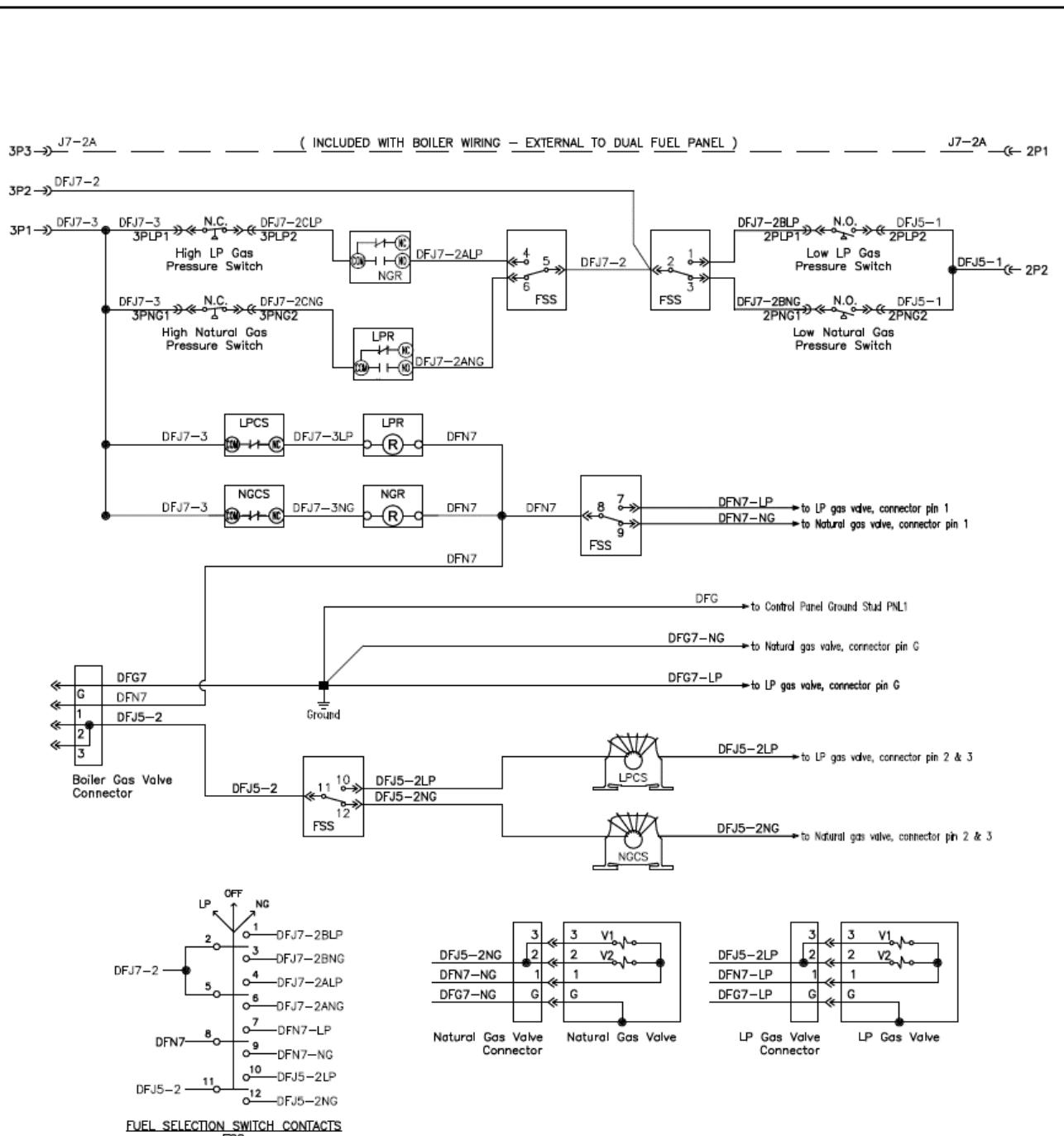




IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

C3000 / C4000 / 240 VOLT  
DUAL FUEL - NURO® Control

2641000061 (2)  
REV. A



## DUAL FUEL PANEL

IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

C3000 / C4000 / 240 VOLT  
DUAL FUEL - NURO® Control

2641000061 (3)  
REV. A

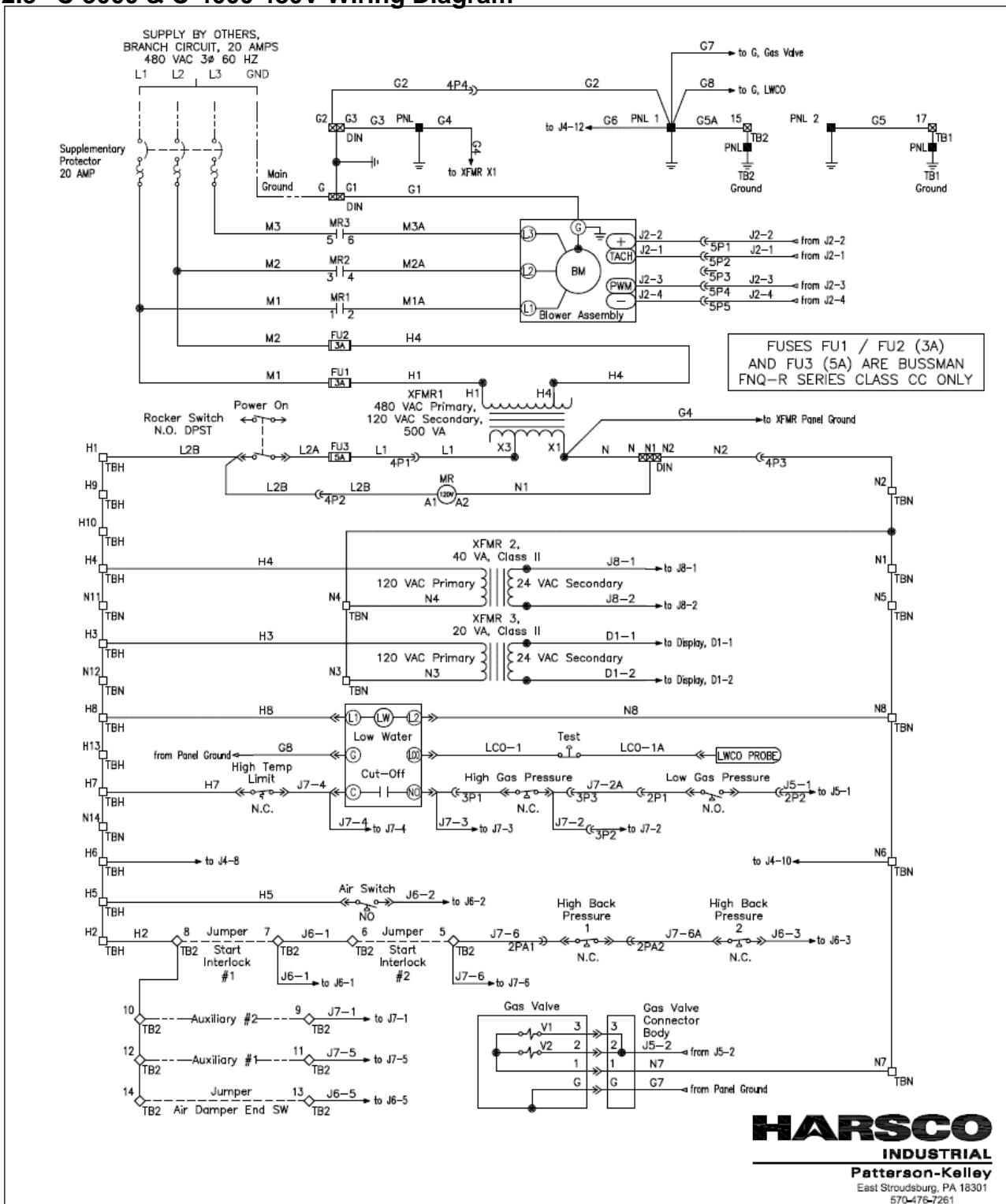
Revised: June 6, 2019  
Released: June 6, 2019

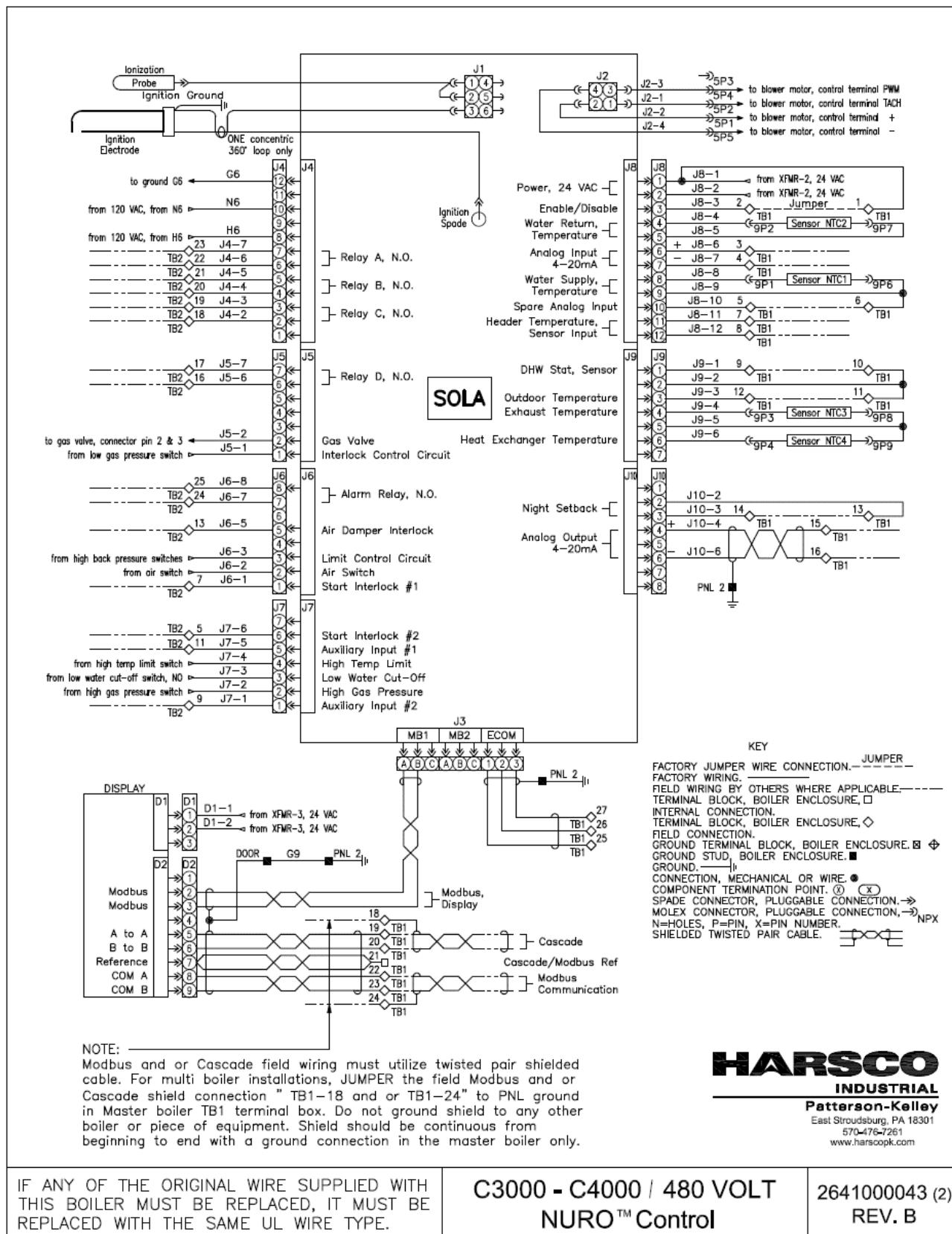
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1004905981 P-K MACH C1500H-C4000 Installation and  
Owners Manual (Rev E Jun-2019) (002).docx  
Page 91

## 7.2.8 C-3000 & C-4000 480V Wiring Diagram

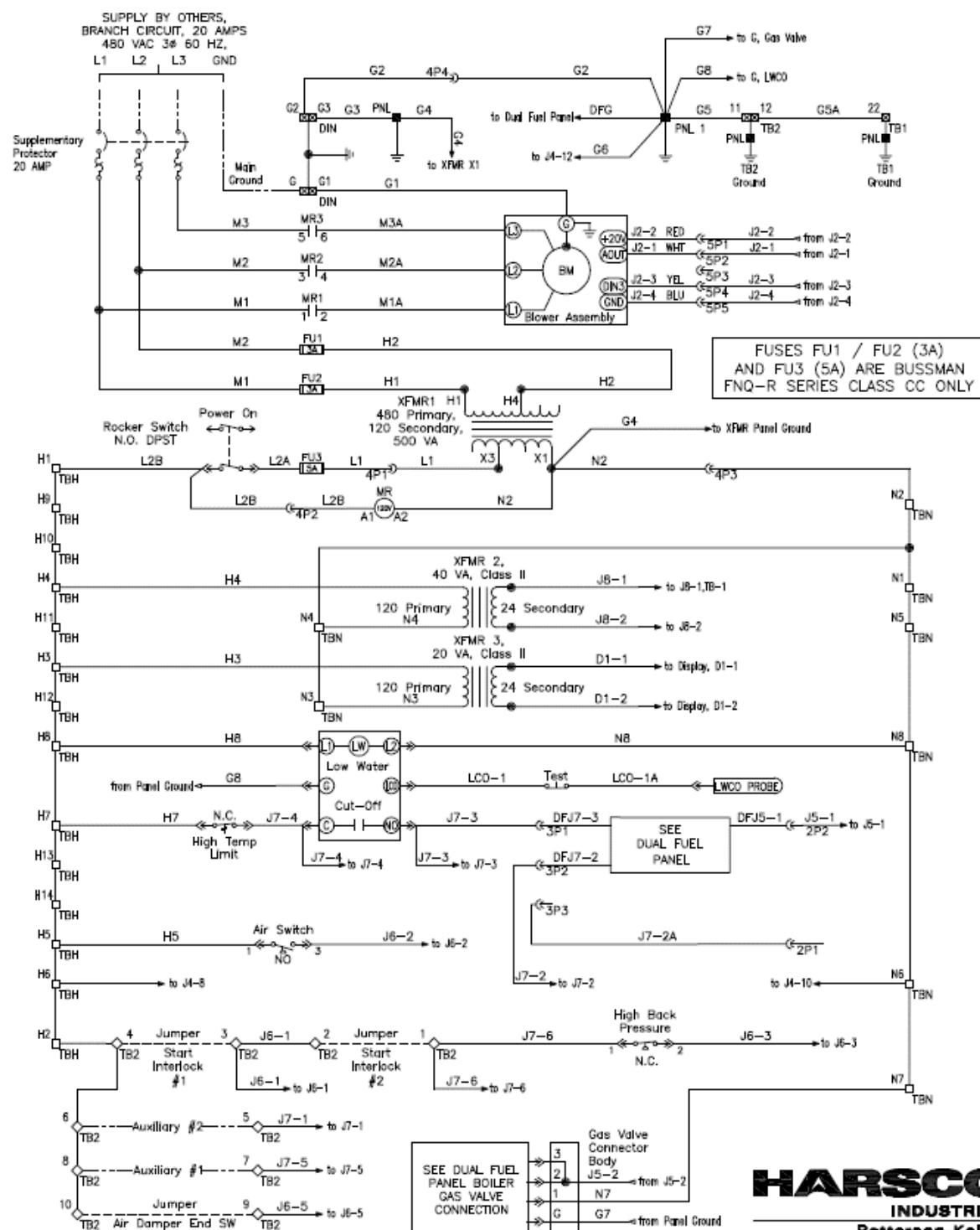




**KEY**

FACTORY JUMPER WIRE CONNECTION. — JUMPER  
FIELD WIRING. — FIELD WIRING BY OTHERS WHERE APPLICABLE.—  
TERMINAL BLOCK, BOILER ENCLOSURE. □ INTERNAL CONNECTION.  
TERMINAL BLOCK, BOILER ENCLOSURE. ◇ FIELD CONNECTION.  
GROUND TERMINAL BLOCK, BOILER ENCLOSURE. ■ GROUND STUD, BOILER ENCLOSURE. ■ GROUND. —|| CONNECTION, MECHANICAL OR WIRE. ● COMPONENT TERMINATION POINT. (X) SPADE CONNECTOR, PLUGGABLE CONNECTION. → MOLEX CONNECTOR, PLUGGABLE CONNECTION. → NPX N=HOLES, P=PIN, X=PIN NUMBER. SHIELDED TWISTED PAIR CABLE.

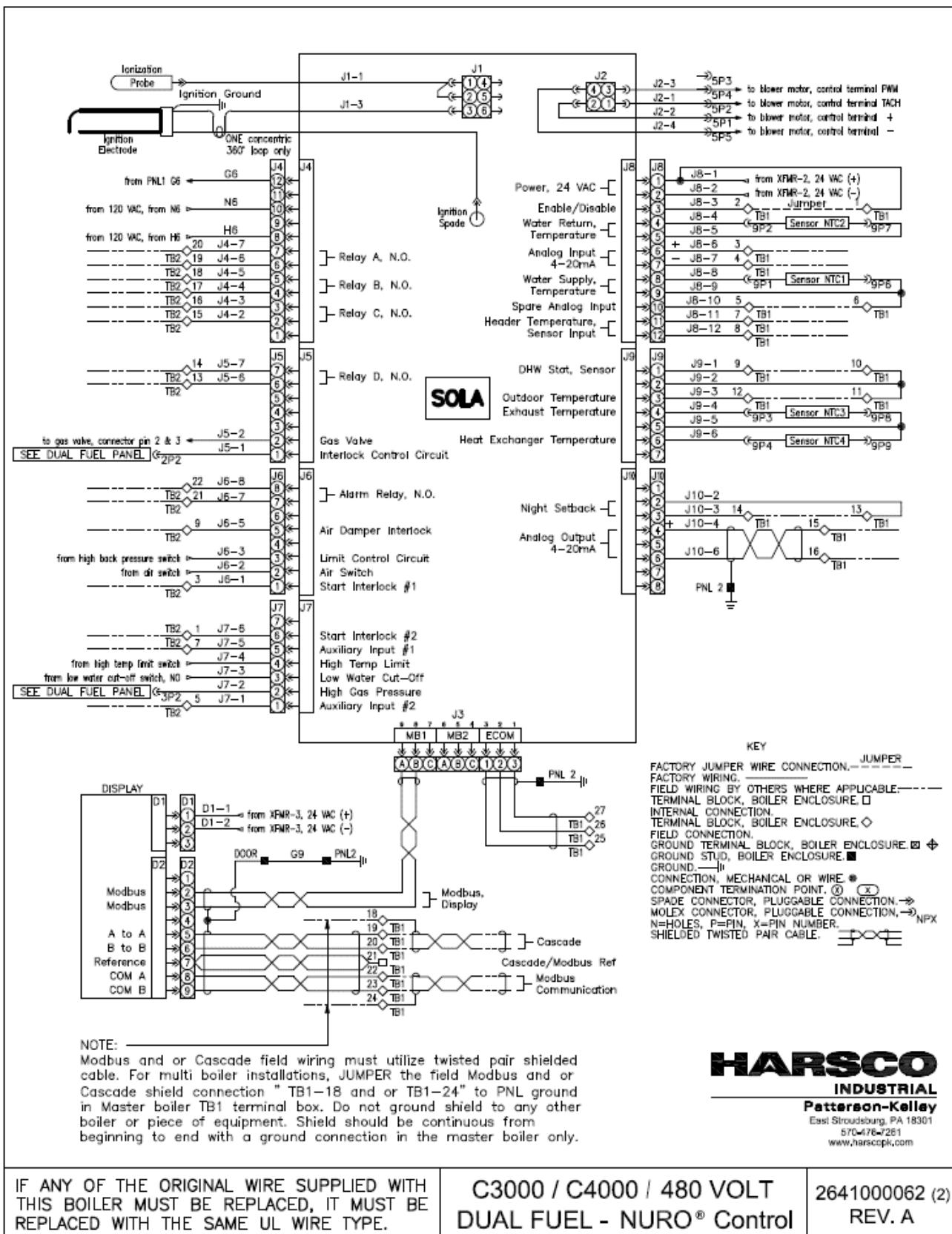
### 7.2.9 C3000GG & C4000GG 480V Dual Fuel Wiring Diagram

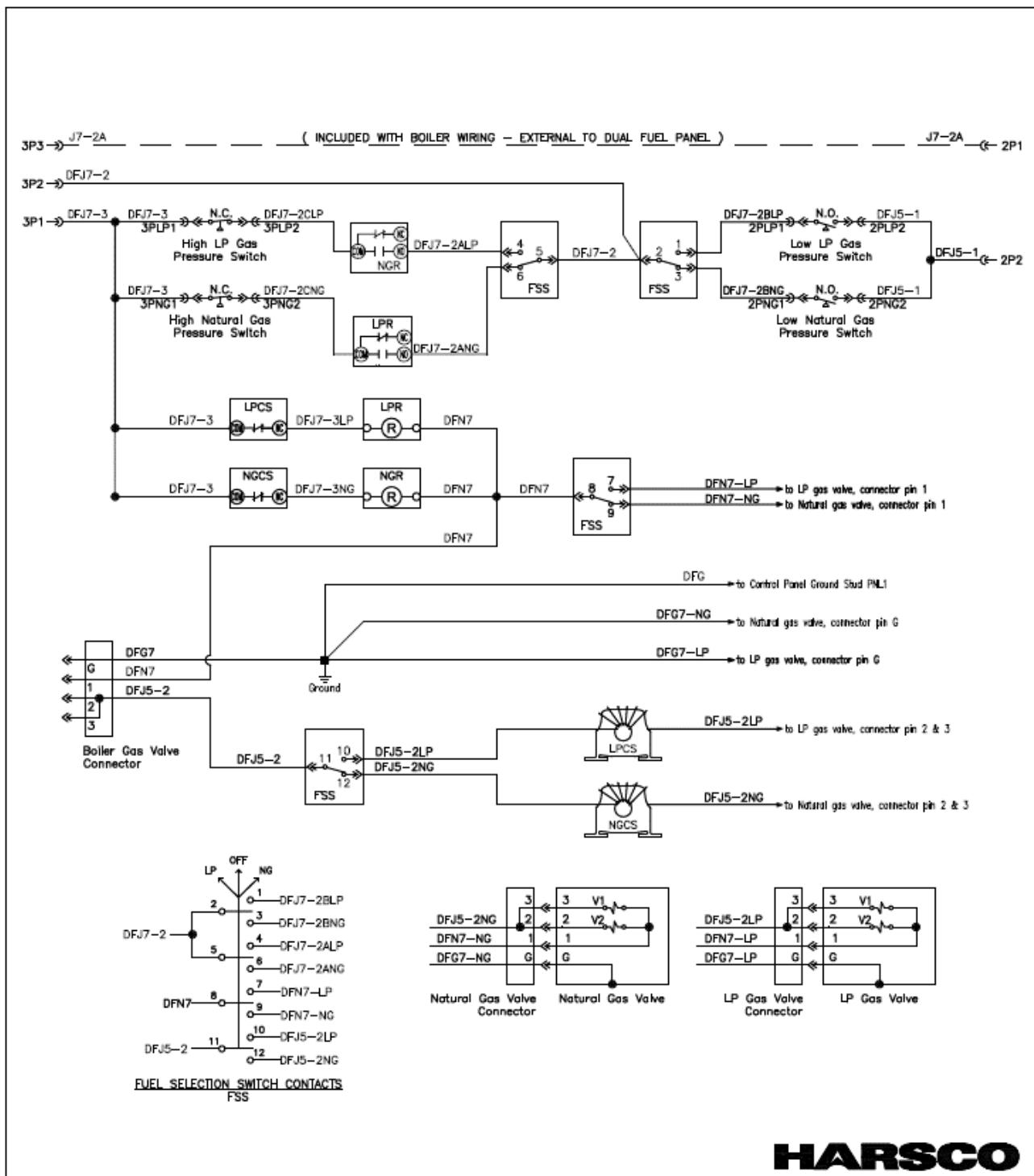


IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

C3000 / C4000 / 480 VOLT  
DUAL FUEL - NURO® Control

2641000062 (1)  
REV. A





## DUAL FUEL PANEL

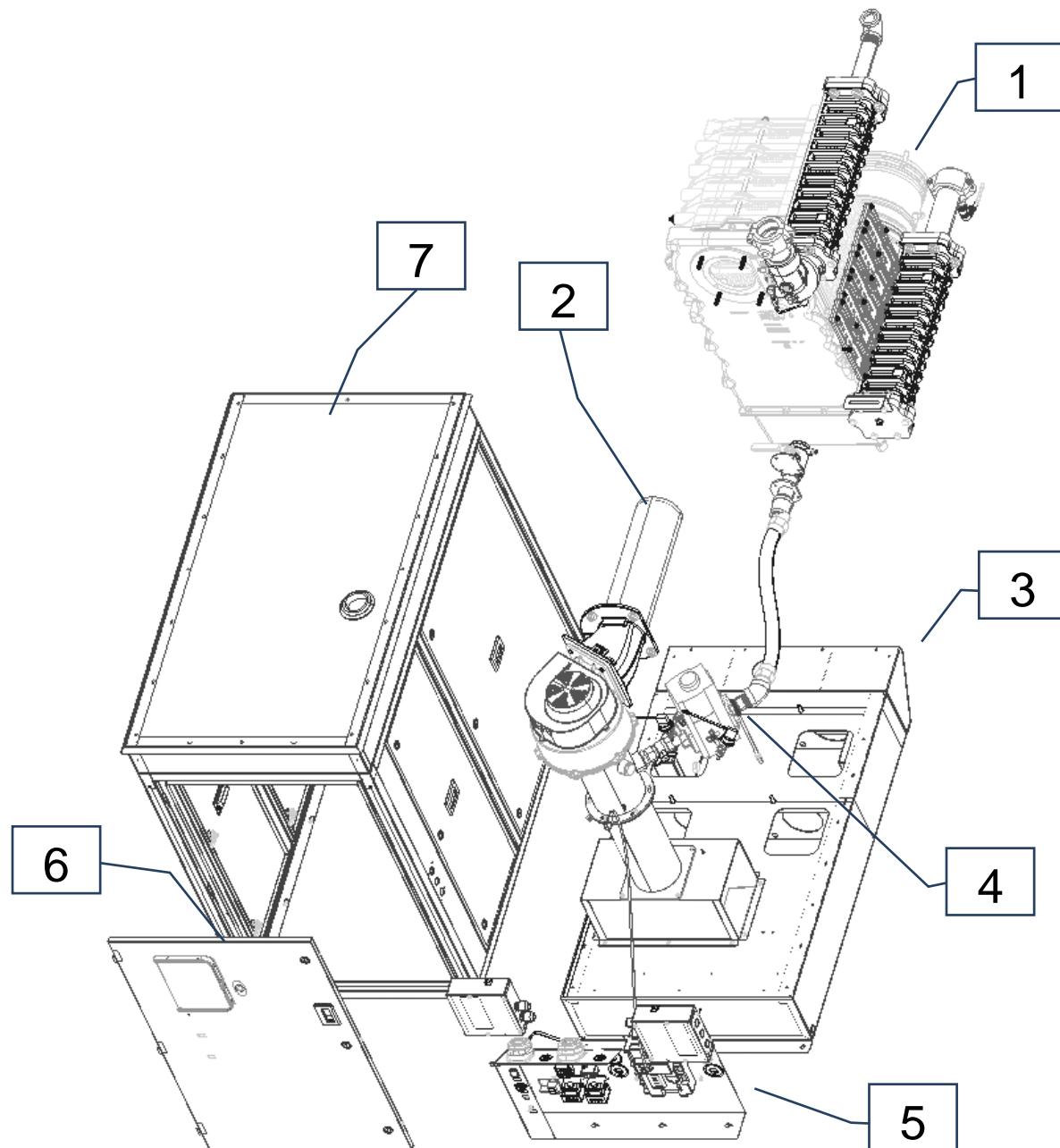
IF ANY OF THE ORIGINAL WIRE SUPPLIED WITH THIS BOILER MUST BE REPLACED, IT MUST BE REPLACED WITH THE SAME UL WIRE TYPE.

C3000 / C4000 / 480 VOLT  
DUAL FUEL - NURO® Control

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REV. A

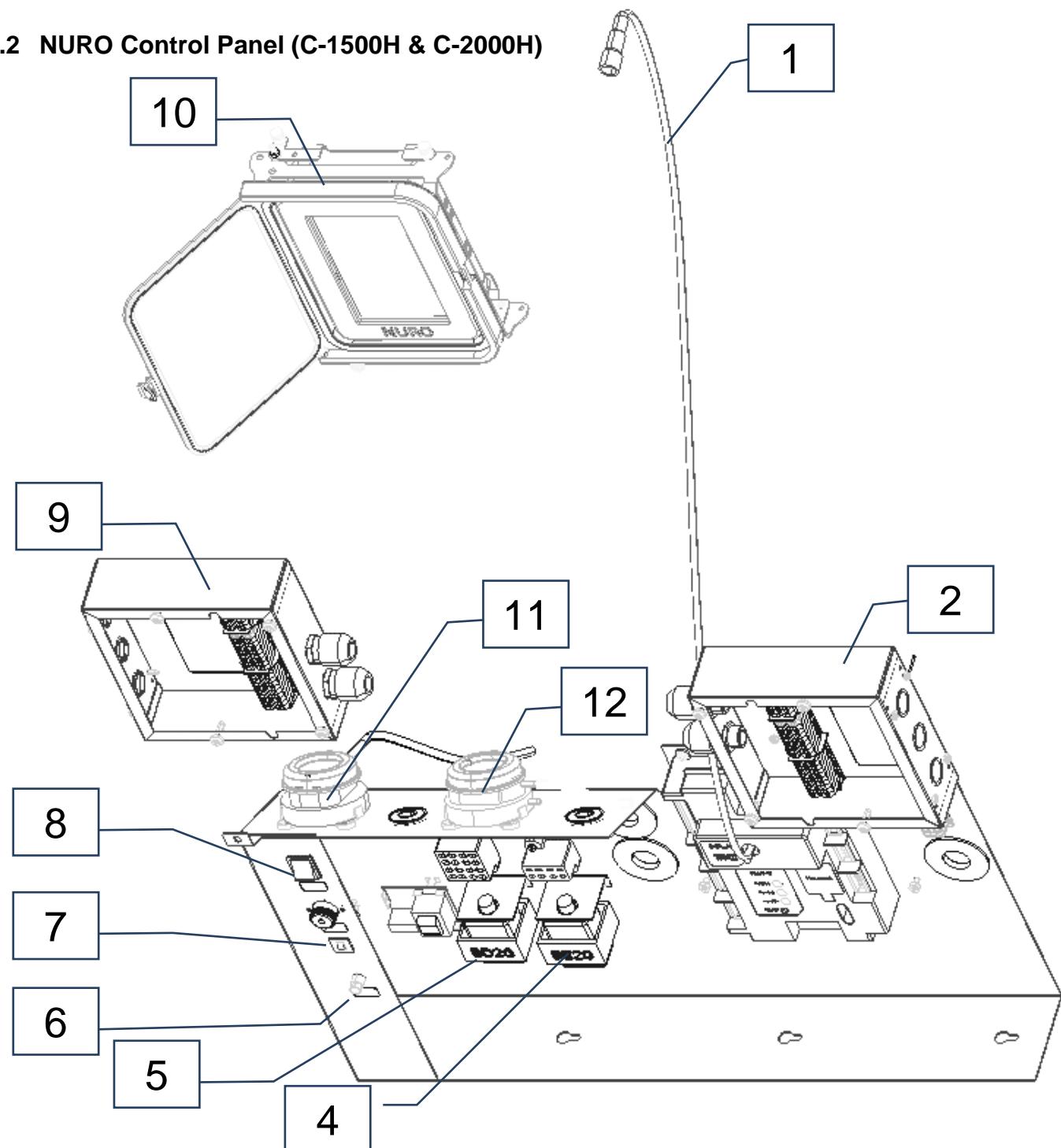
## 7.3 Boiler Parts Identification (C-1500H & C-2000H)

### 7.3.1 Main Boiler Assembly (C-1500H & C-2000H)



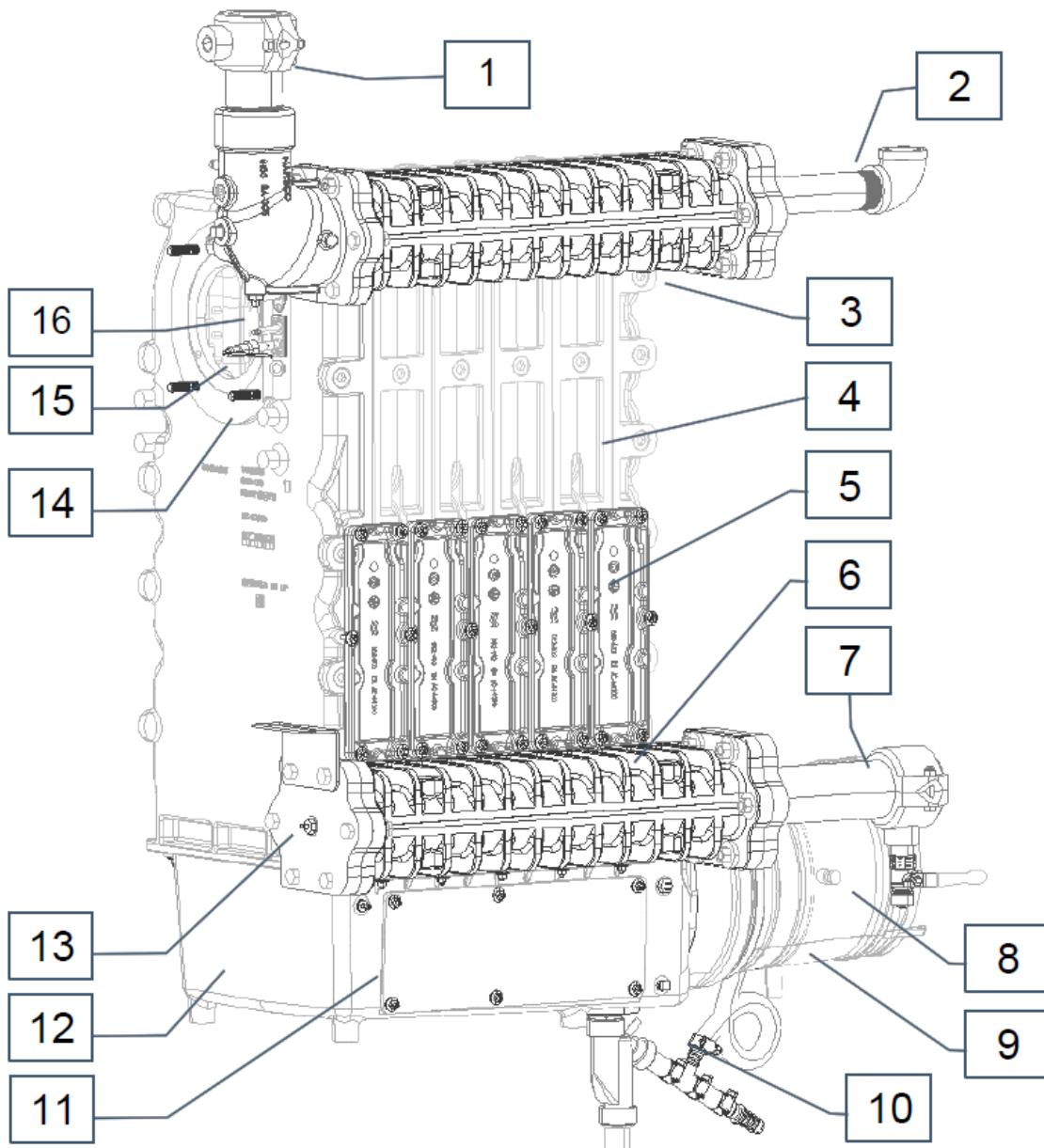
Mark	Description	Mark	Description
1	Heat Engine Assembly	5	NURO Control Panel
2	Burner/Blower Assembly	6	Front Door / NURO Touchscreen
3	Cabinet Base	7	Sheet Metal Cabinet
4	Natural Gas Train		

### 7.3.2 NURO Control Panel (C-1500H & C-2000H)



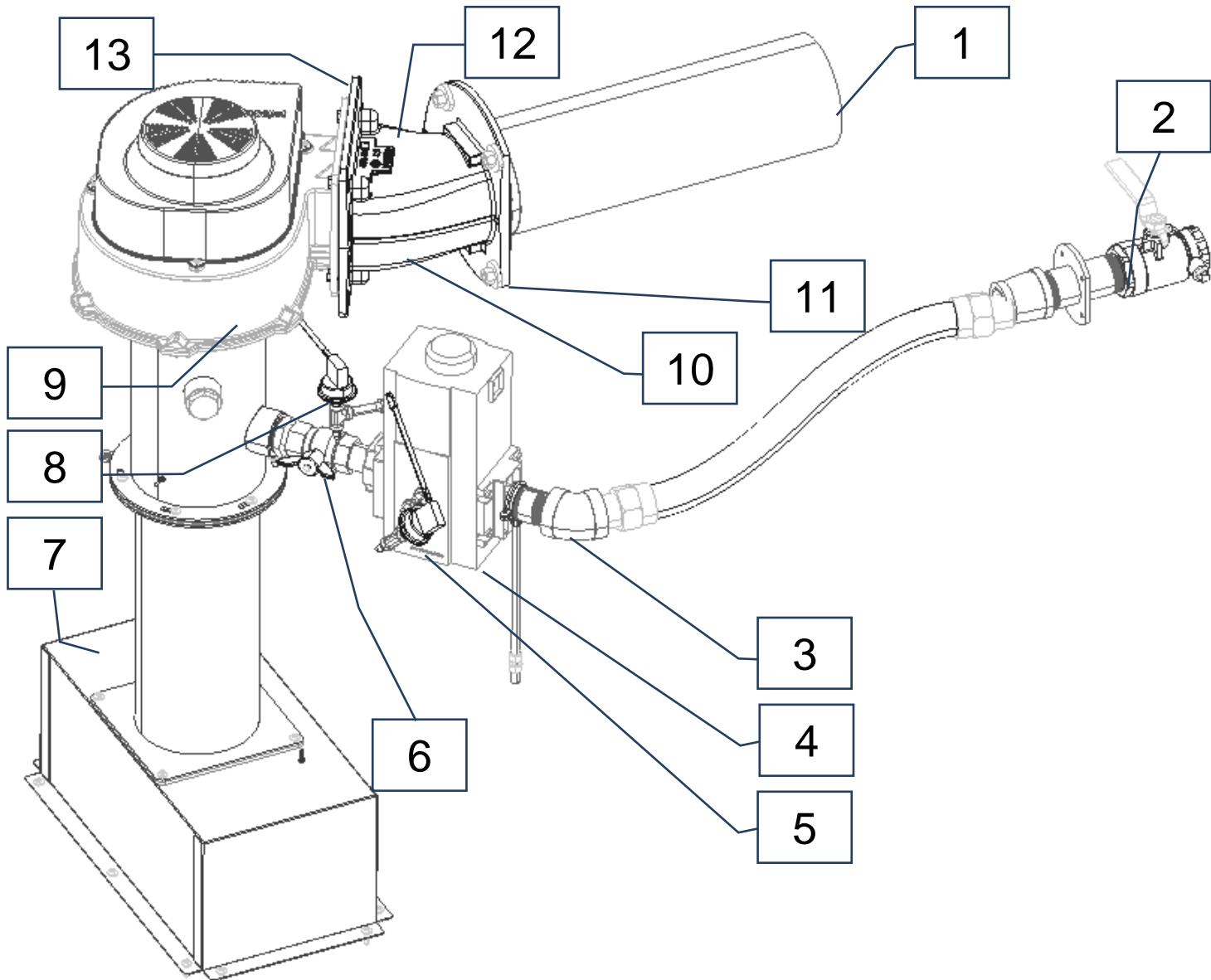
Mark	Description	Mark	Description
1	Ignition Cable	7	5 Amp Fuse & Circuit Breaker
2	High Voltage (TB2) Terminal Block	8	On/Off Switch
3	SOLA Mainboard	9	Low Voltage (TB1) Terminal Block
4	Transformer XFMR2 (40VA)	10	NURO Touchscreen Assembly
5	Transformer XFMR1 (20VA)	11	High Exhaust Back Pressure Switch
6	Push to Test LWCO Button	12	Air Pressure Switch

### 7.3.3 Heat Exchanger Assembly (C-1500H & C-2000H)



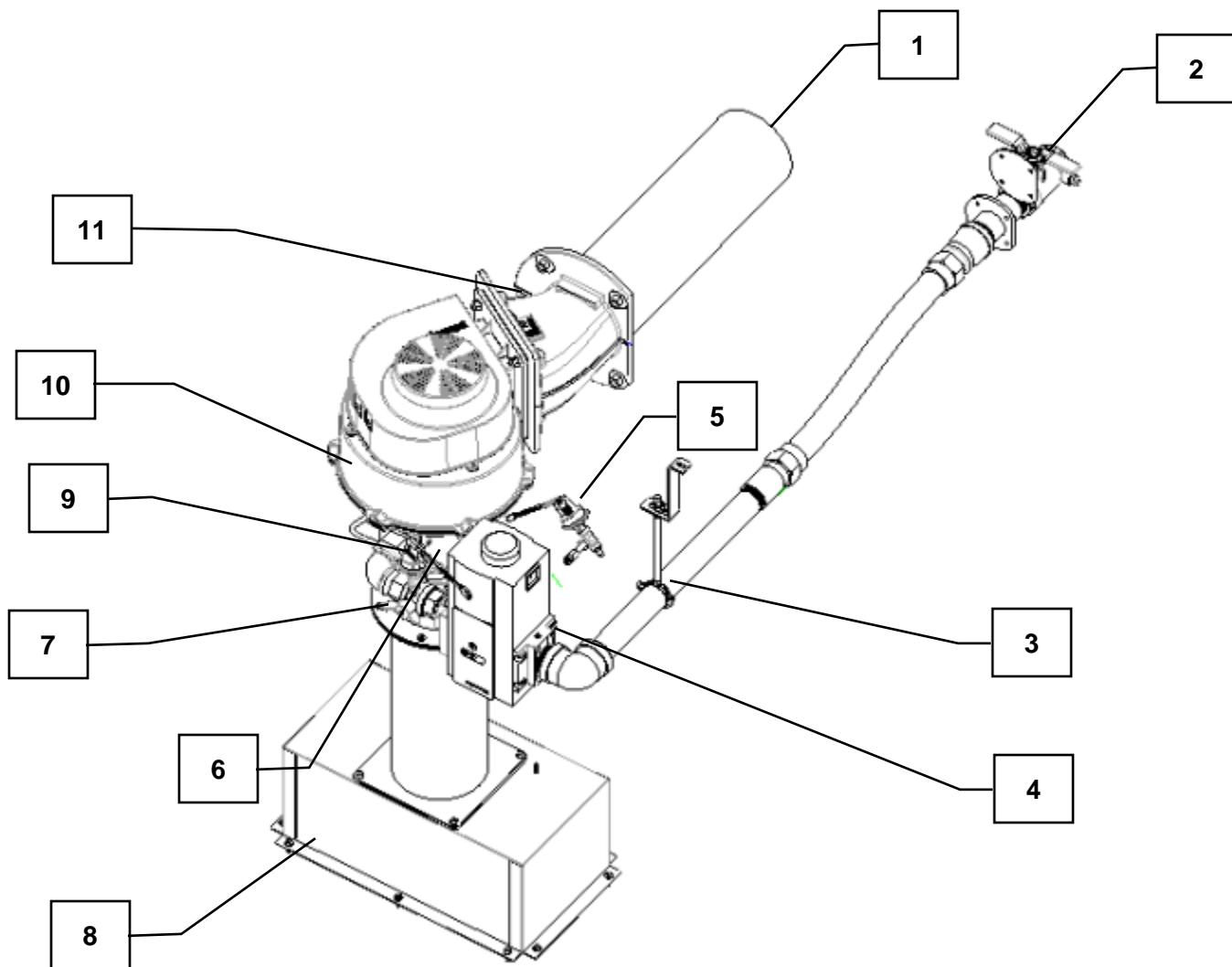
Mark	Description	Mark	Description
1	Outlet Coupling (2-1/2" Victaulic)	9	10" Flue Adapter
2	Relief Valve Port	10	Condensate Trap
3	Supply Manifold/Header	11	Condensate Pan Access Cover
4	Aluminum Castings	12	Condensate Pan
5	Fireside Inspection Covers	13	Return Temperature Sensor
6	Return Manifold/Header	14	Burner Studs
7	Inlet Coupling (2-1/2" Victaulic)	15	Ignition Electrode
8	Manual Drain Valve	16	Supply Temperature Sensor

#### 7.3.4 Natural Gas Train, Burner & Blower Assembly (C-1500H & C-2000H)



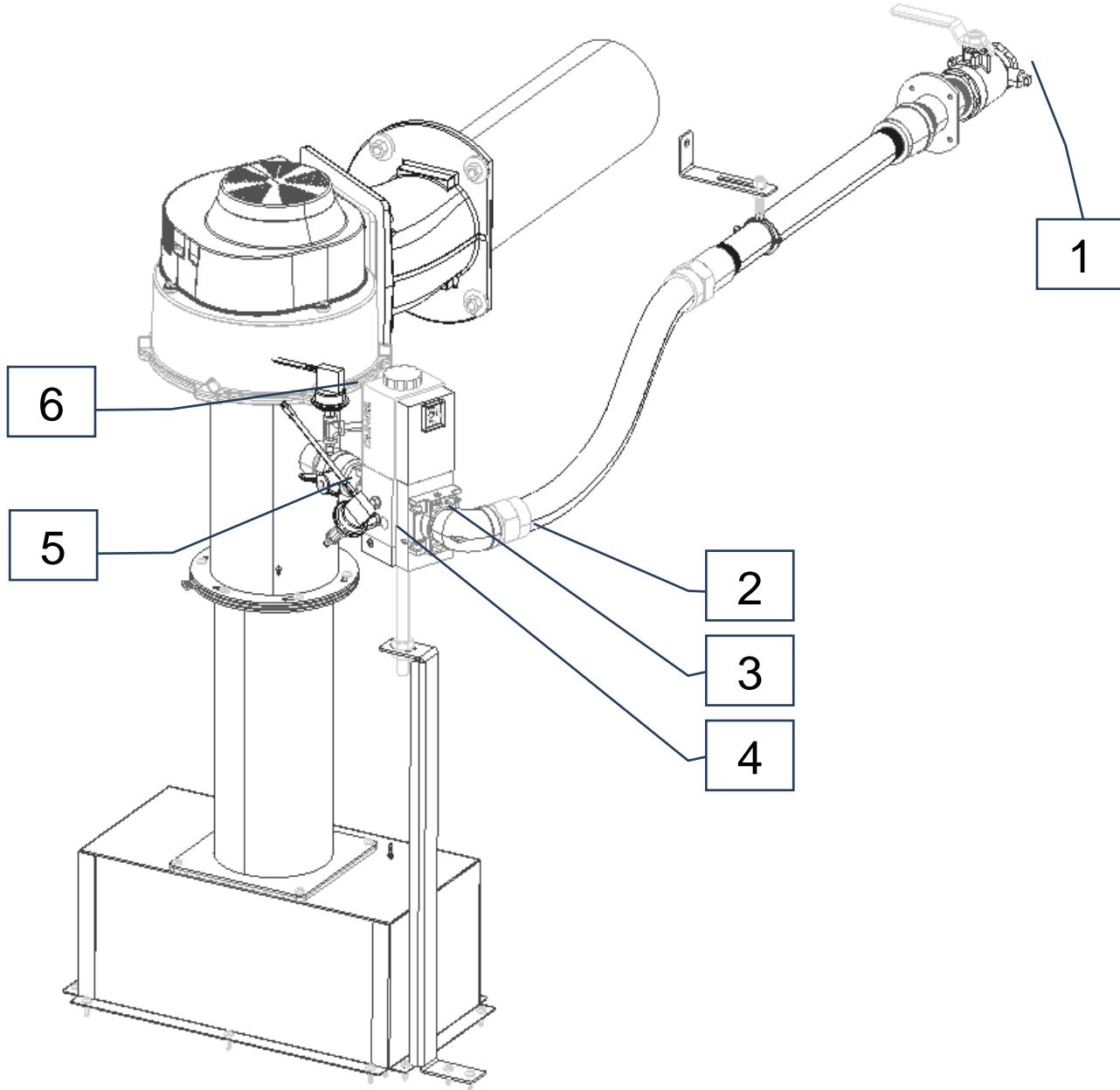
Mark	Description	Mark	Description
1	Stainless Steel Mesh Burner	8	High Gas Pressure Switch
2	External (Upstream) Gas Cock	9	Combustion Blower / Fan
3	Gas Piping & Supports	10	Burner Transition Piece
4	Main Gas Shutoff/Control Valve	11	Burner Gasket
5	Low Gas Pressure Switch	12	Ignition Electrode & Gasket
6	Internal (Downstream) Gas Cock	13	Blower Gasket
7	Air Intake Box & Transition Piece		

### 7.3.5 Natural Gas Train, Burner & Blower Assembly High Turndown (C1500T & C2000T)



Mark	Description		Mark	Description
1	Stainless Steel Mesh Burner		7	Internal (Downstream) Gas Cock
2	External (Upstream) Gas Cock		8	Air Intake Box & Transition Piece
3	Gas Piping & Supports		9	High Gas Pressure Switch
4	Main Gas Shutoff/Control Valve		10	Combustion Blower / Fan
5	Low Gas Pressure Switch		11	Burner Transition Piece
6	Air/Gas Venturi			

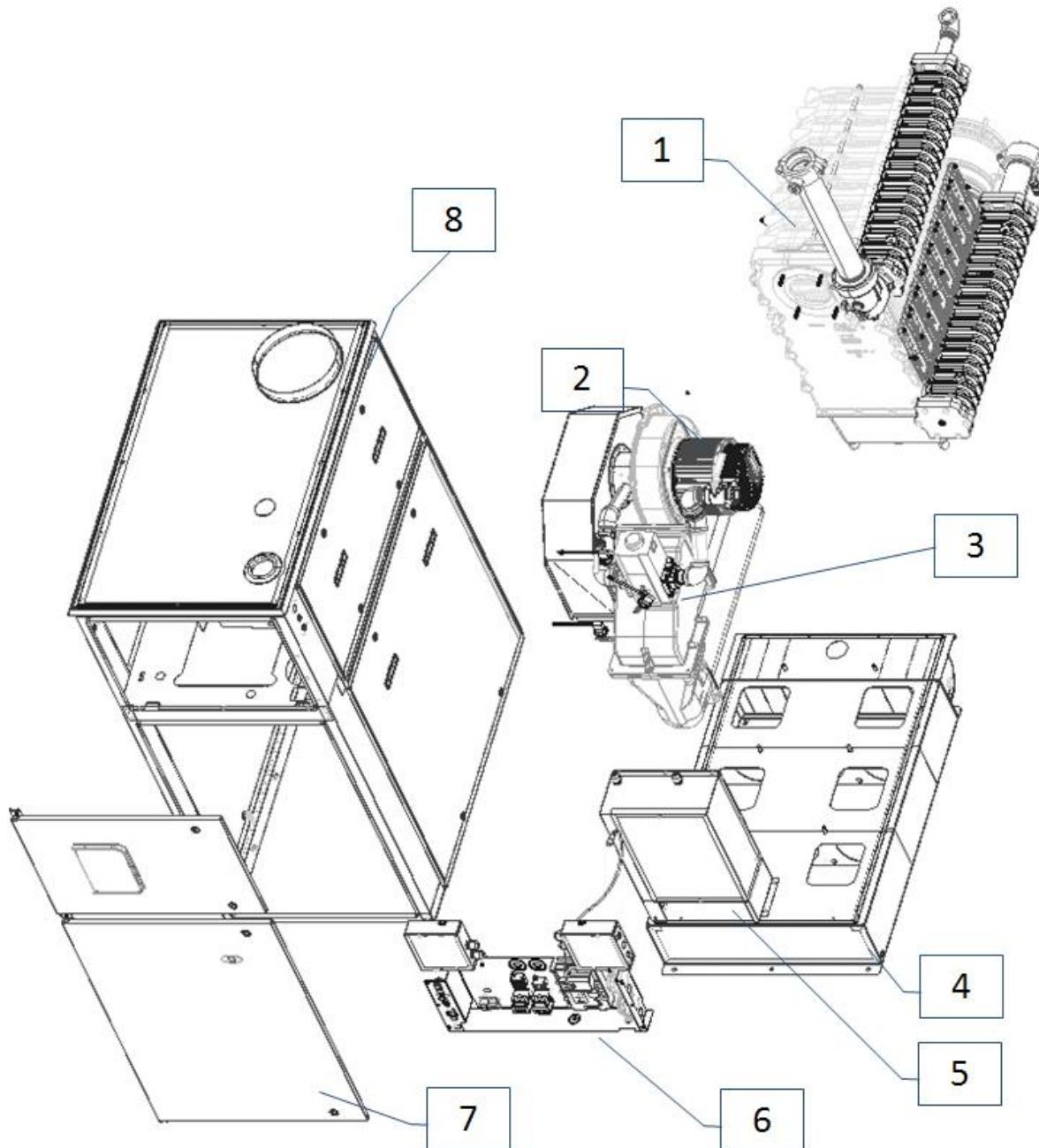
### 7.3.6 Propane Gas Train, Burner & Blower Assembly (C-1500H & C-2000H)



Mark	Description
1	External (Upstream) Gas Cock
2	Gas Piping & Supports
3	Main Gas Shutoff/Control Valve
4	Low Gas Pressure Switch
5	Internal (Downstream) Gas Cock
6	High Gas Pressure Switch

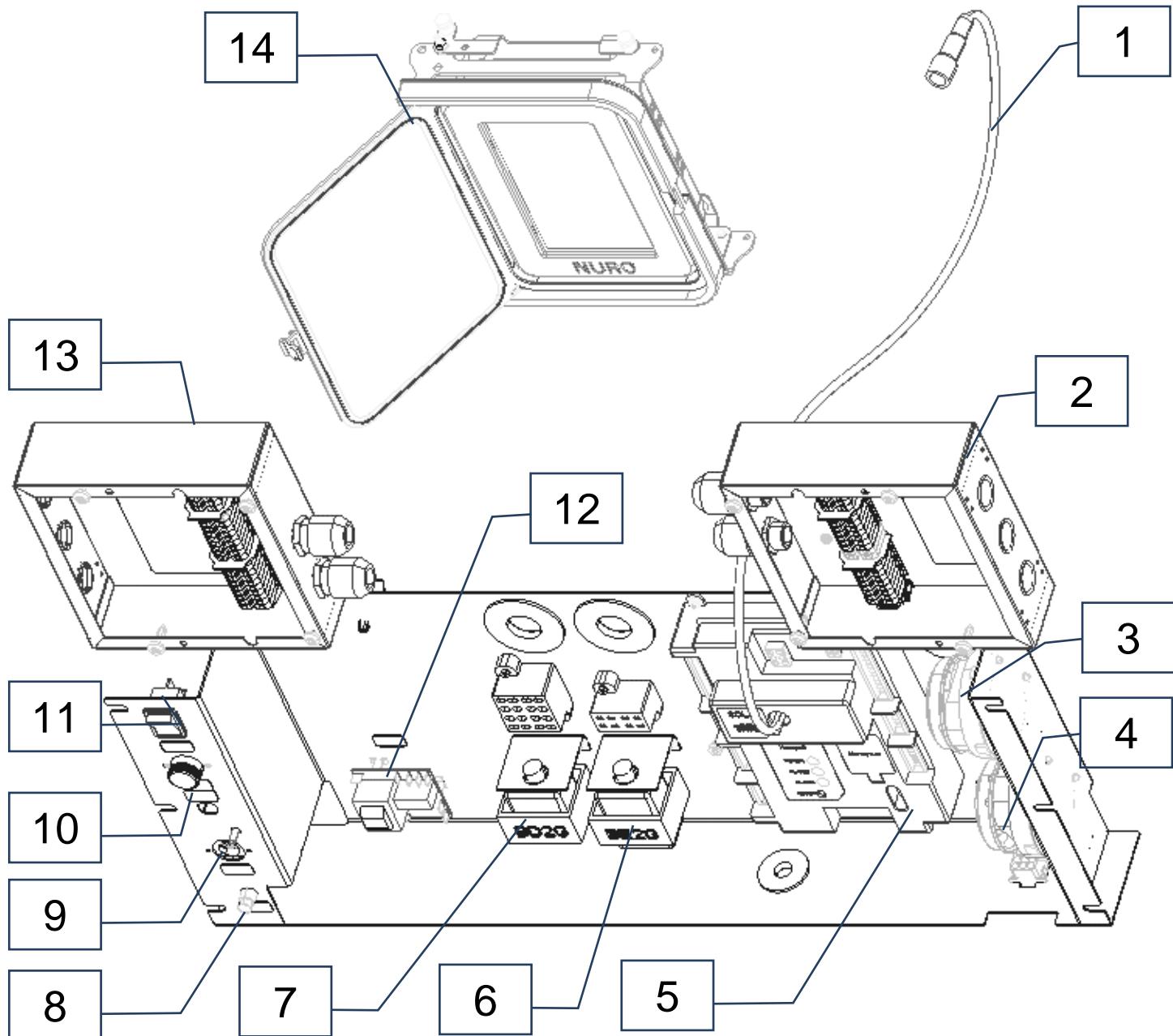
## 7.4 Boiler Parts Identification C-2500, C-3000 & C-4000)

### 7.4.1 Main Boiler Assembly (C-2500, C-3000 & C-4000)



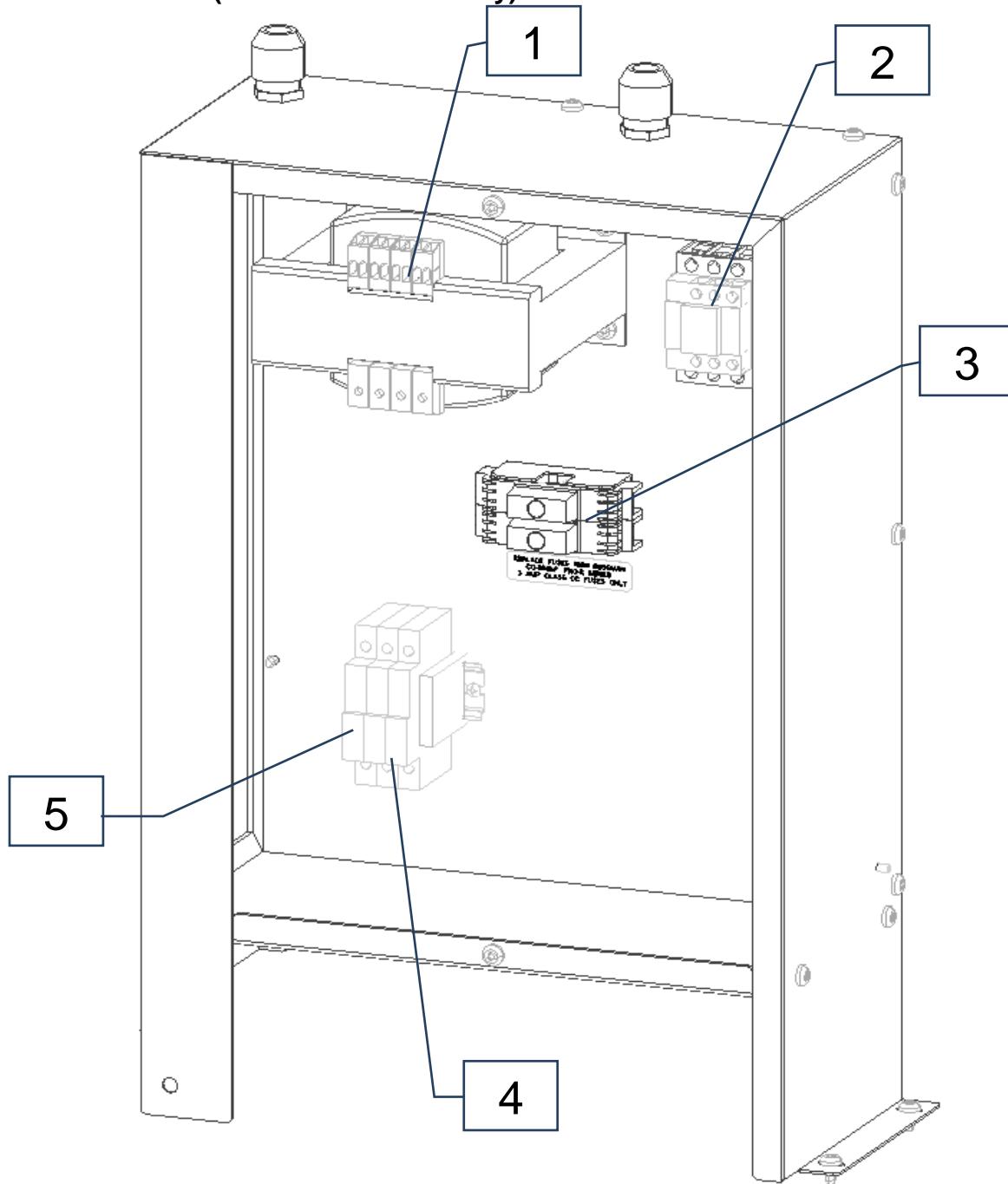
Mark	Description	Mark	Description
1	Heat Engine Assembly	5	Main Power Box (C-3000 & C-4000 Only)
2	Burner/Blower Assembly	6	NURO Control Panel
3	Natural Gas Train	7	Front Door / NURO Touchscreen
4	Cabinet Base	8	Sheet Metal Cabinet

#### 7.4.2 NURO Control Panel (C-2500, C-3000 & C-4000)



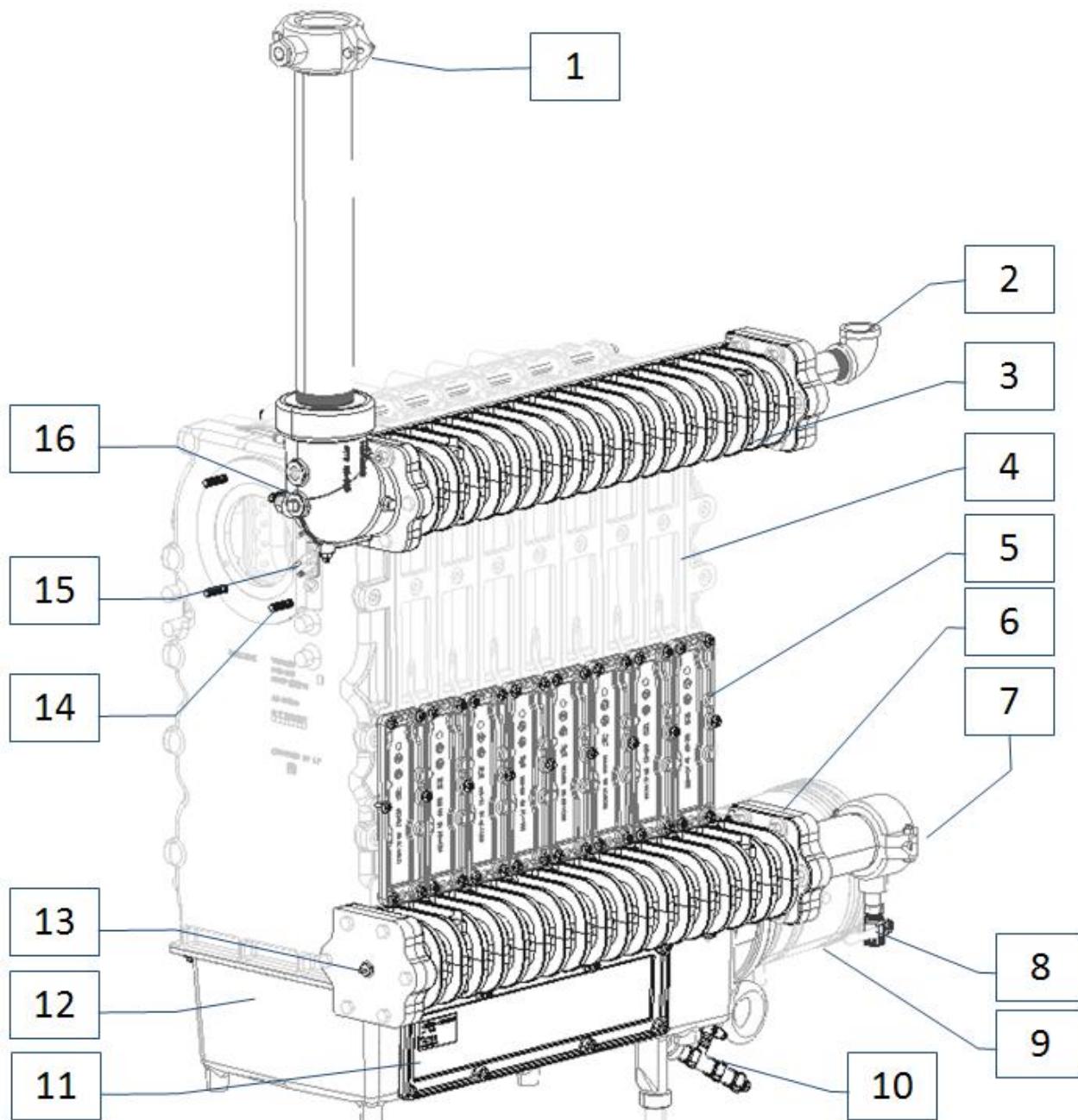
Mark	Description	Mark	Description
1	Ignition Cable	8	Push to Test LWCO Button
2	High Voltage (TB2) Terminal Block	9	Manual Reset Hi Temp Limit
3	Air Pressure Switch	10	Fuse / Circuit Breaker
4	High Exhaust Back Pressure Switch	11	On/Off Switch
5	SOLA Mainboard	12	LWCO Circuit Board
6	Transformer XFMR2 (40VA)	13	Low Voltage (TB1) Terminal Block
7	Transformer XFMR1 (20VA)	14	NURO Touchscreen Assembly

### 7.4.3 Main Power Box (C-3000 & C-4000 Only)



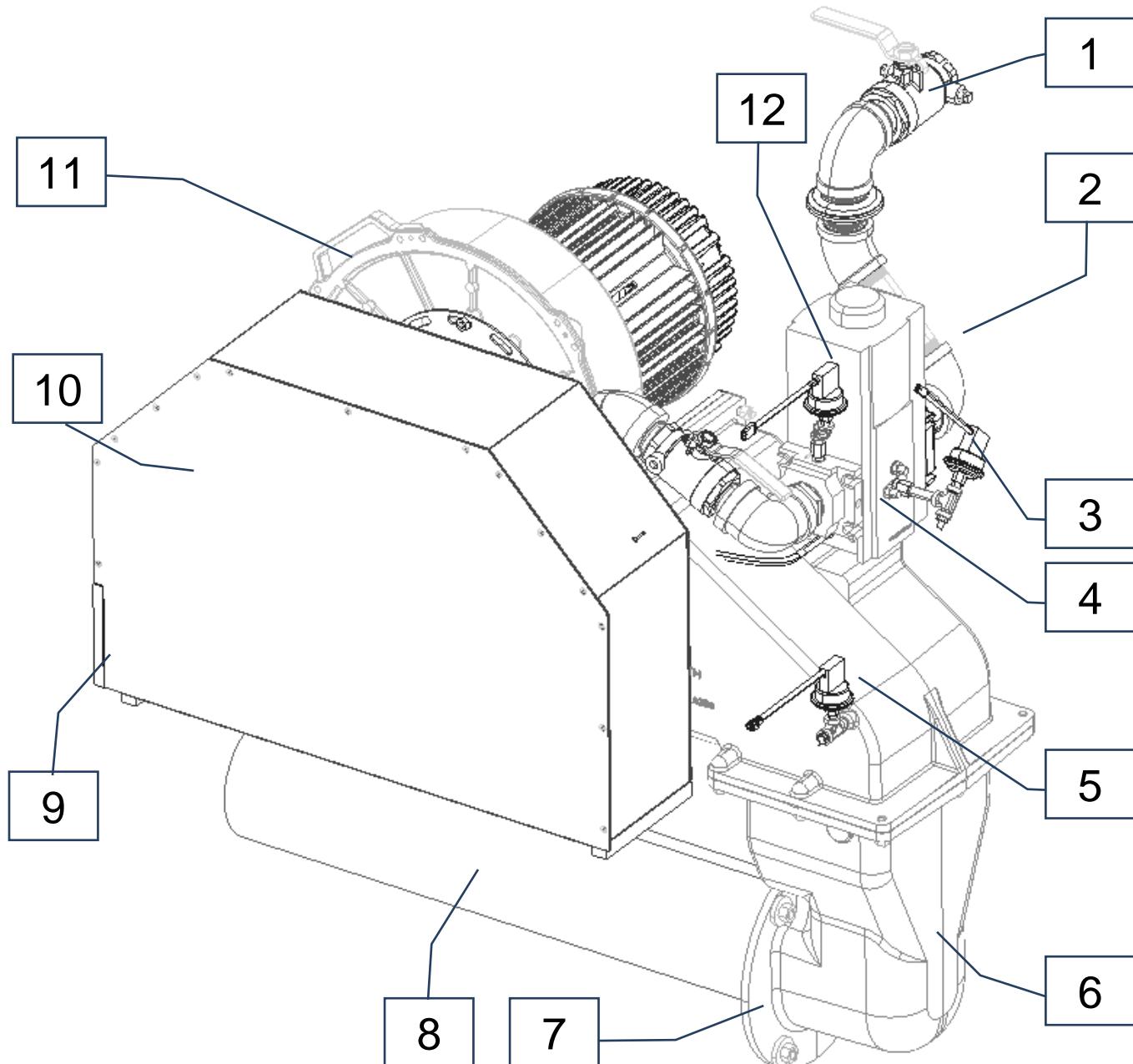
Mark	Description	Mark	Description
1	Control Transformer	4	Grounding Terminal
2	Blower Motor Relay	5	20A Three Phase Breaker (Incoming Three Phase Power)
3	Fuse Holder		

#### 7.4.4 Heat Exchanger Assembly (C-2500, C-3000 & C-4000)



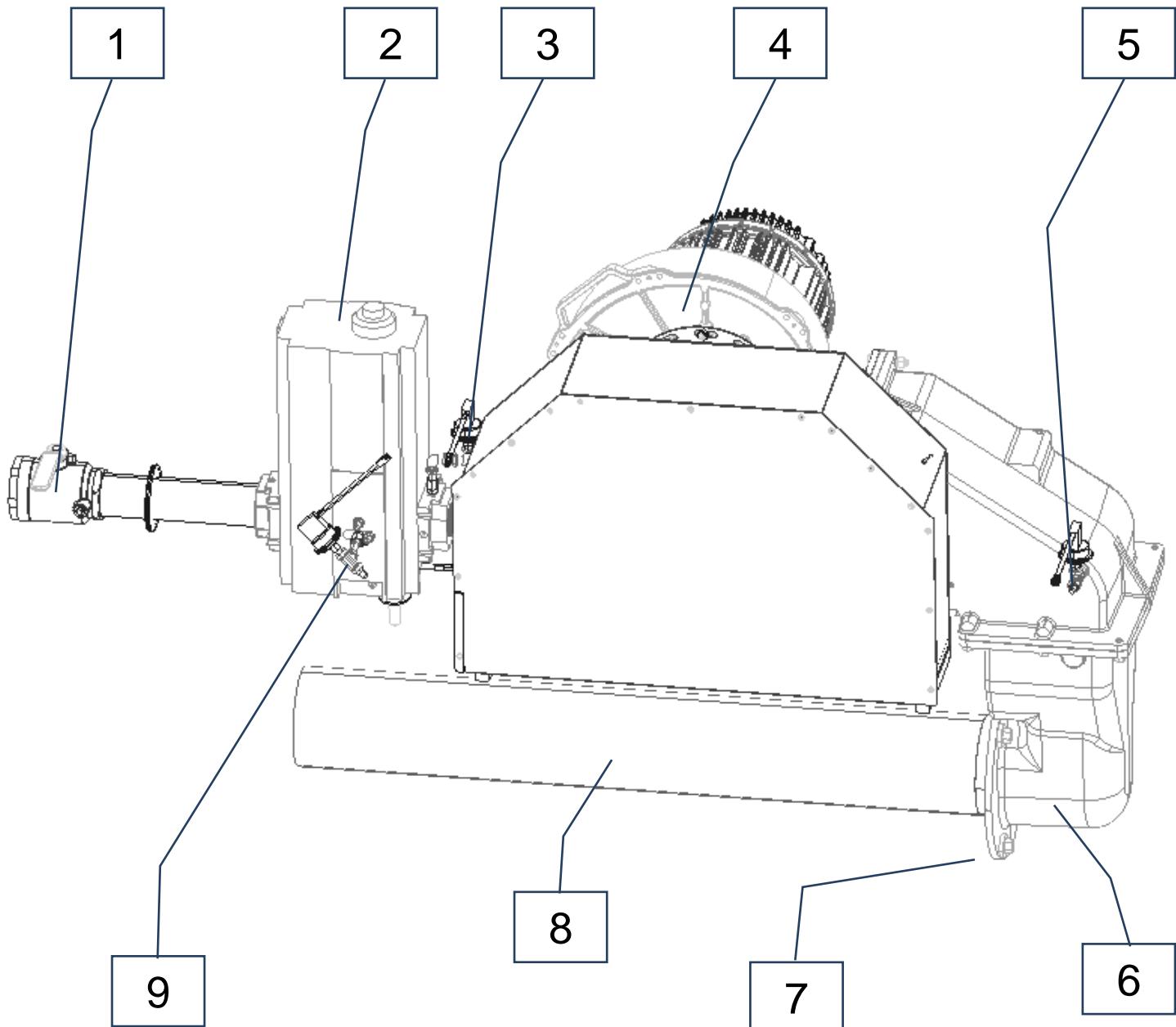
Mark	Description		Mark	Description
1	Outlet Coupling (3 1/4" Victaulic)		9	10" Flue Adapter
2	Relief Valve Port		10	Condensate Trap
3	Supply Manifold/Header		11	Condensate Pan Access Cover
4	Aluminum Castings		12	Condensate Pan
5	Fireside Inspection Covers		13	Return Temperature Sensor
6	Return Manifold/Header		14	Burner Studs
7	Inlet Coupling (3 1/4" Victaulic)		15	Ignition Electrode
8	Manual Drain Valve		16	Supply Temperature Sensor

#### 7.4.5 Natural Gas / Propane Gas Train, Burner & Blower Assembly (C-2500 & C-3000)



Mark	Description	Mark	Description
1	External (Upstream) Gas Cock	7	Burner Gasket
2	Gas Piping & Supports	8	Stainless Steel Mesh Burner
3	Low Gas Pressure Switch	9	Air Intake Box
4	Main Gas Shutoff/Control Valve	10	Air Intake Box Cover Plate
5	Auxiliary High Exhaust Back Pressure ("Dirty Burner") Switch	11	Combustion Blower / Fan
6	Burner Hood Casting	12	High Gas Pressure Switch

#### 7.4.6 Natural Gas / Propane Gas Train, Burner & Blower Assembly (C-4000)



Mark	Description	Mark	Description
1	External (Upstream) Gas Cock	6	Burner Hood Casting
2	Main Gas Shutoff/Control Valve	7	Burner Gasket
3	High Gas Pressure Switch	8	Stainless Steel Mesh Burner
4	Combustion Blower / Fan	9	Low Gas Pressure Switch
5	Auxiliary High Exhaust Back Pressure ("Dirty Burner") Switch		

## **P-K MACH® SPECIFIC LIMITED WARRANTY**

**Last Update 12/12/2016**

Subject to the terms and conditions herein and the Terms and Conditions of Sale (as defined herein), Harsco Industrial Patterson-Kelley ("Seller") warrants to the purchaser of the product ("Buyer") that the heat exchanger and burner are free of defects in material and workmanship, when operated in accordance with the conditions stated herein, for a period of ten (10) years for the heat exchanger, five (5) years for the burner and a ten (10) year warranty against failure due to thermal shock commencing on the date of shipment or, if a start-up report is furnished to Seller, on the start-up date shown on the report furnished to Seller (the "Warranty Period"), provided that startup is completed within six (6) months of shipment and the start-up report is furnished to Seller within thirty (30) days of startup (this "Specific Limited Warranty"). The Exclusions and limitations of liability set forth in the Terms and Conditions of Sale (as defined herein) apply to this Specific Limited Warranty. Capitalized terms used but not defined herein have the meanings ascribed to them under Seller's terms and conditions of sale for the product, which can be found at <http://harscopk.com/warranty.php> (the "Terms and Conditions of Sale"). This Specific Limited Warranty is transferrable to the owner that utilizes the product(s) purchased hereunder for its intended use at the original installation site (the "Original Owner"). This Specific Limited Warranty is non-transferable to anyone who subsequently receives or purchases products from the Original Owner. If the Original Owner did not purchase the product directly from Seller, the Original Owner should contact the reseller from whom it purchased the product for a copy of the Terms and Conditions of Sale attached to the Order Acknowledgement received by the original purchaser of the product from Seller.

### **I. REMEDY**

Seller's obligations under this Specific Limited Warranty is limited to repairing or, if in Seller's judgment it seems more appropriate, to furnishing without charge (installation not included), FCA Seller's factory (Incoterms 2010), a similar part to replace any part which after examination shall, to Seller's own satisfaction be determined to have been defective at the time it was shipped. In the event that a replacement is provided by Seller, the defective item will become the property of Seller. Transportation to Seller's facility or other designated facility for repairs of any products or party alleged defective shall, in all events, be at Buyer's sole risk and cost. This warranty applies only if the original installer and Seller (Attention: Harsco Industrial, Patterson-Kelley, 155 Burson Street, East Stroudsburg, PA 18301) receive, within the Warranty Period, an immediate written notice, providing a detailed description of all claimed defects, upon discovery of such defects together with proof of purchase (invoice or Order Acknowledgment) and a copy of the start-up report for the affected product. Seller may seek reimbursement of any costs incurred by Seller where the product is found to be in good working order, or when it has been determined that this Specific Limited Warranty does not apply as per the exclusions set forth below. The remedies available to Buyer set forth herein are exclusive remedies, and all other remedies, statutory or otherwise, including but not limited to the right of redhibition, are waived by Buyer. Buyer acknowledges that the exclusion of remedies is neither unreasonable nor unconscionable. Buyer shall indemnify and hold Seller harmless against, any claim due to any injury or death to any person or damage to any property resulting in whole or in part from any modification or alteration Buyer makes to any product sold hereunder.

### **II. EXCLUSIONS**

To the full extent permitted by law, Seller shall have no liability for and the Warranties do not cover:

- (A) any product which has been altered or repaired by other than Seller's personnel;
- (B) deterioration or failure of any product due to
  - (i) abrasion, corrosion, erosion or fouling,
  - (ii) misuse,
  - (iii) modification not authorized by Seller in writing or
  - (iv) improper installation, lack of or improper maintenance or operation;
- (C) equipment not furnished by Seller by the owner, either mounted or unmounted, or when contracted for by a party or parties other than Seller to be installed or handled;
- (D) the suitability of any product for any particular application;
- (E) 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;
- (F) any damage to the product due to abrasion, erosion, corrosion, deterioration, abnormal temperatures or the influence of foreign matter or energy;
- (G) the performance of any product under conditions varying materially from those under which such product is usually tested under industry standards at the time of shipment;
- (H) 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 or
    - (b) contrary to the written instructions furnished with the product,
  - (ii) adverse local conditions in general and, specifically, sediment or lime precipitation in the tubes, headers and/or shells or corrosive elements in the water, heating medium or atmosphere, or

- (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 heating media, fuels or settings other than those set forth on the rating plate or accidental or exterior damage;
- (I) production of noise, odors, discoloration or rusty water;
- (J) damage to surrounding area or property caused by leakage or malfunction;
- (K) 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;
- (L) 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;
- (M) any claim due to any injury or death to any person or damage to any property resulting in whole or in part from any modification or alteration Buyer makes to any product sold hereunder; and
- (N) Design defects where Seller has complied with Buyer's design specifications.

### **III. PROOF OF PURCHASE**

Proof of purchase (invoice or Order Acknowledgement) and a copy of the start-up report for the affected product must be provided to Seller when requesting service under this Specific Limited Warranty.

### **IV. ORDER OF PRECEDENCE**

The Standard Limited Warranty set forth in the Terms and Conditions of Sale, (b) this Specific Limited Warranty and (c) any applicable Extended Limited Warranty exclusively govern and control Seller's and Buyer's respective rights and obligations regarding the warranty of the product. In case of any inconsistency, conflict, or ambiguity between the Standard Limited Warranty, this Specific Limited Warranty and any applicable Extended Limited Warranty (collectively, the "Warranty Documents"), the documents shall govern in the following order: (w) any applicable Extended Limited Warranty; (x) this Specific Limited Warranty; (y) the Standard Limited Warranty and (z) other provisions in the Terms and Conditions of Sale. Information identified in one Warranty Document and not identified in another shall not be considered a conflict or inconsistency. No sales representative, agent, or employee of Seller or any reseller in the chain of sale of the product is authorized to make any modification, extension, or addition to this Specific Limited Warranty, unless agreed to in writing by Seller.

## 8 Boiler Fire-Test Report

Job Name: _____		Address: _____		City: _____		State: _____		Zip: _____																																																																																											
Model: _____		Serial Number: _____		Start-up Date: _____																																																																																															
<table border="1"> <tr> <td colspan="5"><b>COMBUSTION*</b></td> <td colspan="5"></td> </tr> <tr> <td colspan="5"> <input type="checkbox"/> Valve 1 Low  <input type="checkbox"/> Fire: _____  <input type="checkbox"/> O<sub>2</sub> %: _____  <input type="checkbox"/> CO ppm: _____  <input type="checkbox"/> CO<sub>2</sub> %: _____         </td> <td colspan="5"></td> </tr> <tr> <td colspan="10" style="text-align: center;">CLEARANCES Measure and record (inches) the service clearances from the nearest obstruction (min. 24" required for service):</td> </tr> <tr> <td colspan="2" style="text-align: center;">Front:</td> <td colspan="2" style="text-align: center;">Left Side:</td> <td colspan="2" style="text-align: center;">Top:</td> <td colspan="2" style="text-align: center;">Right Side:</td> <td colspan="2" style="text-align: center;">Rear:</td> </tr> <tr> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> <td colspan="2"></td> </tr> </table>										<b>COMBUSTION*</b>										<input type="checkbox"/> Valve 1 Low <input type="checkbox"/> Fire: _____ <input type="checkbox"/> O <sub>2</sub> %: _____ <input type="checkbox"/> CO ppm: _____ <input type="checkbox"/> CO <sub>2</sub> %: _____										CLEARANCES Measure and record (inches) the service clearances from the nearest obstruction (min. 24" required for service):										Front:		Left Side:		Top:		Right Side:		Rear:																																																			
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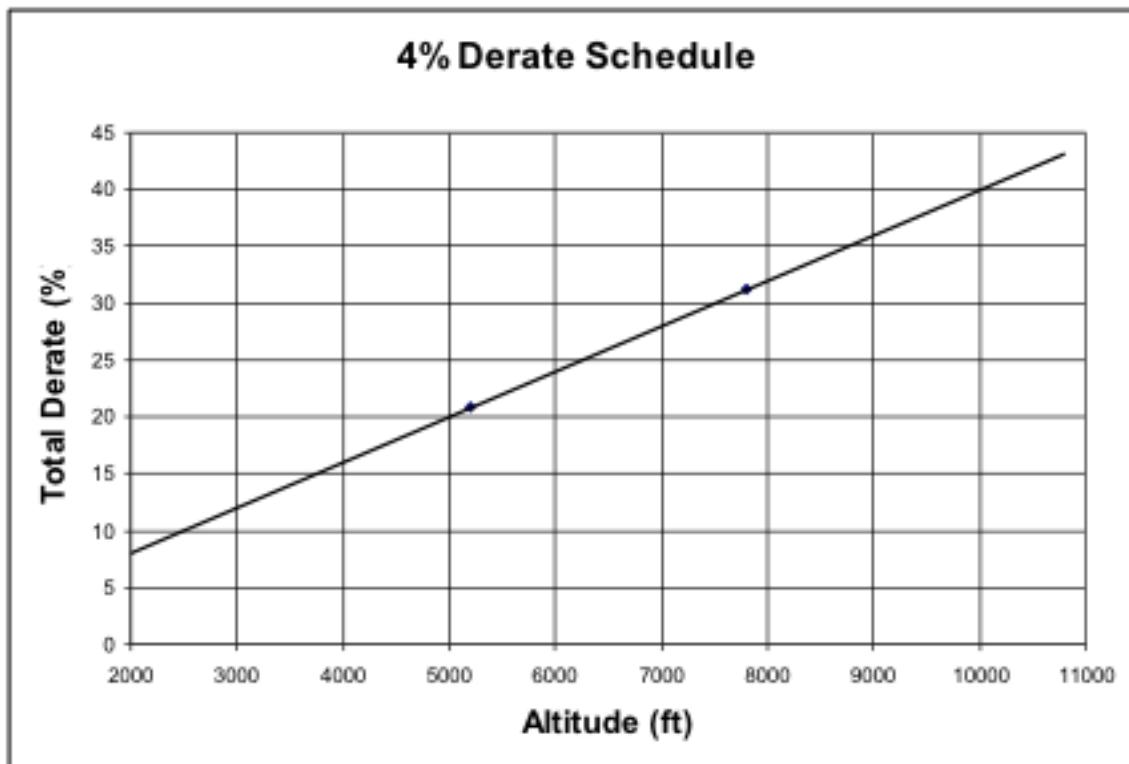
## Dual Fuel Addendum

Job Name: 0	Address: 0	City: 0	State: 0	Zip: 0																																								
<table border="1"> <tr> <td colspan="2">GAS SUPPLY</td> <td colspan="3">COMBUSTION</td> </tr> <tr> <td colspan="2">Gas Pipe Dia. (in.):</td> <td colspan="3">Valve 1 Low Fire: Valve 1 High Fire:</td> </tr> <tr> <td colspan="2">Equivalent Feet:</td> <td>O<sub>2</sub> % _____</td> <td>CO ppm _____</td> <td>CO<sub>2</sub> % _____</td> </tr> <tr> <td colspan="2">Is there an inlet gas lockup regulator on the supply?</td> <td><input type="checkbox"/> Yes</td> <td><input type="checkbox"/> No</td> <td></td> </tr> <tr> <td colspan="2">If Yes, is it 10 ft. upstream from the appliance?</td> <td><input type="checkbox"/> Yes</td> <td><input type="checkbox"/> No</td> <td></td> </tr> <tr> <td colspan="5">Record in. of water column* -</td> </tr> <tr> <td colspan="5">Static Pressure: Pressure Drop @ ignition: _____</td> </tr> <tr> <td colspan="5">Hi-Fire Gas Pressure: Low-Fire Gas Pressure: _____</td> </tr> </table>					GAS SUPPLY		COMBUSTION			Gas Pipe Dia. (in.):		Valve 1 Low Fire: Valve 1 High Fire:			Equivalent Feet:		O <sub>2</sub> % _____	CO ppm _____	CO <sub>2</sub> % _____	Is there an inlet gas lockup regulator on the supply?		<input type="checkbox"/> Yes	<input type="checkbox"/> No		If Yes, is it 10 ft. upstream from the appliance?		<input type="checkbox"/> Yes	<input type="checkbox"/> No		Record in. of water column* -					Static Pressure: Pressure Drop @ ignition: _____					Hi-Fire Gas Pressure: Low-Fire Gas Pressure: _____				
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## **Appendix A – Maintenance Log**

## Appendix B – Boiler Altitude Derate Schedule

For installations over 2,000 ft. elevation, a derate schedule is applied. The appliance's input rating must be reduced by 4% per 1,000 ft. which is illustrated in the graph below:



Although the appliance's capacity is reduced due to the lower air density, the combustion tuning should follow the standard combustion guidelines of Section [3.11.2](#). Tune the combustion for the same O<sub>2</sub> and CO<sub>2</sub> levels as discussed in Section [3.11.2](#).

## Appendix C – Water Quality Standards Quality Standards for Hydronic Boilers in Multi-Metal Systems

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:

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.

### WATER QUALITY STANDARDS FOR PEAK EFFICIENCY

pH	6.5 to 8.5 (6.5-9*)
Alkalinity	<300 ppm
Copper	<3 ppm
Iron	<20 ppm
Aluminum	<3 ppm
TSS	<20 ppm
Chlorides	<100 ppm
Hardness	<200 ppm
Conductivity	<3000 uS/cm
Filtration Rate	10 microns

\* Stainless  
Do not use softened water



## Appendix D – Best Practices For New & Retrofit Systems

### BEST PRACTICES FOR ALL BOILER INSTALLATIONS

1. Patterson-Kelley recommends and most installation codes require isolation valves on both the boiler's inlet (return) and outlet (supply) pipe runs. These are used to hydraulically isolate the boiler from the hydronic system, which should be standard practice when flushing or adding concentrated cleaning chemicals.
2. Patterson-Kelley recommends installing purge valves on the system side of the boiler's isolation valves. These valves should be used to purge the hydronic system of debris and sediment prior to the initial startup of the boiler equipment. Since the purge valves are located on the system side of the boiler's isolation valves, the debris and sediment will not be routed in direct proximity to the boiler's heat exchanger.
3. Patterson-Kelley recommends installing a standard mesh strainer (maximum 20 mesh) on the each boiler's return (inlet) piping. This is intended to prevent large particles, foreign debris, etc. from entering and obstructing flow or heat transfer through the boiler's heat exchanger. Each strainer should feature a manual blow-down valve in order to purge the debris from the strainer.  
**NOTE:** This strainer is not intended to remove fine particulate matter from the boiler system which will be discussed later in this appendix.
4. Patterson-Kelley recommends installing a water meter on the cold water fill piping. The intention of this device is to periodically monitor the amount of fresh water introduced into the system piping. It can also be used to establish a rough estimate of the total system volume during the initial fill. In general, the annual amount of fresh water make-up should be less than 10% of the total system volume. A water meter can also be useful to detect a leak in the hydronic system if you notice an unexpected increase in the volume of fill water.
5. Oxygen (O<sub>2</sub>) elimination is critical to the longevity of any hydronic system. Patterson-Kelley recommends installing an Air Separator (micro-bubbler style) that is capable of eliminating the dissolved Oxygen levels introduced from the cold water fill. In general, air separators are most effective when the boiler water is at highest temperature and lowest pressure.
6. Patterson-Kelley recommends installing an Automatic Air Vent on the Air Separator. In order for the Air Separator to continually purge the system of dissolved Oxygen, an Automatic Air Vent is preferred over a manual air vent.
7. The maximum flow rate requirements vary between Patterson-Kelley boiler models. Please refer to [Appendix E – Installation and Quick Reference](#) a complete listing of the maximum flow rates per boiler model. Exceeding the maximum flow rate of a boiler can cause erosion of the boiler's heat exchanger or piping materials and can damage the paddle type flow switch.
8. The minimum flow rate requirements vary between Patterson-Kelley boiler models. Please refer to [Appendix E – Installation and Quick Reference](#) for a complete listing of the minimum flow rates per boiler model. Flowing below the minimum flow rates can lead to overheating of the boiler's heat exchanger materials and the formation of steam bubbles within the water passages.
9. Well in advance of the equipment startup, turn off all circulation pumps and close the isolation valves on each boiler's inlet (return) and outlet (supply) pipe runs. Connect a hose to the purge

valves and run this hose to a nearby floor drain. Open each purge valve to flush out debris that is present in the water. This process may take several attempts until the discharge water is sufficiently clean. After successfully purging the system, make sure to open the boiler's isolation valves and turn on the circulation pumps.

10. Upon startup, Patterson-Kelley recommends collecting two water samples: one from the hydronic system and another from the cold water fill. It is best practice to circulate the hydronic system for at least one hour prior to collecting this initial water in order to acquire a representative (blended) sample.
11. Within the first three months after startup, Patterson-Kelley recommends collecting a follow-up water sample from the hydronic system. This should be compared to the initial startup sample in order to determine any changes in pH, Alkalinity, conductivity, etc. that may adversely affect the system performance.
12. Although the ongoing water treatment regimen will vary based on the supplier and application, Patterson-Kelley recommends a minimum annual water sample rate. The results of the annual water tests should be compared to past tests in order to determine any changes in pH, Alkalinity, conductivity, etc. that may adversely affect the system performance. Refer to [\*\*Appendix C – Water Quality Standards Quality Standards for Hydronic Boilers in Multi-Metal Systems\*\*](#) for the water quality standard.

### **BEST PRACTICES FOR RETROFIT BOILER INSTALLATIONS**

1. The primary concern in retrofit installations into existing boiler systems is the presence of suspended and dissolved solids. These are typically a result of deteriorating piping, fittings, or legacy boiler's heat exchangers. Patterson-Kelley recommends installing a side-stream filter (maximum 10 micron) to remove this existing particulate, sediment, etc. There are many different types of side-stream filters available, Patterson-Kelley recommends consulting your local water treatment provider in order to determine the best method for your particular application.
2. If the existing hydronic system contains a significant amount of suspended and dissolved Iron, Patterson-Kelley recommends the use of a side-stream filter with built-in magnet. This magnet helps attract and eliminate the Iron particulate.
3. Some water treatment additives/chemicals may cause leaching from the existing system piping. As more contaminants leech from the walls of the piping into the system water, the pH and the level of Total Dissolved Solids (TDS) may gradually climb to levels that will adversely affect the system performance. A side-stream filter will accommodate the increased TDS, but you may need to consult your local water treatment provider in order to combat the increased pH.

### **BEST PRACTICES FOR NEW BOILER INSTALLATIONS**

1. The construction of the hydronic system piping involves many different operations that can introduce contaminants (weld slag, solder, flux, pipe dope, cutting oils, metal shavings, etc.) It is critical to properly flush the system well in advance of startup of the boiler equipment.
2. In order to locate loose pipe connections, leaks, etc. after the initial construction of the hydronic system piping, the Mechanical Contractor may fill and drain the system several times. During these initial fill-ups and drains, Patterson-Kelley recommends closing the boiler's isolation valves in order to separate them from the hydronic system. This will help limit the amount of dissolved Oxygen and particulates that are brought in direct contact with the boiler's heat exchanger.

## Appendix E – Installation and Quick Reference

### Fuel/Gas Supply

- Refer to Section [3.7](#) for information on proper sizing of the gas supply piping. Undersized gas piping with too much pressure drop will negatively impact the boiler's performance.
- Install a lock-up type gas regulator to supply an appropriate gas pressure as described below:

Natural Gas	Propane Gas
Minimum Inlet Pressure = 4.0" W.C.	Minimum Inlet Pressure = 7.0" W.C.
Maximum Inlet Pressure = 14.0" W.C.	Maximum Inlet Pressure = 14.0" W.C.

#### NOTE

Harsco Industrial, Patterson-Kelley recommends installing an individual lock-up type gas regulator in the gas supply piping to each boiler. For installations where one master lock-up type gas pressure regulator will service multiple boilers, Patterson-Kelley recommends contacting the local regulator representative for application assistance specifying the appropriate lock-up type regulator and gas pipe sizing.

### Electrical/Power Supply

- Carefully inspect the boiler's nameplate labels which describe the power supply requirements.
- Provide an appropriate power feed to the boiler with overcurrent protection:

Boiler Model	Power Supply Requirements
C-1500H	110-120VAC, <u>single phase</u> , 60Hz sized for 20 Amps.
C-2000H	110-120VAC, <u>single phase</u> , 60Hz sized for 20 Amps.
C-2500	110-120VAC, <u>single phase</u> , 60Hz sized for 20 Amps.
C-3000 / C-4000 (240V)	208-240VAC, <u>three phase</u> , 60Hz sized for 20 Amps.
C-3000 / C-4000 (480V)	460-480VAC, <u>three phase</u> , 60Hz sized for 20 Amps.

#### NOTE

The C-3000 & C-4000 **MUST** be ordered to the correct voltage! **IT IS NOT POSSIBLE** to convert a C-3000 or C-4000 between the 240V and 480V configurations in the field.

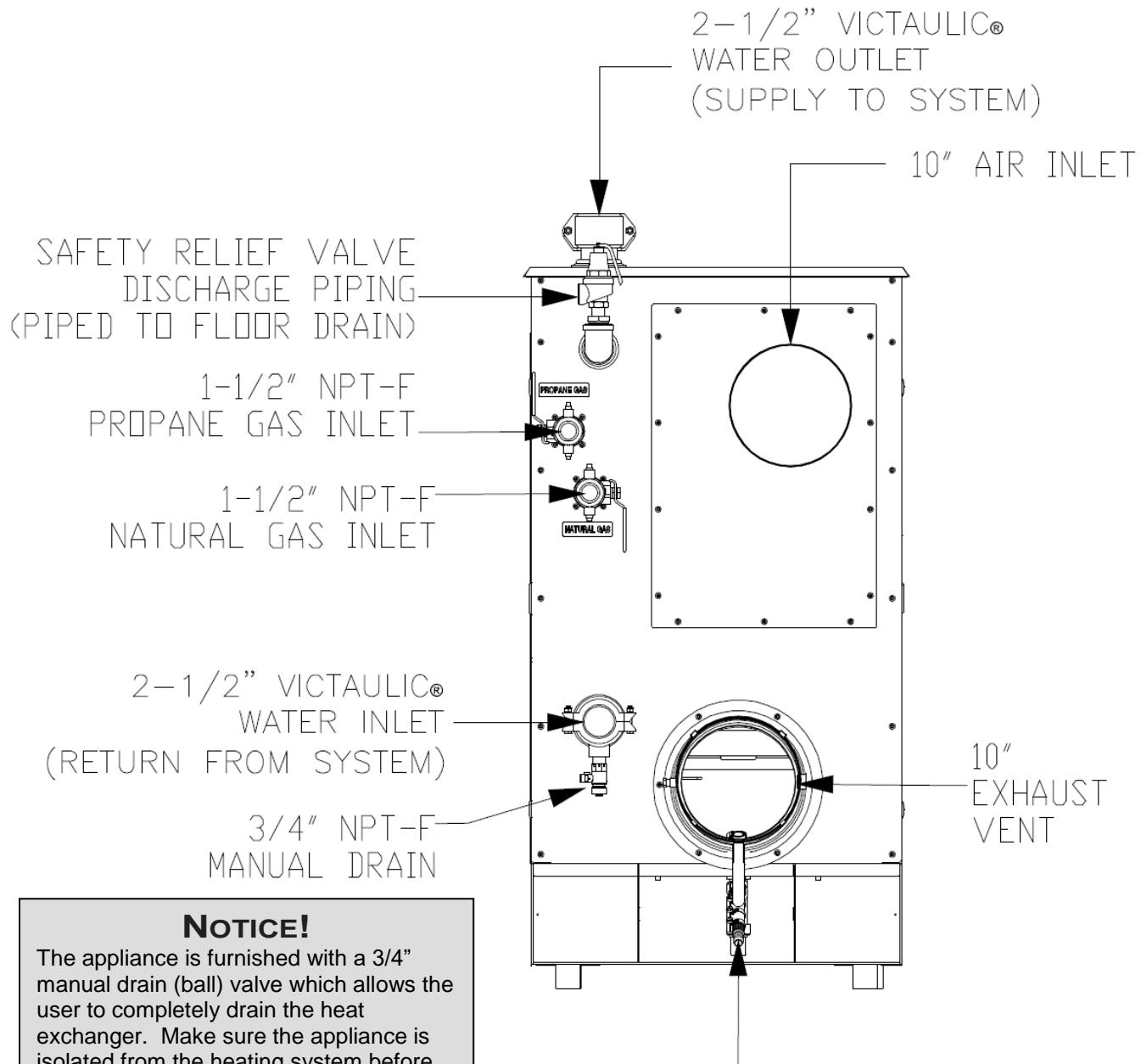
- Prior to startup, carefully check all electrical connections for tightness as connections can come lose during shipping.

### Exhaust Venting

- The P-K MACH boilers are dual-certified as Category II & Category IV appliances, capable of operating with slightly negative to slightly positive exhaust pressure. It is critical to ensure the flue venting material is suitable for use with the boiler.
- For Category II installations, ensure the flue venting system is designed to maintain a slightly negative exhaust pressure **between -0.01" W.C. and -0.04" W.C.**
- For Category IV installations, ensure the flue venting system is designed to maintain a slightly positive exhaust pressure **between +0.01" W.C. and +0.22" W.C.**

## Appliance Connections (MACH C-1500H & C-2000H)

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



### NOTICE!

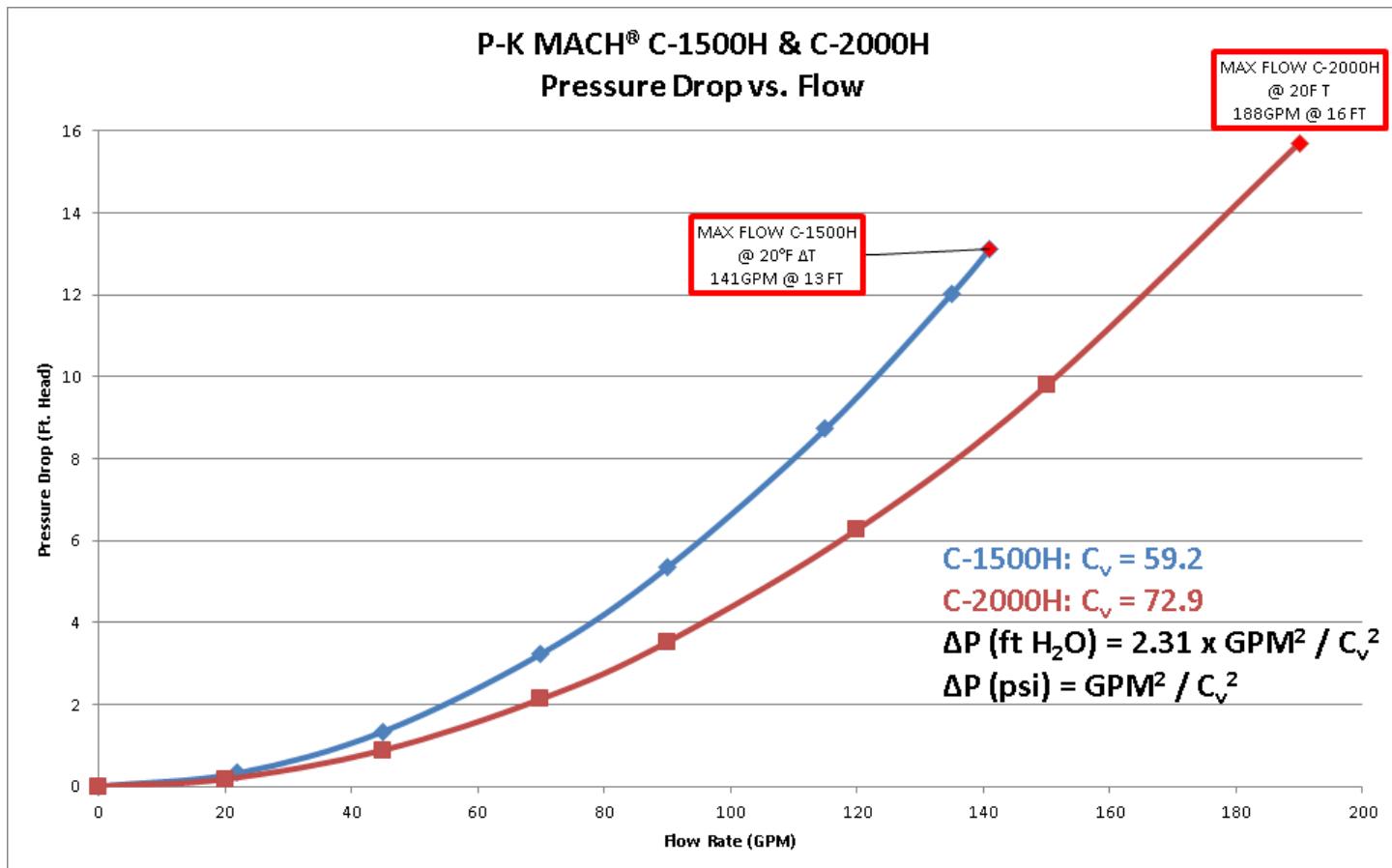
The appliance is furnished with a 3/4" manual drain (ball) valve which allows the user to completely drain the heat exchanger. Make sure the appliance is isolated from the heating system before using the manual drain valve.

### NOTICE!

The appliance is furnished with 3/4" drain tubing which is used to drain built-up condensation inside the appliance's combustion chamber. Connect this 3/4" drain tubing to the condensate neutralization system.

## Hydraulics/Water Flow (C-1500H & C-2000H)

The chart below represents the pressure drop (Ft of Head) versus the water flow rate (GPM) for the MACH C-1500H & C-2000H. This information is useful to help size an appropriate circulation pump. Keep in mind this pressure drop represents the boiler only, additional consideration is needed for any connected piping, valves, strainers, couplings, flanges, etc.



The table below summarizes the minimum and maximum flow restrictions for the C-1500H:

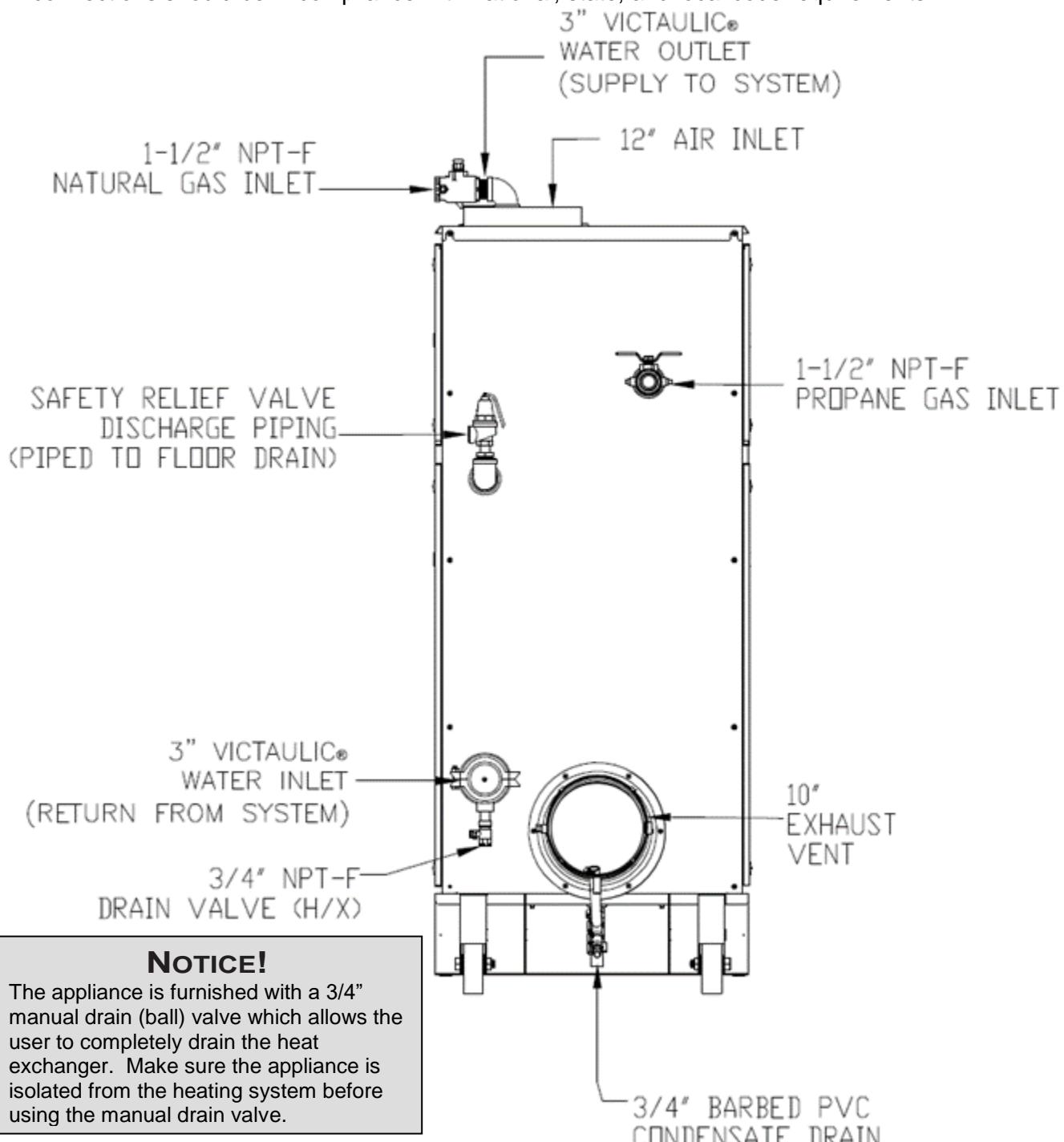
Flow Condition	Boiler Operation	Flow Rate	Approximate ΔT
Maximum Flow	High Fire	141 GPM	20°F
Minimum Flow	High Fire	71 GPM	40°F
Minimum Flow	Ignition	36 GPM	40°F
Minimum Flow	Low Fire	28 GPM	20°F

The table below summarizes the minimum and maximum flow restrictions for the C-2000H:

Flow Condition	Boiler Operation	Flow Rate	Approximate ΔT
Maximum Flow	High Fire	188 GPM	20°F
Minimum Flow	High Fire	94 GPM	40°F
Minimum Flow	Ignition	47 GPM	40°F
Minimum Flow	Low Fire	38 GPM	20°F

## Appliance Connections (MACH C-2500 & C-3000)

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



### NOTICE!

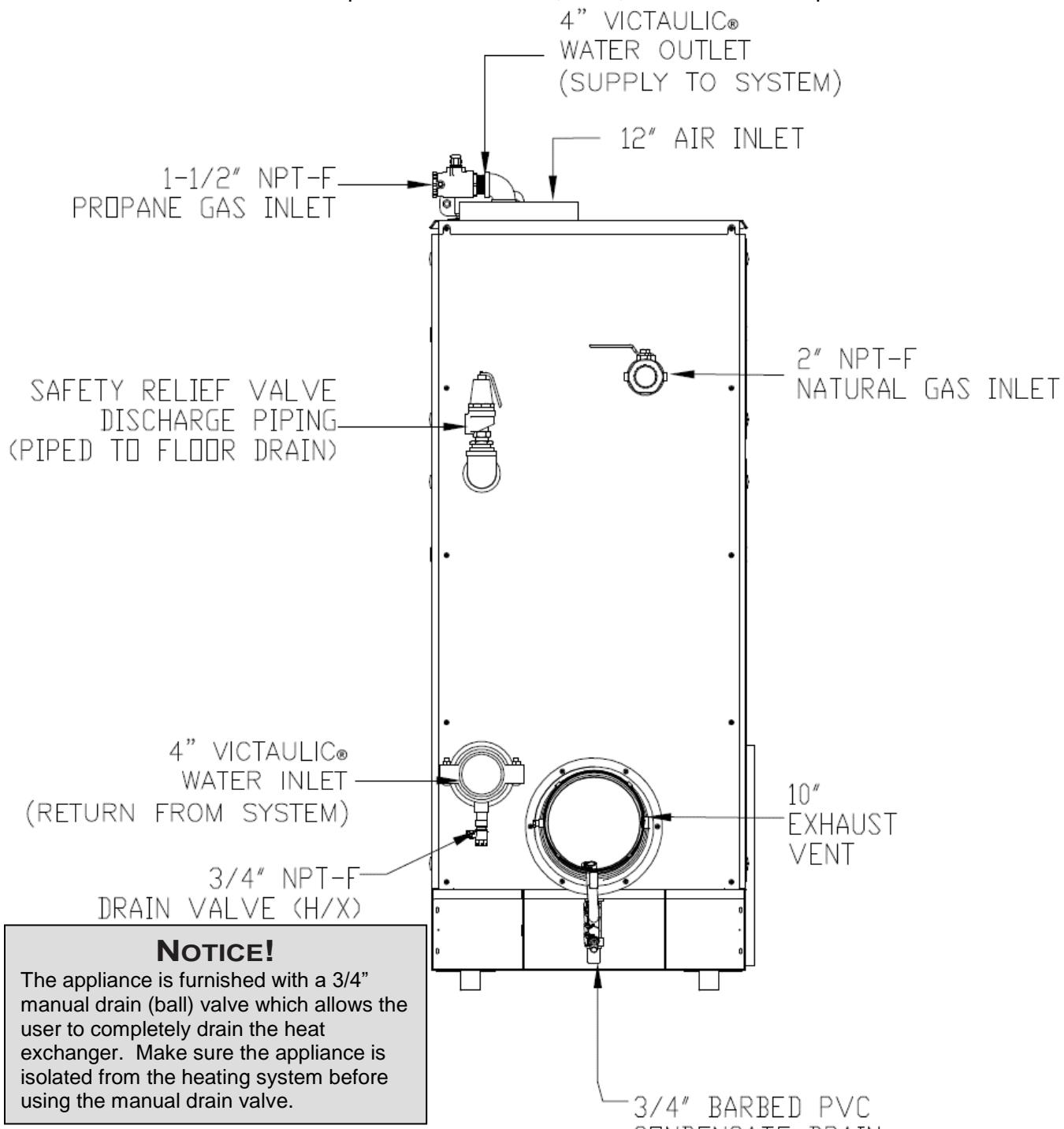
The appliance is furnished with a 3/4" manual drain (ball) valve which allows the user to completely drain the heat exchanger. Make sure the appliance is isolated from the heating system before using the manual drain valve.

### NOTICE!

The appliance is furnished with 3/4" drain tubing which is used to drain built-up condensation inside the appliance's combustion chamber. Connect this 3/4" drain tubing to the condensate neutralization system.

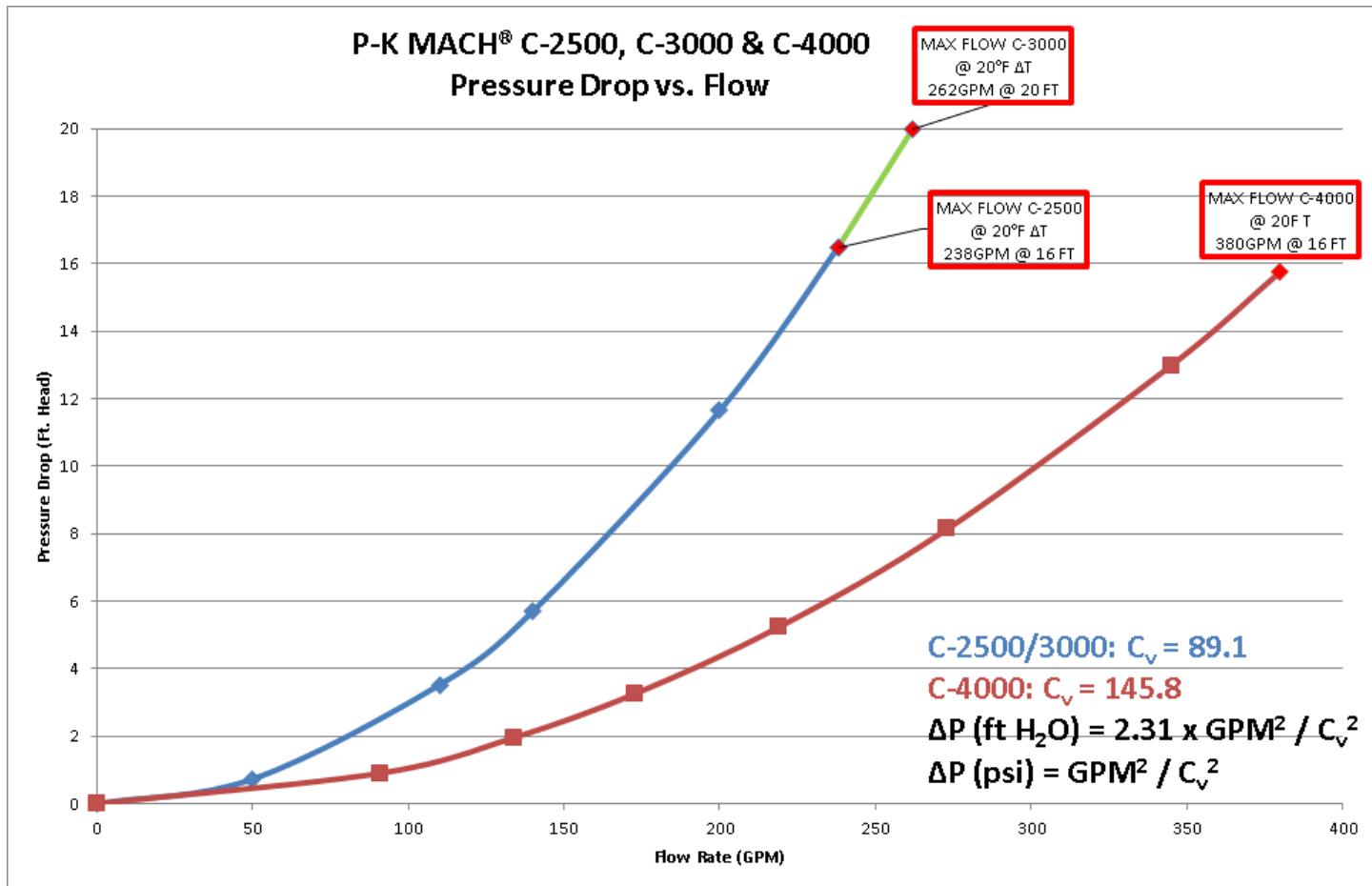
## Appliance Connections (MACH C-4000)

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



## Hydraulics/Water Flow (C-2500, C-3000 & C-4000)

The chart below represents the pressure drop (Ft of Head) versus the water flow rate (GPM) for the MACH C-2500, C-3000 & C-4000. This information is useful to help size an appropriate circulation pump. Keep in mind this pressure drop represents the boiler only, additional consideration is needed for any connected piping, valves, strainers, couplings, flanges, etc.



The table below summarizes the minimum and maximum flow restrictions for the MACH C-2500/3000:

Flow Condition	Boiler Operation	C-2500 Flow Rate	C-3000 Flow Rate	Approximate ΔT
Maximum Flow	High Fire	238 GPM	285 GPM	20°F
Minimum Flow	High Fire	120 GPM	143 GPM	40°F
Minimum Flow	Ignition	60 GPM	72 GPM	40°F
Minimum Flow	Low Fire	47 GPM	57 GPM	20°F

The table below summarizes the minimum and maximum flow restrictions for the MACH C-4000:

Flow Condition	Boiler Operation	Flow Rate	Approximate ΔT
Maximum Flow	High Fire	380 GPM	20°F
Minimum Flow	Low Fire	190 GPM	40°F
Minimum Flow	Ignition	95 GPM	40°F
Minimum Flow	Low Fire	76 GPM	20°F

## Propylene Glycol Flow

The table below summarizes the flow for the MACH appliances with different Propylene Glycol mixtures:

Model →	C1500H		C2000H		C2500	
Mixture ↓	Flow	Pressure	Flow	Pressure	Flow	Pressure
<b>0%</b>	141.5 GPM	13.2 ft	190.3 GPM	15.7 ft	236.1 GPM	16.2 ft
<b>10%</b>	143.2 GPM	13.5 ft	192.6 GPM	16.1 ft	239.0 GPM	16.6 ft
<b>20%</b>	144.9 GPM	13.8 ft	194.9 GPM	16.5 ft	241.8 GPM	17.0 ft
<b>30%</b>	147.5 GPM	14.3 ft	198.3 GPM	17.1 ft	246.1 GPM	17.6 ft
<b>40%</b>	152.9 GPM	15.4 ft	205.6 GPM	18.4 ft	255.1 GPM	18.9 ft
<b>50%</b>	159.9 GPM	16.9 ft	215.0 GPM	20.1 ft	266.8 GPM	20.7 ft
<b>60%</b>	168.1 GPM	18.6 ft	226.0 GPM	22.2 ft	280.4 GPM	22.9 ft

Model →	C3000		C4000	
Mixture ↓	Flow	Pressure	Flow	Pressure
<b>0%</b>	273.4 GPM	21.8 ft	376.6 GPM	15.4 ft
<b>10%</b>	276.8 GPM	22.3 ft	381.2 GPM	15.8 ft
<b>20%</b>	280.0 GPM	22.8 ft	385.7 GPM	16.2 ft
<b>30%</b>	285.0 GPM	23.6 ft	392.5 GPM	16.7 ft
<b>40%</b>	295.4 GPM	25.4 ft	406.9 GPM	18.0 ft
<b>50%</b>	309.0 GPM	27.8 ft	425.6 GPM	19.7 ft
<b>60%</b>	324.7 GPM	30.7 ft	447.2 GPM	21.7 ft