Power Flame Incorporated

VECTOR BURNER
START-UP AND OPERATING INSTRUCTIONS

THE POWER TO MANAGE ENERGY
2001 South 21st Street, Parsons, Kansas 67357
Telephone: 620-421-0480, Fax: 620-421-0948
Web Site: www.powerflame.com
E-Mail: CSD@powerflame.com

VECSU 0694

Copyright© Power Flame Incorporated 1994 RPT 0702

TABLE OF CONTENTS

VECTOR

Burner Start-up and Operation

Each Power Flame VECTOR burner is factory test fired to ensure that components and systems are functional. Because each field application is unique the final burner set-up and calibration must be conducted after burner installation by a qualified Burner Service Technician. Contact your Power Flame Representative for rates and scheduling of factory authorized VECTOR installation and commissioning assistance.

NOTE:
Every Power Flame VECTOR burner is shipped with a burner specification sheet, bill of materials, piping diagram and other reference materials specific to this job. A thorough understanding of and familiarity with these documents is required prior to burner installation, commissioning, operation or troubleshooting.

I. PRE-START-UP CHECKS:

A. Confirm that gas, oil, air, steam or other utility piping is connected and configured per Power Flame piping diagrams. Ensure that lines are free and clear of debris and foreign matter that may cause plugging or other operational problems. Check all connections to ensure that they are tight and leak free.

B. Confirm that gas, oil, air, steam or other utility services are supplied at the pressure and conditions noted on the VECTOR specification sheet.

C. Confirm that electrical utilities are supplied at the voltages, phase and frequency (hertz) noted on the burner specification sheet.

D. Reference the Power Flame VECTOR wiring diagram and ensure that all external control and interlock terminations are as depicted and that any interconnections resulting from remote panels or other sources are wired per the diagram.

E. Confirm that pressure switch settings, regulator settings and other calibrations are as depicted on the VECTOR burner specification sheet or piping and wiring diagram. These set points may require additional adjustment during burner commissioning to account for application dependent installation variations. Consult with the factory if questions concerning appropriate set points are encountered.

F. For Low NOx installations ensure that the FGR piping is connected and the stack breach is appropriately located. General installation recommendations are as follows:

FGR Piping;
Material - Carbon Steel

Type - Schedule 10
Size - refer to General Assembly Drawing or Figure A

Insulation;

Insulation requirements are dictated by personnel protection concerns and allowable heat source criterion at the installation location. Typical insulation would be 1 inch of fiberglass blanket covered with aluminum cladding.

Stack Breach;

The FGR breach into the stack should be made upstream of barometric dampers, stack dampers or other fittings that may contribute intrusive air into the FGR stream. Suggested installation at the stack is to enter the breach with a 45E miter cut facing into the stack flow. The additional velocity pressure "boost" for the FGR ensures adequate FGR flow rates under all conditions.

Burner Connection;

The FGR connection to the burner is via a plate flange conforming to ANSI 150# FF flange dimensions. Refer to General Assembly Drawing or Figure B for pipe size.

FGR Duct Routing;

Traverse the distance from stack to burner as directly as possible limiting the number of ells and other fittings to the fewest practical. Avoid "low spots" that will act as condensate collection points.

G. Ensure that all mechanical linkage arms, swivels and connection points are tight on the fuel/air ratio control system.

H. Consult the Boiler or Fired Equipment manufacturer, general contractor, building engineer or other appropriate authority to ensure that feed water, interlocks and other non-burner systems are properly configured and commissioned for operation.

II. GAS COMMISSIONING:

WARNING:
Commissioning or adjustment of the Power Flame VECTOR burner must be made by competent and experienced factory authorized Service Technicians to ensure safe and satisfactory operation of the system.

CAUTION:
It is not possible to foresee or document every potential operating situation or system condition. The following text should be used as a commissioning guideline by competent and experienced burner service technicians. Specific situations may mandate deviations based on sound engineering judgement and experience. Consult the Power Flame factory if questions or problems develop.

NOTE:

The following sequences assume that a Power Flame control panel and burner management system have been supplied with the burner. If these items have been supplied by others the general sequences and intent will be as follows but the control system manufacturer will have to be consulted for operational details.

CAUTION:

During gas firing of combination gas/oil burners the oil atomizing gun assembly should be removed and the collar blanking plug (supplied with the burner) must be installed to close the sleeve tube opening. Alternately, the oil atomizing gun assembly may be retracted and locked in place with a minimum of 6" to 8" between the adjustment collar and the oil/atomizing media manifold block to ensure the nozzle tip is out of the gas flame zone.

This commissioning sequence should be followed upon initial burner installation and start-up or immediately following any major system modifications.

A. COMBUSTION AIR FAN

1. Ensure that all fuel manual block valves and cocks are closed.

2. Position the adjustable air inlet "cap" with an approximate 4 inch spacing between the cap and the blower housing sidewall noise lagging. Adjustments are made by alternately turning the 4 positioning nuts on the back wall of the air inlet adapter.

3. Position the Burner Management System (BMS) panel power switch in the "OFF" position, the auto-manual switch in "MANUAL", the firing rate control at minimum and the fuel select switch to "GAS".

4. Supply electrical power to the BMS. The white POWER ON light will illuminate.

5. Open the gas supply manual block valve (upstream) leaving the burner gas cock (downstream) closed.

6. Position the BMS panel power switch to "ON". Actuate manual resets on low and high gas pressure switches, high limit pressure and temperature switches, liquid (water) level controls and flame safeguard as applicable. All Flame Safeguard interlocks should be proved, the combustion air blower should turn on and the burner pre-purge sequence should be initiated. Turn BMS panel power switch to "OFF". Confirm that blower motor rotation is proper. (If interlocks are not made and the blower does not come on, reference the VECTOR wiring diagram and Flame Safeguard literature to isolate the interlock fault and then repeat II.A.5 to confirm motor rotation).

B. PILOT

1. Confirm that pilot is inserted to a point approximately 2 inches behind the swirler.

2. Open pilot gas manual block valves and cocks.

3. Turn BMS panel power switch to "ON" and begin the pre-purge sequence. The fuel/air modulation motor should drive the combustion air damper to the 100% open position for maximum air flow for system purge. Ensure that mechanical linkage travel is full and not impeded or binding. All automatic fuel safety block valves should remain closed.

4. Upon completion of the pre-purge the fuel/air modulation motor will drive the combustion air back to the minimum or light-off position.
5. With interlock confirmation of air at light-off position the pilot gas automatic valve(s) actuate to supply fuel gas to the pilot and simultaneously initiate the high voltage ignition spark.

6. Pilot ignition and recognition by the Flame Safeguard system should be accomplished within a 10 second trial for ignition period. The pilot will remain on without the spark for an additional 10 seconds for main fuel trial for ignition (main fuel manual valves are closed preventing main flame ignition). If the pilot does not light, troubleshoot the pilot and electrical systems with emphasis on the following:

    a. Gas

        1. Confirm that pilot fuel gas manual valves are open and fuel gas is available.

        2. Ensure that regulator is set and functional (nominal 1.5 psig).

        3. Confirm that pilot automatic block valves are actuating.

        4. Ensure that no plugging of pilot orifices is present.

    b. Electrical - visually confirm that ignition spark is present. If not check the following:

        1. Confirm that high voltage ignition cable is plugged into pilot ignition rod and transformer.

        2. Ensure that pilot ignition rod is not shorting against pilot body or guide tube.

        3. Ensure that ignition transformer primary voltage is present.

c. Make adjustments noted in II.B.8. a, b and c.

7. After the main fuel trial for the ignition has expired the pilot will extinguish and a flame failure interlock outage will occur initiating a burner post-purge.

8. Repeat steps II.B.2 through II.B.6 until a consistent and steady pilot is obtained with maximum flame scanner detector signal. Adjustments to accomplish this are:

   a. Change pilot gas regulator set pressure .

   b. Change pilot insertion depth using the set screw collar located on the pilot mounting flange (normal depth is 2 inches behind the swirler).

   c. Ensure that the combustion air damper blades are fully closed during trial for ignition.

C. MAIN GAS BURNER

1. Install a combustion gas analyzer in the fired equipment stack to monitor flue gas composition.

2. With the BMS panel power switch in the "OFF" position open the main fuel gas upstream manual block valve (leaving the burner manual cock -downstream - closed), ensure that the auto-manual select switch is in "MANUAL" , that the firing rate control is at minimum and that the Flue Gas Recirculation (FGR) manual damper (if used) is closed.

CAUTION:
During initial main fuel light-off it is advisable to have additional trained personnel assisting with the start-up to visually observe the flame and monitor the BMS panel power switch in the event of a combustion upset.

3. Turn the BMS panel power switch to "ON" and initiate the pre-purge and pilot ignition.

WARNING:
If flame instability, fuel rich combustion or other severe combustion problems are evident immediately shutdown the burner by turning the BMS panel power switch to the "OFF" position and closing fuel manual block valves.

4. Immediately following the pilot trial for ignition ensure that the main fuel gas automatic safety block valves actuate. Slowly open the main fuel gas downstream manual block valve (cock) sending fuel gas to the burner before the 10 second main fuel gas trial for ignition period expires. The pilot will extinguish and the main fuel flame should be established and proved by the flame safeguard system.

5. Monitor the flame visually to ensure stability and monitor the flue combustion analyzer for oxygen and carbon monoxide. Expected flue oxygen readings should range from 3% to 4% at <4:1 fuel turndowns and 4% to 10% at =>4:1 turndowns. If no excess air is present, if instability occurs or if Carbon Monoxide is in excess of .1% immediately shutdown the burner by turning the BMS panel power switch to the "OFF" position. Make a burner fuel/air linkage adjustment to alter stoichiometry as required and repeat II.C.3 through II.C.5 until a satisfactory flame is present.

> **WARNING**:
> Ensure that all nuts, bolts and devices are tight and seated after adjustment of any mechanical linkage or controls in the fuel/air ratio system.

6. At the established lightoff conditions determine what fuel rate is being fired via fuel metering, fuel pressure at the burner or pressure drops across known components. Using mechanical linkage arm and/or rod adjustments set the fuel rate to the desired minimum flow. Monitor the flue combustion analyzer and visually confirm flame quality to ensure stable and satisfactory operation.

> **CAUTION**:
> New boiler or fired equipment installations or major retrofits may have large sections of uncured castable refractory. Rapid initial heating of these sections may cause cracks, spauling and premature failure of the refractory. Consult the boiler or fired equipment manufacturer, refractory supplier or other appropriate authority for cureout recommendations, schedules and procedures.

7. If the desired minimum firing rate is = or < 4:1 turndown make mechanical linkage arm and/or rod adjustments to obtain a flue oxygen content of 5%. If the desired minimum firing rate is > 4:1 turndown make mechanical linkage arm/rod adjustments to ensure that the combustion air damper is fully closed.

D. FUEL AIR CHARACTERIZATION

1. If fuel turndowns of =< 4:1 are desired use mechanical linkage arms and/or rods to adjust the combustion air damper to obtain the desired

flue oxygen content (3% nominal).

2. If Power Flame has provided the burner throat refractory allow the burner to run at minimum fire rates for 15 minutes. Turn the burner off for 15 minutes. Repeat this process over a 3 hour period to ensure adequate curing of the throat refractory.

> **NOTE**:
> Cracks in the throat refractory section are normal. If spauling occurs or if hot spots develop on the burner front, shut down the system and consult the factory.

3. With the burner operational on gas at minimum rate turn the manual rate adjustment potentiometer to obtain a 10% increase in modulating fuel/air linkage position. Monitor flue excess oxygen and visually confirm flame stability. If instability or sub-stoichiometric conditions exist return the potentiometer to the original minimum position. When satisfactory conditions return increase the rate setting to obtain a 5% travel adjustment.

4. Use the "VARICAM" characterization set screws to adjust flue oxygen content to the desired level. Increase the manual rate adjustment potentiometer another 5 to 10% noting flue excess oxygen and burner stability and again make VARICAM adjustments to the desired excess air levels. Repeat this process until maximum firing rates are achieved.

> **NOTE**:
> Reference the VECTOR burner specification sheet for anticipated fuel gas pressure at the burner at maximum firing rate.

If required adjustment exceeds the VARICAM adjustment range make a mechanical linkage arm and/or rod adjustment in the appropriate direction and begin the VARICAM characterization again starting at minimum rate. This sequence may have to be repeated several times to achieve desired operation.

> **NOTE**:
> Fuel air characterization for units with 4:1 turndown or less can be set at constant excess air levels of 10% or higher throughout the firing range. Turndowns greater than 4:1 will experience increasing excess air levels as the turndown increases beyond the 4:1 point.

5. If insufficient combustion air is available at elevated firing rates

adjustment of the air inlet assembly adjustable "cap" may be required. With the burner turned off adjust the air inlet cap to a more open position by alternately and equally turning the 4 adjustment bolts on the back of the assembly counterclockwise opening the "gap" between the cap and blower housing. Locking nuts for each adjustment nut must be loosened and subsequently tightened after each adjustment. Repeat steps II.D.1 through II.D.5 as required.

If "too much" air is available or a "lack of controllability" is exhibited by the combustion air control damper the air inlet assembly cap can be adjusted to restrict available air. With the burner turned off adjust the air inlet cap to a more closed position by alternately and equally turning the 4 adjustment bolts on the back of the assembly clockwise closing the "gap" between the cap and blower housing. Locking nuts for each adjustment nut must be loosened and subsequently tightened after each adjustment. Repeat steps II.D.1 through II.D.5 as required.

E. FLUE GAS RECIRCULATION (If used)

CAUTION:
The introduction of FGR will reduce excess air levels and can result in combustion instability if FGR rates are too great.

CAUTION:
The burner FGR system is equipped with a fresh air diverter damper to prevent FGR recycle during purge and ignition periods. If the FGR rates are too great or if the FGR is too cold when introduced to the burner, flame instability may result.

NOTE:
A timer circuit is provided in the BMS that allows the diverter damper to stay in the fresh air position for up to 17 minutes after establishing main flame. This timer is factory set at 1 minute but can be field adjusted as required to allow system warmup before FGR introduction, if needed.
NOTE:
FGR damper position and rates will be dependent on the fired equipment and FGR duct configurations as well as the desired level of emissions reductions.

1. Slowly open the FGR damper to a 5E open position. Monitor flame stability, flue oxygen and emissions levels. Allow 5 minutes for the system to reach equilibrium. Repeat this process in 5E damper increments until desired emissions levels are obtained or until the 60E open position is reached. If a stability limit is reached reduce the existing FGR damper position by 10E and proceed.

NOTE:
Reference the Power Flame "VARICAM" manual provided with this job prior to making fuel/air characterized adjustments.

2. If insufficient amounts of FGR are being induced, the air inlet assembly "cap" may be adjusted to increase FGR flow. With the burner turned off adjust the air inlet cap to a more closed position by alternately and equally turning the 4 adjustment bolts on the back of the assembly clockwise closing the "gap" between the cap and blower housing. Locking nuts for each adjustment nut must be loosened and subsequently tightened after each adjustment. Making this adjustment may change the air/fuel ratios previously set in section II.D. Repeat steps II.D.1 through II.D.5 as required.

F. FLAME SHAPE

The Power Flame VECTOR burner is factory adjusted to provide the anticipated optimum flame shape in the unit being fired. Variations in actual field conditions may necessitate adjustments at the jobsite however. These adjustments can include the following:

1. Swirler insertion depth. The swirler is provided with insertion depth adjustment utilizing the threaded rod and nut arrangement attached to the jacket tube on the burner drawer assembly mounting plate.

CAUTION:
Swirler insertion depth adjustment can impact flame stability and fuel/air ratios. If adjustments are made while the unit is firing, a safety watch person should be monitoring the BMS power switch to immediately turn the burner "OFF" if operational problems develop.

a. To insert the swirler farther into the unit loosen the nut on the threaded adjustment rod nearest the burner (inner nut). Turn the outer nut to force the jacket tube and swirler assembly to travel inward. Repeat until desired depth is achieved and tighten both nuts. Make these adjustments in small increments (1/8 inch nominal). Do not loosen and make large travel adjustments on the inner nut because air pressure on the swirler may cause a sudden movement of the assembly over the entire distance. This swirler insertion adjustment typically results in a wider and shorter flame.

b. To retract the swirler loosen the outer nut on the threaded adjustment assembly and use the inner nut to force the jacket tube/swirler outward. Make small incremental adjustments (1/8

inch nominal). This swirler retraction adjustment typically narrows and lengthens the flame. Repeat until desired depth is achieved and tighten both nuts.

NOTE:
The insertion depth should be measured and recorded (or marked) after final adjustment to ensure repeatability after maintenance or other activities which might alter the setting.

2. Gas tip (poker) orientation adjustments. Gas tip orientation redistributes gas into the primary and secondary combustion zones altering flame shape. Orienting the gas tips towards the swirler (center) typically results in a more narrow and short flame. Tip orientations away from the center typically widen and lengthen the flame.

CAUTION:
Altering gas tip orientation may impact burner stability, emissions and performance. Consult the Power Flame factory before making this adjustment.

Gas tip orientation adjustment is made by removing the burner center drawer assembly. With electrical power, all fuels and utilities off, blocked and secured disconnect piping, hoses, linkage and other accessories that may interfere with drawer removal. Remove the nuts on the drawer assembly mounting flange.

CAUTION:
The burner drawer assembly is heavy. On larger burners the use of hoists or other mechanical lifting devices is recommended for drawer removal.

Withdraw the drawer assembly out of the burner windbox and place on the floor or a convenient work surface. Loosen the set screw or hold down nut on each individual gas tip. Rotate the gas tips to the desired orientation and tighten the set screw or hold down nuts. Install the drawer assembly back into the windbox exercising caution to ensure concentric placement. Install and tighten all drawer assembly flange nuts, connect all piping, linkage, hoses and accessories. Make sure that all connections are tight and leak free. Place the burner back in service.

G. EMISSIONS PERFORMANCE

The Power Flame VECTOR burner is designed to provide Low NOx operation with efficient combustion in its base configuration. When equipped with the induced FGR system the VECTOR is capable of meeting very stringent emission guidelines. Consult job specifications or the factory for emission expectations on individual applications. VECTOR emission performance optimization can include the following:

1. FGR rate adjustment. The VECTOR FGR system is designed to provide a relatively constant ratio of FGR to combustion air over the entire firing spectrum without modulation of the FGR damper. Reference sections II.C and II.D. If NOx emission reductions are desired subsequent to the FGR damper setting made in II.D. increase the FGR damper setting in 5E increments using the procedure noted in II.D.1. Ensure that flame stability is maintained throughout the entire firing range.

If the FGR manual damper is positioned wide open and adequate FGR is not being induced an adjustment of the air inlet assembly "cap" position may be required. Reference section II.E.2 for this adjustment. Repeat step II.G.1.

2. Adjust primary and secondary combustion zone air splits. The amount of combustion air being directed to the primary and secondary combustion zones is adjustable via swirler insertion depth in the refractory throat. Reference II.F.1. a and b to effect swirler adjustments.

3. Adjust primary and secondary combustion zone fuel distribution. The amount of fuel gas going to each combustion zone can be adjusted via gas tip orientation. Reference II.F.2 for gas tip orientation adjustment procedure. Consult the Power Flame factory before embarking on this adjustment.

III. OIL COMMISSIONING:

WARNING:
Commissioning or adjustment of the Power Flame VECTOR burner must be made by competent and experienced factory authorized Service Technicians to ensure safe and satisfactory operation of the system.

CAUTION:
It is not possible to foresee or document every potential operating situation or system condition. The following text should be used as a commissioning guideline by competent and experienced burner service technicians. Specific situation may mandate deviations based on sound engineering judgement and experience. Consult the Power Flame factory if questions or problems develop.

NOTE:
The following sequences assume that a Power Flame control panel and burner management system have been supplied with the burner. If these items have been supplied by others the general sequences and intent will be as follows but the control system manufacturer will have to be consulted for operational details. This commissioning sequence should be followed upon initial burner installation and start-up or immediately following any major system modifications.

A. COMBUSTION AIR FAN

1. Ensure that all fuel manual block valves and cocks are closed.

2. Position the Burner Management System (BMS) panel power switch in the "OFF" position, the auto-manual switch in "MANUAL", the firing rate control at minimum and the fuel select switch to "OIL".
3. Supply electrical power to the BMS. The white POWER ON light will

illuminate.

4. Open the oil supply manual block valve (upstream) leaving the burner oil valve (downstream) closed. For heavy oil systems or other systems with fuel recirculation ensure that the recirculation manual block valves are open.

5. Position the BMS panel power switch to "ON". Actuate manual resets on low and high oil pressure switches, high limit pressure and temperature switches, liquid (water) level controls, heavy oil temperature switches and flame safeguard as applicable. All Flame Safeguard interlocks should be proved, the combustion air blower should turn on and the burner pre-purge sequence should be initiated. Turn BMS panel power switch to "OFF". Confirm that blower motor rotation is proper. (If interlocks are not made and the blower does not come on reference the VECTOR wiring diagram and Flame Safeguard literature to isolate the interlock fault then repeat III.A.5 to confirm motor rotation).

B. PILOT

Refer to section II.B. under Gas Commissioning for pilot operation.

C. OIL BURNER OPERATION

1. Install a combustion gas analyzer in the fired equipment stack to monitor flue gas composition.

2. Start the fuel oil pumping system and provide oil to the VECTOR oil piping system. Nominal supply pressure is 175 psig.

3. With the BMS panel power switch in the "OFF" position open the fuel oil upstream manual block valve (leaving the burner oil valve - downstream - closed), ensure that the auto-manual select switch is in "MANUAL" , that the firing rate control is at minimum and that the Flue Gas Recirculation (FGR) manual damper (if supplied) is closed.

CAUTION:
During initial main fuel light-off it is advisable to have additional trained personnel assisting with the start-up to visually observe the flame and monitor the BMS panel power switch in the event of a combustion upset.

4. Provide atomizing media to the VECTOR atomizing media valve train as specified. Nominal supply pressure for air or steam is 125 psig. Ensure that 125 psig atomizing steam is at enthalpy conditions consistent with 125 psig saturated steam.

5. Turn the BMS panel power switch to "ON" and initiate the pre-purge and pilot ignition.

WARNING:
If flame instability, fuel rich combustion, excessive smoke or other severe combustion problems are evident immediately shutdown the burner by turning the BMS panel power switch to the "OFF" position and closing fuel manual block valves.

NOTE:
Any fuel oil being used by the VECTOR burner must exhibit a viscosity of less than 100 SSU to ensure satisfactory atomization. If a heavy oil is being used ensure that heating and recirculation systems supply the oil at specified temperatures and viscosity.

6. Immediately following the pilot trial for ignition (assuming the pilot lit and was detected) the main and auxiliary oil automatic safety block valves open. Slowly open the oil downstream manual block valve sending fuel oil to the burner before the 15 second oil trial for ignition period expires. The oil flame should be established, the pilot extinguished and the oil flame proved by the flame safeguard system.

7. Monitor the flame visually to ensure stability, satisfactory atomization and smoke free operation and monitor the flue combustion analyzer for oxygen and carbon monoxide. Expected flue oxygen readings should range from 3% to 4% at <4:1 fuel turndowns and 4% up to 10% at =>4:1 turndowns. If no excess air is present, if instability occurs, if Carbon Monoxide is in excess of 100 ppm or if heavy smoking occurs immediately shutdown the burner by turning the BMS panel power switch to the "OFF"" position. Make a burner fuel/air linkage adjustment to alter stoichiometry as required and repeat III.C.3 through III.C.6 until a satisfactory flame is present. If smoking, excessive "wetting" of the walls, poor atomization or impingement occurs reference section III.F, Flame Shaping, and institute the corrective measures therein noted.

8. At the established lightoff conditions determine what fuel rate is being fired via fuel metering, fuel pressure at the burner or pressure drops across known components. Using mechanical linkage arm and/or rod adjustments set the fuel rate to the desired minimum flow. Monitor the flue combustion analyzer and visually confirm flame quality to ensure stable and satisfactory operation.

CAUTION:
New boiler or fired equipment installations or major retrofits may have large sections of uncured castable refractory. Rapid initial heating of these sections may cause cracks, spauling and premature failure of the refractory. Consult the boiler or fired equipment manufacturer, refractory supplier or other appropriate authority for cureout recommendations, schedules and procedures.

9. If the desired minimum firing rate is = or < 4:1 turndown make mechanical linkage arm and/or rod adjustments to obtain a flue oxygen content of 5%. If the desired minimum firing rate is > 4:1 turndown make mechanical linkage arm/rod adjustments to ensure that the combustion air damper is fully closed.

D. FUEL AIR CHARACTERIZATION

1. If fuel turndowns of =< 4:1 are desired use mechanical linkage arms and/or rods to adjust the combustion air damper to obtain the desired flue oxygen content (3% nominal).

2. If Power Flame has provided the burner throat refractory allow the burner to run at minimum fire rates for 15 minutes. Turn the burner off for 15 minutes. Repeat this process over a 3 hour period to ensure adequate curing of the throat refractory.

NOTE:
Cracks in the throat refractory section are normal. If spauling occurs or if hot spots develop on the burner front, shut down the system and consult the factory.

3. With the burner operational on oil at minimum rate turn the manual rate adjustment potentiometer to obtain a 10% increase in modulating fuel/air linkage position. Monitor flue excess oxygen and visually confirm flame stability. If instability or sub-stoichiometric conditions exist return the potentiometer to the original minimum position. When satisfactory conditions return increase the rate setting to obtain a 5% travel adjustment.

4. Use the "VARICAM" characterization set screws to adjust flue oxygen content to the desired level. Increase the manual rate adjustment potentiometer another 5 to 10% noting flue oxygen, smoke and flame stability and again make VARICAM adjustments to the desired excess air levels. Repeat this process until maximum firing rates are achieved.

NOTE:
Reference the VECTOR burner specification sheet for anticipated fuel oil pressure at the burner at maximum firing rate. If required adjustment exceeds the VARICAM adjustment range make a mechanical linkage arm and/or rod adjustment in the appropriate direction and begin the VARICAM characterized again starting at minimum rate. These adjustments may have to be repeated several times to achieve desired operation.

NOTE:
Fuel air characterization for units with 4:1 turndown or less can be set at constant excess air levels of 10% or higher throughout the firing range. Turndowns greater than 4:1 will experience excess air levels as the turndown increases beyond the 4:1 point.

NOTE:
Smoke emissions from the VECTOR burner firing No. 2 or lighter oils should not exceed number 2 on the Bacharach scale.

5. a. If insufficient combustion air is available at elevated firing rates adjustment of the air inlet assembly adjustable "cap" may be required. With the burner turned off adjust the air inlet cap to a more open position by alternately and equally turning the 4 adjustment bolts on the back of the assembly counterclockwise opening the "gap" between the cap and blower housing. Locking nuts for each adjustment nut must be loosened and subsequently tightened after each adjustment. Repeat steps II.D.1 through II.D.5 as required.

   b. If "too much" air is available or a "lack of controllability" is exhibited by the combustion air control damper the air inlet assembly cap can be adjusted to restrict available air. With the burner turned off adjust the air inlet cap to a more closed position by alternately and equally turning the 4 adjustment bolts on the back of the assembly clockwise closing the "gap" between the cap and blower housing. Locking nuts for each adjustment point must be loosened and subsequently tightened after use.

E. FLUE GAS RECIRCULATION (If Used)

CAUTION:
The introduction of FGR will reduce excess air levels and can result in flame instability if FGR rates are too great.

Refer to the Flue Gas Recirculation section (II.E) under Gas Commissioning.

F. FLAME SHAPE

The Power Flame VECTOR burner is factory adjusted to provide the anticipated optimum flame shape, atomization and smoke free operation in the unit being fired. Variations in actual field conditions may necessitate adjustments at the jobsite however. These adjustments can include the following:

1. Oil gun insertion depth. The spatial relationship between the oil gun tip and diffuser can be varied by using different oil gun insertion depths. This is accomplished by moving the gun in or out using the spring loaded locking knob and collar set screw on the approximal end of the jacket tube assembly. Retracting the gun tends to "collapse" the flame up to the point that impingement on the swirler results.

2. Swirler insertion depth. The swirler is provided with insertion depth adjustment utilizing the threaded rod and nut arrangement attached to the jacket tube on the burner drawer assembly mounting plate.

CAUTION:
Swirler insertion depth adjustment can impact flame stability and fuel/air ratios. If adjustments are made while the unit is firing, a safety watch person should be monitoring the BMS power switch to immediately turn the burner "OFF" if operational problems develop.

   a. To insert the swirler farther into the unit loosen the nut on the threaded adjustment rod nearest the burner (inner nut). Turn the outer nut clockwise to force the jacket tube and swirler assembly to travel inward. Repeat until desired depth is achieved and tighten lock nuts. Make these adjustments in small increments (1/8 inch nominal). Do not loosen and make large travel adjustments on the inner nut because air pressure on the swirler may cause a sudden movement of the assembly over the entire distance. This swirler insertion adjustment typically results in a wider and shorter flame.
   b. To retract the swirler loosen the inner nut on the threaded adjustment assembly and use the outer nut to force the jacket tube/swirler outward. Make small incremental adjustments (1/8 inch nominal). This swirler retraction adjustment typically narrows and lengthens the flame.

NOTE:
The insertion depth should be measured and recorded (or marked) after final adjustment to ensure repeatability after maintenance or other activities which might alter the setting.

3. Atomizing Media Pressure - Atomizing media quality and pressure can

have a significant effect on oil atomization and combustion. Design pressures for both air and saturated steam is 100 psig at the oil gun. If smoking, atomization or wetting problems exists adjustments to this atomizing media gun pressure may alleviate the problem.

NOTE:
Atomizing steam must be dry and not be superheated. Ensure that steam lines have been drained of condensate before burner operation. Atomizing air must be dry and free of entrained water.

4. Oil gun port plugging. Foreign matter may clog or partially clog ports within the oil gun tip. If poor atomization or unsymmetrical flame patterns exist the oil gun should be removed and the tip disassembled and checked for blockages. The gun is removed by loosening the set screw locking collar and spring loaded retaining pin at the end of the oil gun assembly. The gun assembly can be completely removed.

WARNING:
The oil gun may be hot if removed immediately after burner operation. Burns may occur if not allowed to cool or not handled with appropriate protective equipment.

CAUTION:
An atomizing media purge should be accomplished prior to gun removal to ensure that excess oil in the gun is expunged. Caution should be exercised to prevent spillage if small amounts of oil still remain.

The oil gun assembly should be secured in a pipe vise. The end cap or tip is removed by unscrewing. The receiver is unscrewed from the guide pipe and the inner tube assembly and atomizer (sprayer plate) are retracted from the guide pipe. The atomizer can be removed from the inner tube assembly exercising caution not to damage the elastomer sealing rings. Air, brushing or solvents can be used to clear plugages in the atomizer. When clean, reassemble ensuring that all connections are tight and that the sealing rings are properly placed.

G. EMISSIONS PERFORMANCE

When equipped with FGR capability the VECTOR is capable of reduced NOx emissions performance within the limitations of fuel bound nitrogen concentrations in the oil being employed. Consult job specifications or the factory for emissions expectations on individual applications.

VECTOR NOx emissions performance optimization can include the following:

1. FGR rate adjustment. The VECTOR FGR system is designed to provide a relatively constant ratio of FGR to combustion air over the entire firing spectrum without modulation of the FGR damper. Reference sections III.C and III.D. If NOx emission reductions are desired subsequent to the FGR damper setting made in III.D increase the FGR damper setting in 5E increments using the procedure noted in II.D.1. Ensure that flame stability is maintained throughout the entire firing range.

   If satisfactory FGR rates can not be attained the air inlet "cap" position may require adjustment. Refer to section III.5.b for adjustment instructions.

2. Adjust primary and secondary combustion zone air splits. The amount of combustion air being directed to the primary and secondary combustion zones is adjustable via swirler insertion depth in the refractory throat. Reference III.F.2. a and b to effect swirler adjustments.

3. Atomizing media pressure may have an effect on emissions. Adjustments above or below the nominal 125 psig at the oil gun can be tried.

IV. **NORMAL OPERATION**

NOTE:
Utilization of the operating guidelines noted in this section is predicated upon successful initial commissioning of the system as depicted in sections I, II and III.

NOTE:
If problems are encountered during the start-up cycle, reference section II, Gas Commissioning, for troubleshooting assistance.

A. GAS FIRING - START-UP

1. Position controls on the Burner Management System (BMS) panel as follows:
   Power : "OFF"
   Fuel Select: "GAS"
   Control: "MANUAL"
   Rate: "MINIMUM"

2. Ensure that fired equipment water levels and other peripheral systems are "ON" and functional.

3. Open the pilot and main gas upstream and downstream manual block valves.

4. Turn the BMS Panel Power switch to "ON"
   Upon interlock verification the BMS will initiate the following sequence:

   a. The combustion air blower will turn "ON"

   b. The fuel/air modulating motor will drive the combustion air damper "OPEN" to the purge position.

   c. A fresh air purge of the firing chamber and stack will ensue for a specified period.

   d. Upon completion of the purge time the fuel/air modulating motor will drive the combustion air damper to the "LIGHT OFF" position.

   e. With verification that the air damper is at "LIGHT OFF" the pilot gas automatic safety block valves will open sending fuel gas to the pilot. Simultaneously the ignition transformer will be energized providing a 6000 volt potential to the pilot ignition rod for spark ignition. This pilot "Trial for Ignition" period will last for

10 seconds.

f. The pilot will light during the trial for ignition period, the ignition transformer will be de-energized and the BMS will confirm "Flame Proved" via the flame scanner.

g. Upon successful completion of the pilot "trial for Ignition" period a 10 second main fuel "Trial for Ignition" will commence. The main fuel gas automatic safety block valves will open and the vent valve will close sending main fuel gas to the burner. Gas in the main fuel burner elements will ignite.

h. After the main gas "Trial for Ignition" period the pilot gas will turn "OFF" and the BMS "Flame Proved" will be supported by the main gas burner flame.

i. A 10 second flame stabilization period is started. After this period the unit will be "Released to Modulate". While in "MANUAL" the firing rate can be modulated via the rate potentiometer. If switched to "AUTO" modulation control will be from the process control system.

NOTE:
If immediate process control is desired or if a lowered firing rate warmup period is not required, the control switch may be put in the "AUTO" position in step IV.A.1. Be aware that in this position most control systems will immediately drive the burner to its maximum firing rate.

j. In systems supplied with FGR the timed FGR delay will begin upon opening of the main fuel valves. This timer is factory set at one minute. If additional system warmup time is required this timer can be set at up to 17 minutes. Note that during the time delay before FGR introduction the burner will be operating at higher excess air rates than with FGR.

k. The system should be fully functional and operating on gas.

B. GAS FIRING - SHUTDOWN

1. Turn the BMS panel "POWER" switch to "OFF"

2. Close the pilot and main fuel gas manual block valves

> **NOTE**:
> When the burner "shuts down" a 30 second post purge is initiated to sweep potentially combustible gases out of the system. This will happen with the BMS power switch in the "OFF" position or with an interlock outage.

C. OIL FIRING - START-UP

The following sequences include heavy (#6) oil procedures. All passages pertaining only to heavy oil are marked with an asterisk (*) and should be omitted for light oil firing.

1. Position controls on the Burner Management System (BMS) panel as follows:

Power :	"OFF"
Fuel Select:	Intermediate Position
Control:	"MANUAL"
Rate:	"MINIMUM"

2. Ensure that fired equipment water levels and other peripheral systems are "ON" and functional. If atomizing media and oil supply systems are external to the BMS ensure that they are operational and at specified parameters.

3. Open the pilot gas, fuel oil and atomizing media upstream and downstream manual block valves.

> **NOTE**:
> If steam atomization with compressed air start is being utilized, open the air manual block valves and leave the steam manual block valve closed immediately downstream of the steam supply inlet connection.

4. Turn the BMS fuel select switch to "OIL"
*The remote oil pump and the oil heater, if PFI supplied or *interlocked, will turn "ON" and heavy oil will recirculate through the *system.

***NOTE**:
*If electrical power is supplied to the BMS panel and the Fuel *Select switch is in the "OIL" position (for heavy oils) the remote *oil pump and the fuel heater, if PFI supplied or interlocked, will *be energized regardless of BMS panel power switch position.

5. Turn the BMS Panel Power switch to "ON". Upon interlock verification the BMS will initiate the following sequence:

   a. The combustion air fan will turn on and the atomizing air compressor, if applicable and PFI supplied, will be energized. For light oil firing the remote oil pump, if PFI supplied or interlocked, will be turned on.

***NOTE**
*On heated heavy oil systems the fan will not turn on until oil *temperature limits have been satisfied.

   b. The fuel/air modulating motor will drive the combustion air damper "OPEN" to the purge position.

   c. A fresh air purge of the firing chamber and stack will ensue for a specified period. Concurrently the atomizing medium automatic block valve(s) will open to purge the oil gun.

   d. Upon completion of the purge time the fuel/air modulating motor will drive the combustion air damper to the "LIGHT OFF" position. The atomizing media remains on.

   e. With verification that the air damper is at "LIGHT OFF" the pilot gas automatic safety block valves will open sending fuel gas to the pilot. Simultaneously the ignition transformer will be energized providing a 6000 volt potential to the pilot ignition rod for spark ignition. This pilot "Trial for Ignition" period will last for 10 seconds.

   f. The pilot will light during the trial for ignition period, the ignition transformer will be de-energized and the BMS will confirm "Flame Proved" via the flame scanner.

   g. Upon successful completion of the pilot "trial for Ignition" period a 15 second fuel oil "Trial for Ignition" will commence. The fuel oil automatic safety block valves will open sending fuel oil to the burner. Atomized fuel oil will ignite.

h. After the main gas "Trial for Ignition" period the pilot gas will turn "OFF" and the BMS "Flame Proved" will be supported by the fuel oil flame.

i. A 10 second flame stabilization period is started. After this period the unit will be "Released to Modulate". While in "MANUAL" the firing rate can be modulated via the rate potentiometer. If switched to "AUTO" modulation control will be from the process control system.

> **NOTE**:
> If immediate process control is desired or if a lowered firing rate warmup period is not required the control switch may be put in the "AUTO" position in step IV.A.1. Be aware that in this position most control systems will immediately drive the burner to its maximum firing rate.

j. In systems supplied with FGR the timed FGR delay will begin upon opening of the main fuel valves. This timer is factory set at one minute. If additional system warmup time is required this timer can be set at up to 17 minutes. Note that during the time delay before FGR introduction the burner will be operating at higher excess air rates than with FGR.

k. If the burner is supplied with steam atomization and provisioned with air start the switchover will occur after the system has generated steam pressures sufficient to drive the atomizer (125 psig nominal).

> **CAUTION**:
> Ensure that all condensate has been drained from atomizing steam lines before effecting an air to steam switchover on an operating burner. Introduction of condensate to the burner may quench and extinguish the oil flame.

To perform the air to steam atomizing media switch perform the following:

1. Open the manual block valve on the atomizing steam drain and steam trap line. Ensure that all condensate has been purged from the steam line.

2. Confirm that steam pressure to the atomizing steam pipe train is 125 psig.

3. Slowly open the steam downstream manual block valve allowing steam into the operating atomizing media line. Open the valve 100%.

4. Slowly close the atomizing air upstream block valve and the 1/4" manual air start bypass valve at the automatic block valve.

CAUTION:
If the atomizing air is from a dedicated compressor ensure that the compressor is "OFF" to prevent "dead heading" and potential compressor damage.

NOTE:
If the burner system is supplied with an automatic atomizing media switchover function steps IV.1.a, b and c will be performed electronically without manual operator interference.

l. The system should be fully functional and operating on oil.

D. OIL FIRING - SHUTDOWN

1. Simultaneously open the oil gun atomizing media purge valve and close the oil manual block valve to remove oil from the oil tip and gun.

NOTE:
If an automatic oil gun atomizing media purge is provided the functions noted in IV.D.1. will be performed electronically each time a shutdown is experienced.

2. Turn the BMS panel "POWER" switch to "OFF"

3. Close the pilot gas and atomizing media manual block valves.

NOTE:
When the burner "shuts down" a 30 second post purge ensues to sweep potentially combustible gases out of the system. This will happen with the BMS power switch in the "OFF" position or with an interlock outage.

***NOTE**:
Heavy oil installations will continue to heat and recirculate oil as long as the Fuel Select switch is in the "OIL" position regardless of BMS panel power switch position.

4. Turn the Fuel Selector switch to the intermediate position (between oil and gas).

V. SERVICE AND SPARE PARTS

A. SPARE PARTS

A recommended spare parts list is generated along with the "As Built" Spec Sheets and is available upon request. To obtain a copy of the recommended spare parts list, see information provided in the "Owners Information" envelope received with the burner, call or fax the Power Flame Customer Services at: Telephone (316) 421-0480 Fax (316) 421-0948.

B. FIELD SERVICE

Power Flame maintains a Sales Representative network that includes highly trained burner and system technicians. Consult your nearest Power Flame Representative for service scheduling. Call the Power Flame factory to obtain the name and number of your nearest Representative.

Power Flame Factory Service Technicians may be scheduled by contacting the Power Flame Engineering Department at the numbers noted above. Current Service rates are $700 per day plus reasonable travel and living expenses at cost. Request a Service quotation when inquiring about scheduling.

C. WARRANTY

Please consult the Power Flame Incorporated Limited Warranty for specific terms and conditions. Power Flame maintains a "Return Material Authorization" system to ensure prompt evaluation and return of warranted parts. Contact the Power Flame Customer Services/Parts department for parts return. Field backcharges for labor or materials covered by warranty must be authorized in writing in advance of the work being performed.

BURNER START UP INFORMATION & TEST DATA

The following information shall be recorded for each burner start up:

Power Flame Model_____Invoice No._____Serial No.

Installation Name_____Start Up Date

Start Up Contractors Name_____ Phone

Name of Technician Doing Start Up

Type of Gas: Nat._____ LP_____ Other_____ Fuel Oil Grade No.

Gas Firing

Gas Pressure at Train Inlet
Burner in Off Position_____" W.C.

Gas Pressure at Train Inlet
Low Fire
High Fire

Gas Pressure at Firing Head
Low Fire
High Fire

Gas Pressure at Pilot Test Tee

Power Supply
Volts____ Ph____Hz
Control Circuit Volts
Blower Motor amps at high fire

Induced FGR Damper Position
Low
Fire_____
High
Fire_____

Flame Signal Readings
Pilot
Low Fire
High Fire

CO_2 or O_2 (Specify)
Low Fire
High Fire

CO
Low Fire
High Fire

Input Rate BTU/HR
Low Fire
High Fire

Over Fire Draft
Low Fire
High Fire

Windbox O_2
Low Fire
High Fire

Stack Outlet Test Draft
Low Fire
High Fire

Net Stack Temperature
Low Fire
High Fire

Combustion Efficiency
Low Fire
High Fire

NOx Measured
Low Fire_____
HIgh Fire_____

Sound Attenuator Setting
Low Fire_____
High Fire_____

Windbox Pressure
Low Fire_____
High Fire_____

Oil Firing

High Fire Vacuum Reading at Oil Pump Inlet_____" H.G

Gas Pressure at Pilot Train Inlet
(If Applicable)

Gas Pressure at Pilot Test Tee
(If Applicable)

Oil Nozzle Pressure
High Fire

Atomizing Medium Nozzle Pressure
Low Fire
High Fire

Power Supply
Volts____Ph____ Hz
Control Circuit Volts

Blower Motor amps at
High Fire

Remote Oil Pump Motor amps
High Fire

Flame Signal Readings
Pilot (If Applicable)
Low Fire
High Fire

GPH Firing Rate
Low Fire
High Fire

CO_2 or O_2 (Specify)
Low Fire
High Fire

Bachrach Scale Smoke Number
Low Fire_____
High Fire_____

Over Fire Draft
Low Fire_____
High Fire_____

Stack Outlet Test Point Draft
Low Fire

High Fire

Net Stack Temperature
Low Fire
High Fire

Combustion Efficiency
Low Fire _____ %
High Fire _____ %

30

NOx Measured
Low Fire _____
High Fire _____

Sound Attenuator Setting
Low Fire _____
High Fire _____

Induced FGR Damper Position
Low Fire _____
High Fire _____

Windbox O_2
Low Fire _____
High Fire _____

Windbox Pressure
Low Fire _____
High Fire _____

Control Settings

General	Gas	Oil	
Operating control cut out setting	Low gas pressure switch	Low oil pressure switch psig	_____
Operating control cut in setting	High gas pressure switch	High oil pressure switch psig	_____
Limit control cut out setting			
Limit control cut in setting			

Operation Checklist

Checked For Proper Operation Of:	Yes	No	Yes	No
Low water cut off	( )	( )	Barometric damper	( ) ( )
High water cut off	( )	( )	Boiler room combustion air and	
Flame safeguard control ignition failure	( )	( )	ventilation provisions correct	( ) ( )
Flame safeguard control main flame failure	( )	( )	Oil tank vent system checked	( ) ( )
burner air flow switch	( )	( )	All oil lines checked for leaks	( ) ( )
Induced draft fan controls	( )	( )	All gas lines checked for leaks	( ) ( )
Over fire draft controls	( )	( )	Gas lines and controls properly vented	( ) ( )
Fresh air damper end switch	( )	( )	Other system components (specify)	( ) ( )

Notified_____ of the following system deficiencies:_____