Hot Surface & Spark Ignition

Gas Heating Repair Guide

Electrical & Mechanical Test Procedures

A step-by-step guide to problem solving

Topics Include:

- Vent pressure safety switch circuits
- ECM motors
- Airflow calculation
- Flame detection safety circuit
- Spark ignition intermittent pilot system
- Direct spark ignition systems
- Induced draft blower motors

And more....

Prokup Media™

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Important Notice:

The material in this guide is for instructional use only and in no way supersedes or replaces the manufacturer's installation and operating instructions. Always follow manufacturer instructions. Prokup Media Inc. assumes no responsibility for failure to follow directions and poor safety practices of installers and technicians using this guide.

The two most common causes of furnace malfunction

When a gas furnace has locked out due to a malfunction, modern gas furnaces will flash an LED indicator light to indicate the problem. In many cases, the actual safety circuit problem may be caused by a fundamental mistake made at the time of installation.

There are two common problems that furnaces encounter, one is a lack of combustion air and the other is low inlet gas pressure to the gas valve. Both of these conditions can lead to nuisance problems with the furnace safety circuits.

Before beginning testing of a potential problem, first ensure that proper combustion air is present and that there is adequate gas pressure at the inlet to the gas valve.

Combustion Air Requirements

When a gas furnace draws combustion air from the room where it is installed, the room area must be large enough to provide enough air for the induced draft blower and burners. If the room is too small, the furnace’s induced draft blower may pull a negative pressure in the area and may draw Carbon Monoxide vent gas back down the vent pipe of other gas fired equipment in the space. For example, a water heater vent pipe. This condition is dangerous and could produce Carbon Monoxide poisoning or may cause ignitor cracking or burner limit trips.

Common signs of this condition are multiple hot surface ignitor failures, dark brown discoloration of the top of the water heater and nuisance burner limit trips. The condition will primarily occur during periods where the furnace has long run times such as cold days.

The National Fuel Gas Code requires that a minimum of 50 cubic feet of combustion air must be present for every 1000 BTUH of gas capacity input of all appliances contained in the space. If the space has adequate area, the job is classified as UNCONFINED. If the area is too small, the job is classified as CONFINED.

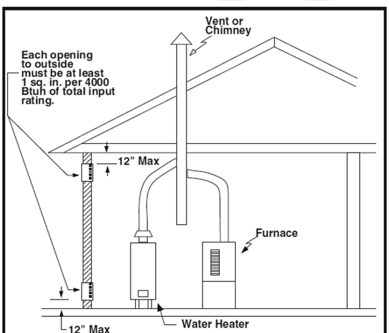
In confined spaces, combustion air must be brought into the room per the instructions in the furnace installation guide that came with the appliance. In most cases, two permanent openings are required into the furnace installation area. In some cases, the openings cannot be obtained per the instructions in the furnace installation guide. In that case, a direct vent two pipe 90% efficient furnace may be required. Always refer to the installation instructions that came with the furnace for details.

Example: Combustion Air Requirements (continued)

CAUTION:
Do not supply combustion air from an attic space that is equipped with power ventilation or any other device that may produce a negative pressure.

Air Directly Through An Exterior Wall (Figure 10)
If combustion air is provided directly through an exterior wall, the two openings must each have free area of at least one square inch per 4000 Btuh of total appliance input.

Outdoor Air Using a Crawl Space and Ventilated Attic (Figure 11)
When directly communicating with the outdoors, each opening shall have a minimum free area of 1 square inch per 4,000 Btuh of total appliance input. The openings shall communicate directly, or by ducts, with the outdoor spaces (crawl or attic) that freely communicate with the outdoors.



Total Input Rating (Btuh)	Minimum Free Area (Each Opening)	Round Duct Diameter
40,000	10 sq. in.	4"
60,000	15 sq. in.	5"
80,000	20 sq. in.	5"
100,000	25 sq. in.	6"
120,000	30 sq. in.	6"
140,000	35 sq. in.	7"
160,000	40 sq. in.	8"

Figure 10. Equipment in a Confined Space with Combustion Air Drawn from the Outside through Exterior Wall

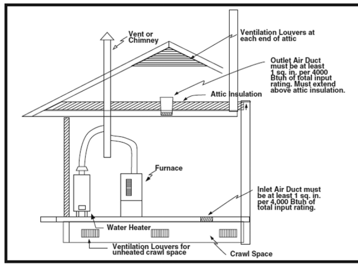
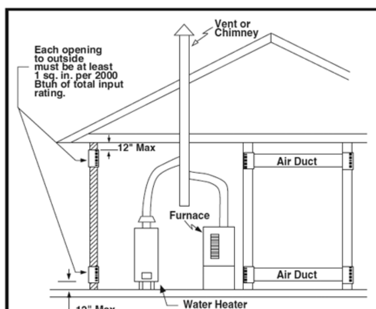


Figure 11. Equipment in a Confined Space with Combustion Air Drawn from a Crawl Space and Ventilated Attic

Outdoor Air Using Horizontal Ducts (Figure 12)
If combustion air is taken from outdoors through horizontal ducts, the openings and ducts must have a minimum free area of one square inch per 2,000 Btuh of total appliance input.

If the unit is installed in an area with an exhaust fan, provide sufficient ventilation to prevent negative pressures from occurring in the room.

The combustion air openings must not be restricted in any manner.



Total Input Rating (Btu/hr)	Minimum Free Area (Each Opening)	Round Duct Diameter
40,000	20 sq. in.	5"
60,000	30 sq. in.	6"
80,000	40 sq. in.	7"
100,000	50 sq. in.	8"
120,000	60 sq. in.	9"
140,000	70 sq. in.	10"
160,000	80 sq. in.	10"

Figure 12. Equipment in a Confined Space with Combustion Air Drawn from the Outside through Horizontal Ducts

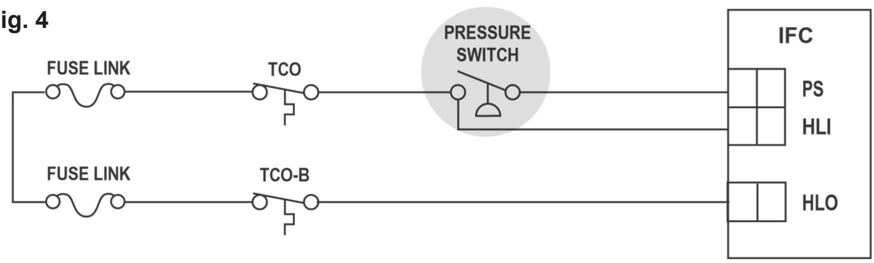
Check the calibration of the vent pressure switches to ensure they operate properly. If the furnace cannot produce enough pressure to close the pressure switch(es), there is a mechanical problem with either the furnace or the vent. Ensure both are properly operating.

Perform any maintenance possible to the vent motors such as oiling. Check condensate drains on 90% furnaces to ensure they are not plugged or leaking.

Prepurge Period		
80% Efficient Models		
Motor Condition: Good Fair Poor (Oil if Possible)	**Inner Housing and Wheel Condition:** Good Fair Poor	**Check Pressure Switch Tubing for Cracks:** OK Needs Replacing
Flue Condition: Good Needs Replacing Problem:	**Pressure Switch Have Shorted Prior to Induced Draft Motor Operation Safety:** Yes No	
Pressure Switch Safety Check: Switch Closes @_________"w.c. Within Specs?: Yes No	**Conditions Requiring Repair:**	
90% Efficient Models		
Model Type: Non-Direct Vent Direct Vent	**Pipe Size:**	**Estimated Pipe Length (ft):**
Piping Visual Inspection: OK If not, Problem:	**Condensate Drain:** OK If not, Problem:	**Inducer Motor Type:** Variable Speed PSC Shaded Pole
Motor Condition: Good Fair Poor (Oil if Possible	**Tubing Condition:** Good Needs Replacing	**Pressure Switch Have Shorted Prior to Induced Draft Motor Operation:** Yes No
Pressure Switch Safety Check: Switch Closes @________"w.c. Within Specs?: Yes No	**Conditions Requiring Repair:**	
Low Efficiency Models Below Current 80% Efficiency		
Inspect Flue Piping: OK Needs Repair If so, Problem:	**Draft Hood Condition:** Good Fair Poor	**Draft Hood Limit:** OK Needs Replacing If so, Problem

A Typical Vent Pressure Safety Switch Circuit

Fig. 4



This schematic drawing **(Fig. 4)** shows a vent pressure safety circuit that is connected to an integrated furnace control (IFC) from White-Rodgers. The IFC control sends 24 volts through the vent pressure safety switch to monitor the position of the switch during a call for heat. In this series of White-Rodgers IFC controls, the switch is monitored to make sure it is in the open position prior to induced draft motor operation, and in the closed position during induced draft motor operation.

By monitoring the switch position prior to induced draft motor operation, the IFC confirms that the switch is not in a stuck closed position and that the switch has not been tampered with. If the IFC receives 24 volts back to the PS terminal without the induced draft motor being energized, the IFC knows that a jumpered, stuck, or shorted vent pressure safety switch is present. If this condition is detected, the IFC will not allow the ignition sequence to occur. The furnace burner section will remain OFF until the problem is corrected.

If the IFC detects that the vent pressure safety switch is in the open position prior to induced draft motor operation, it will then energize the induced draft motor to begin a pre-purge cycle.

With the induced draft motor energized by the IFC, the control now checks for 24 volts on its PS terminal. If the switch is closed, there will be 24 volts present. This tells the IFC that adequate negative pressure is present and to initiate the trial for ignition sequence.

Most, if not all, modern gas furnace IFC boards function in a manner similar to the sequence just described. In addition, some furnace designs may have the vent pressure safety switch wired in series with the gas valve 24 volt signal. This type of configuration will not be able to detect a jumpered or shorted vent pressure safety switch.

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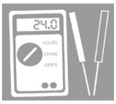
Vent Pressure Safety Switch Check

The vent pressure safety switch may fail to close due to a problem with the furnace, flue system, or the vent pressure safety switch may be bad. This procedure will determine which problem is present.



What you will need:
- Multimeter
- Magnehelic gauge

Procedure

1. Inspect the wire and hose connections to the vent pressure safety switch for defects such as cracked hosing. If any defects are found, make the necessary repairs. If all hoses and connections are sound, disconnect power to the furnace and remove the wires from the vent pressure safety switch terminals.

2. Using an ohmmeter, measure the resistance across the switch terminals **(Fig. 4,5)**. If no resistance is measured, the switch is shorted and must be replaced with one of equal rating.* Once the pressure switch has been replaced, recycle the furnace to confirm proper operation. If the resistance is infinite, the switch is in an open position. If the switch is open, proceed to the next step.

Fig. 4

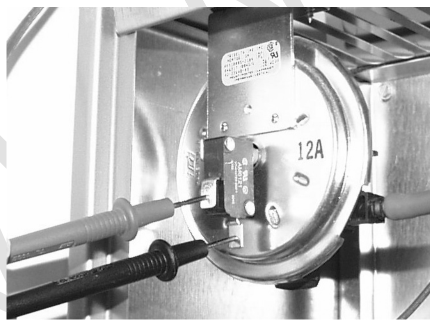
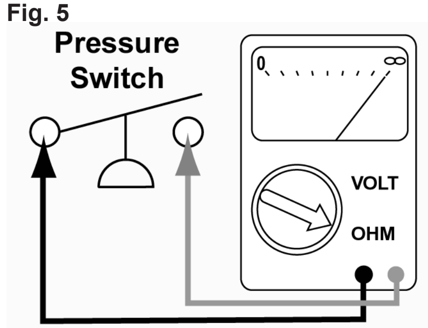


Fig. 5



**Make sure the switch does not have water in it. If there is water, drain the water from the switch and recheck the resistance. If it is now infinite, try recycling the furnace to see if the switch operates properly.*

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Purpose

Flame roll-out/over-temperature switches protect the burner area from abnormally high temperatures. These switches are located in the gas burner compartment and are wired in series with the safety control circuit of the gas furnace. Some earlier furnace designs had these switches wired in series with the furnace gas valve or W signal from the thermostat. When an abnormally high temperature level occurs at the burner area, the switch will open to shut down the gas valve circuit. There are three types of switches you may encounter, a onetime fail device such as the fuse link type **(Fig. 1)**, a bi-metal manual reset type **(Fig. 2)**, or a bi-metal one time fail switch.

Fig. 1

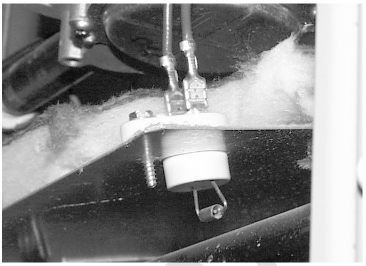
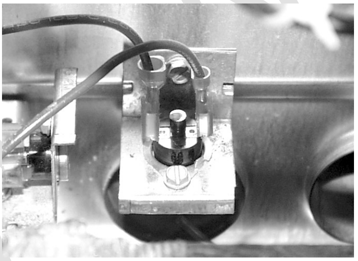


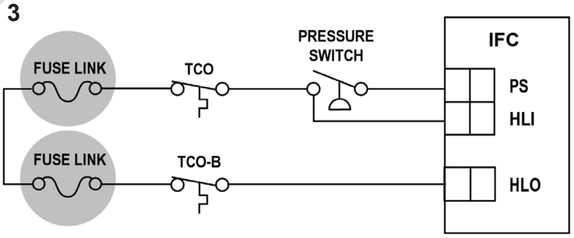
Fig. 2



Flame Roll-Out/Over-Temperature Switch Circuits

These switches are typically wired into a safety circuit **(Fig. 3)** that informs the furnace IFC board when a switch has opened. The IFC monitors this circuit by applying a 24 volt signal to the safety circuit loop. If the IFC senses the loss of the 24 volt signal from the safety circuit, it knows that the flame roll-out switch has opened. If this condition occurs, the IFC shuts down the gas valve, and in most cases runs the induced draft blower motor and indoor air blower motor until the switch is reset or replaced. *IF THE SWITCH OPENS, THE CAUSE OF ABNORMALLY HIGH BURNER AREA TEMPERATURE MUST BE DETERMINED.*

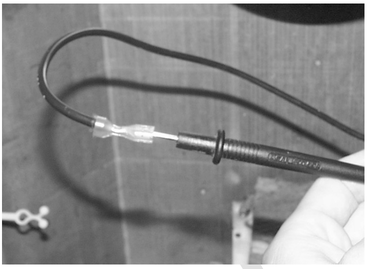
Fig. 3



With furnaces that have the switch wired in series with the gas valve, the 24 volt signal from the thermostat is broken by the switch in cases of abnormally high burner area temperature. In this type of circuit, the gas valve cannot energize if the flame roll-out/ over-temperature switch opens.

5 Connect the black lead from the multimeter to the wire connector earlier removed from the flame sensing rod assembly **(Fig. 1)**.

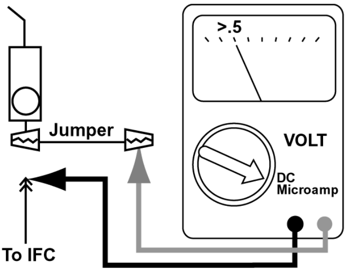
Fig. 1



6 Set the multimeter scale to read DC microamperes. Restore power to the furnace and initiate a call for heat from the thermostat.

7 Once the flame is established, read the flame current level on your multimeter scale **(Fig. 2)**. You should measure a flame current that meets or exceeds the minimum flame detection microamp rating for that specific furnace. (Typically in excess of .5 DC microamps.)* Please note that some controls only need .5 DC microamps to operate properly.

Fig. 2



If the flame current is insufficient, check for the following:

Make sure that the flame is properly enveloping the flame sensor rod. If not, check for improper gas pressure at the manifold assembly and for plugged burner orifices.

Make sure the furnace is wired to provide proper power polarity to the IFC. The flame detection circuit can be adversely affected by reverse polarity.

Make sure the flame rod is clean. The flame sensor rod may conduct low current flow due to contamination build up. A flame rod can be cleaned with fine steel wool.

Make sure the ceramic insulator is not cracked, which may short the flame sensing voltage to ground. If it is cracked, replace the flame sensing rod assembly.

Make sure the wire that connects the flame sensing rod to the IFC control is not broken and is in good condition.

End

Purpose

Intermittent spark ignition systems use a high voltage spark generator circuit to provide the ignition source for a pilot flame, that in turn ignites the air/fuel mixture at the burners. This type of system first lights a pilot flame, proves the pilot flame is present via flame rectification, then energizes the main gas valve solenoid to allow gas flow to the burners. The main gas valve solenoid will remain energized as long as there is a call for heat present and adequate flame current is being sensed at the ignitor /sensor assembly **(Fig. 5)**. *Intermittent spark ignition systems are used on atmospheric gas burners. Use on direct vent and power burners is prohibited.*

Fig. 5

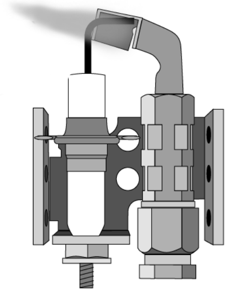
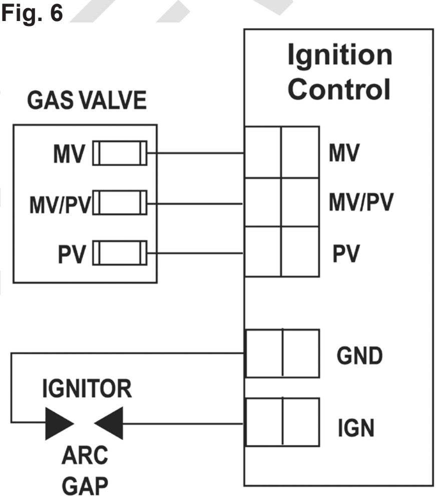


Fig. 6



How the Circuit Works

When a call for heat occurs, the spark generator will send a high voltage signal through a high tension lead to the spark ignitor assembly **(Fig. 6)**. This high voltage will jump the gap from the spark rod to the ground rod or pilot flame hood on the spark ignitor assembly. *The gap is typically 1/8" between the spark rod and ground.* At this same instant, another out of phase AC voltage is sent out on the same high tension lead to the ignitor. This voltage signal is the source voltage for the flame detection circuit.

The control board will energize the pilot solenoid valve by sending a 24 volt signal to the gas valve's 24 volt pilot solenoid terminal (usually labeled "PV"). Pilot gas will begin to flow through the pilot tube assembly to the pilot orifice that meters the pilot gas at the ignitor assembly.

With pilot gas flowing and oxygen present, the high voltage spark ignites the air/fuel mixture and a pilot flame is established. The flame envelopes the ignitor rod and the pilot flame hood or ground rod of the ignitor. With the out of phase AC potential present at the ignitor rod and flame making a conductor path between the rod and ground, flame

Procedure *The following procedure assumes the ignitor is failing to spark and no pilot gas is present at the pilot burner orifice.*

1. Recycle power to the furnace by removing and restoring power. This will reset the ignition control if it is in lockout mode. Initiate a new call for heat to retry ignition. If the ignition fails to initiate another retry, proceed to step 2.

2. With a call for heat present, use a voltmeter to check for 24 volts to the ignition control on the TH terminal (Call for heat terminal) to ground **(Fig. 1,2)**. If 24 volts are not present, check the low voltage wiring circuit for an open safety control or a 24 volt control circuit problem. Make any repairs or adjustments to the low voltage circuit and retry ignition. If voltage is present to the ignition control, check to make sure the ignition control is grounded properly. If not, correct the ground problem and retry ignition. If the control is properly grounded, yet fails to initiate a trail for ignition, replace the control.

End

Fig. 1

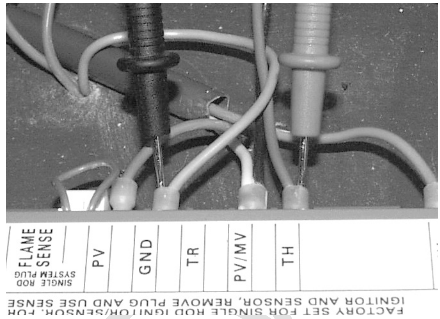
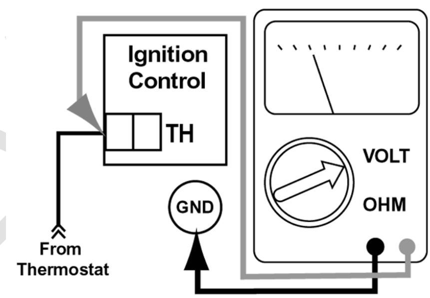


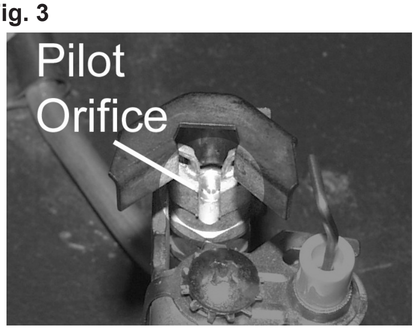
Fig. 2



Procedure *The following procedure assumes the ignitor is sparking and no pilot gas is present at the pilot burner orifice.*

1. Check the pilot orifice at the ignitor assembly for an obstruction **(Fig. 3)**. If the pilot is clogged, clean the orifice and retry ignition. If the pilot assembly is clear of obstruction yet no pilot gas is present, proceed to the next step.

Fig. 3



2. Initiate a call for heat. When the ignitor begins sparking, check for 24 volts at the ignition control PV (pilot valve solenoid) terminal to ground **(Fig. 4,5)**. You should measure 24 volts. If you do not have voltage, replace the ignition control. If proper voltage is present, confirm the presence of voltage on the PV terminal at the gas valve **(Fig. 6,7)**. If no voltage is present, the wire between the gas valve and ignition control terminal is open and must be replaced. If voltage is present, proceed to the next step.

Fig. 4

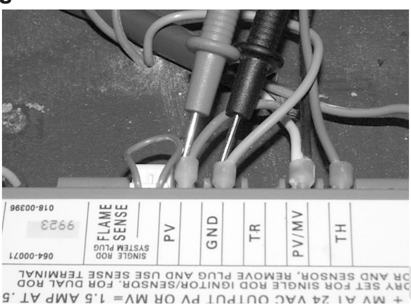


Fig. 5

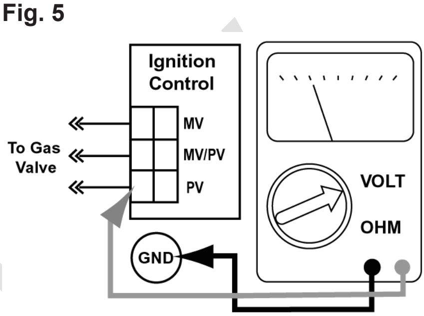
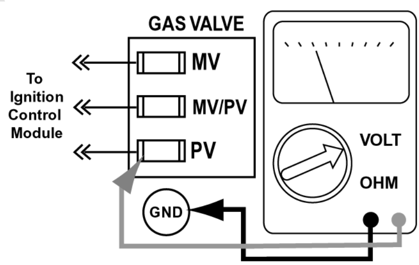


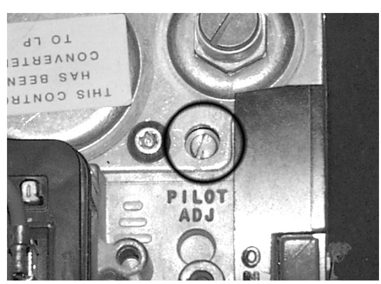
Fig. 6

Fig. 7



3. Determine if proper incoming supply gas pressure* is present at the gas valve and confirm the pilot gas valve is a turned ON position **(Fig. 8)***. Make any necessary adjustments and attempt a trail for ignition. If the pilot continues to fail, the gas valve pilot solenoid is bad and the gas valve must be replaced.
** See the gas valve portion of this book for procedure*

Fig. 8



End

between the rod and ground, flame rectification occurs. A small DC microampere current is sensed by the ignition control.

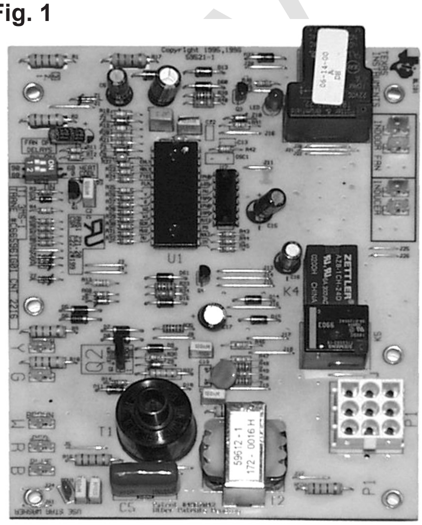
If the flame current level is within the required minimum range of the ignition control, the ignition control maintains a 24 volt signal to the gas valve as long as a call for heat is present. If at any time during the call for heat, the flame current should drop below the minimum level required by the ignition control, the control will immediately de-energize the main gas valve.

Lock out and non-lockout IFC controls

The two common types of IFC controls **(Fig. 1)** are the lockout type and non-lockout type. The lockout type of control will begin a timed sequence during which ignition is attempted. If the control fails to detect flame during this time period, the control will typically go through a time delay period and retry ignition. If the control fails to detect flame after a predetermined number of consecutive attempts for ignition, the control will lockout and prevent further ignition attempts until the call for heat or power to the IFC is interrupted. This control is common to both natural and LP (Liquid Petroleum) fuel systems. Non-lockout controls will continuously attempt ignition regardless of the number of failed ignition attempts and as long as a call for heat is present. This type of control should never be used with LP fuel systems.

The flame detection response time of various controls is usually less than 1 second. This means that if flame current is lost, the control will detect the loss of flame and respond very rapidly to shut off gas flow to the main burners by de-energizing the gas valve main solenoid.

Fig. 1



Testing a Silicon Nitride Ignitor

What you will need:
- Multimeter

Procedure *Checking Line Voltage Neutral*

When servicing gas furnaces with Silicon Nitride ignitors, always check for a proper line voltage neutral by measuring for AC voltage potential on the neutral line.

1. When servicing gas furnaces with Silicon Nitride ignitors, always check for a proper line voltage neutral by measuring for AC voltage potential between a white neutral wire **(Fig. 2)** on the furnace control board and a green ground wire **(Fig. 3)**.

2. If the neutral connection is proper, the voltage should read 0 volts. (Voltage potential above 9 volts AC will cause eventual ignitor failure.) If a voltage potential is detected, check for a loose neutral wire connection between the furnace and the home's electrical service.

3. Correct any loose wire connections. In some instances it may be necessary to contact a licensed electrician to perform these tests.

End

Fig. 2

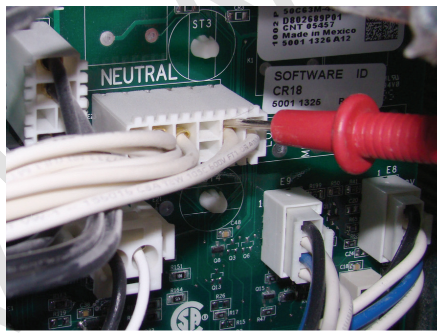
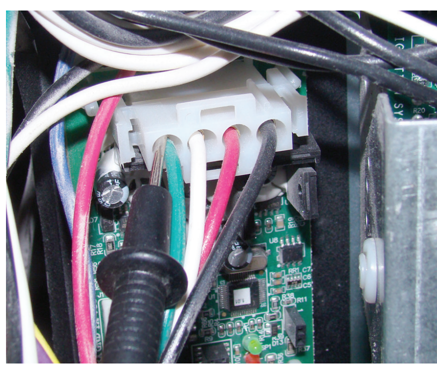


Fig. 3

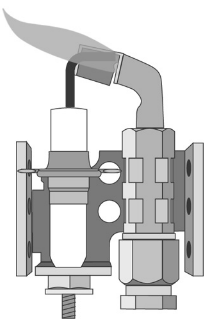
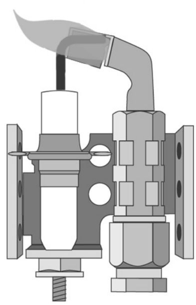
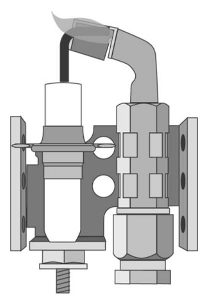


Procedure

Gas valve pilot pressure adjustment

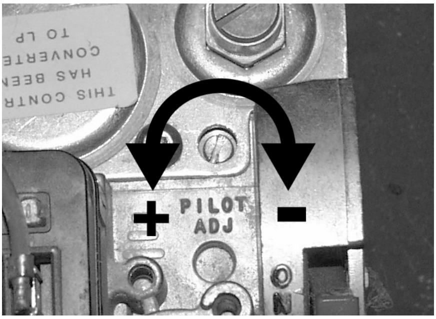
1. The furnace control will fail to recognize the presence of pilot flame via flame rectification if the pilot flame does not provide proper coverage of the flame sensing rod. Before performing this procedure, remove the wire from the MV terminal at the ignition control to prevent the main gas valve from opening.

2. Initiate a call for heat and observe the pilot flame once pilot flame ignition occurs. Note the position of the pilot flame to the flame sensing rod. The pilot flame should adequately envelope the tip of the flame sensor rod without lifting from the pilot hood or burning back toward the burner orifice.

Pilot gas pressure too high	**Proper pilot gas pressure**	**Pilot gas pressure too low**
		
Pilot flame lifts above pilot hood	Flame provides maximum coverage of flame rod	Flame burns back towards orifice

3. To adjust the pilot flame, locate the pilot adjustment screw on the gas valve **(Fig. 4)**. If the pilot gas pressure is too high, turn the screw clockwise to decrease the pilot flame. If the pilot gas pressure is too low, turn the screw counterclockwise to increase the pilot flame.

Fig. 4



End

Indoor Blower Fan PSC Motor Check

The blower motor features an internal thermal overload to protect the motor winding from overheating. If the motor is hot, allow it to cool down before checking the motor.

What you will need:
- Multimeter

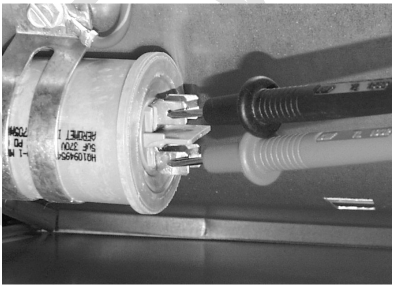
Procedure

Single speed PSC motor with internal overload

1. Disconnect power to the furnace.

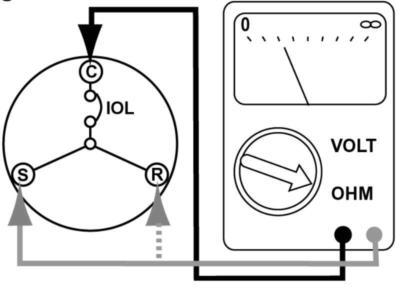
2. Use an ohmmeter to check the indoor blower motor capacitor. After discharging the capacitor with an insulated screw driver or like device (Use caution to avoid shock and potential injury), Place one ohmmeter lead on each of the capacitor terminals. If the capacitor is working properly, the ohmmeter should ramp up and then ramp down. If the capacitor fails to respond, it is bad and must replaced. If it is good, go to the next step.

Fig.1



3. Using an ohmmeter, check for resistance between Common and Run winding, and between Common and Start winding of the indoor blower motor. You should measure resistance between each winding **(Fig. 3)**. If you measure infinite resistance from both Common to Run and Common to Start windings, the internal overload is open and the motor must be replaced. If you measure infinite resistance from common to only one winding, that winding is open and the motor must be replaced.

Fig. 3



The information in this portion is provided courtesy of Regal-Beloit Corporation

The ***motor control*** **(Fig. 2)** is the brains of the device, where single phase (1Ø) 120 or 240 VAC 60 cycle (Hertz/frequency) power is connected. The control then converts AC power to DC power to operate the internal electronics, thus the name DC motor. The microprocessor in the motor control is programmed to then convert DC power (by means of electronic controls) to a three phase (3Ø) signal to drive the motor, thus the name Three Phase Motor. It also has the added ability to control the frequency (which controls the speed in revolutions per minute) and the amount of torque (current/power) it delivers to the motor.

Fig. 2

Fig. 3

The ***motor*** **(Fig. 3)** is essentially a three phase motor with a permanent magnet rotor. The permanent magnet rotor contributes to the electrical efficiency of the ECM and also to its sensor-less ability to control the rpm (revolutions per minute) and commutation (when to alternate the cycle). Typical DC motors require brushes to provide the commutation function. This is where the motor gets the name brushless DC motor.

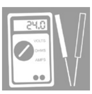
The benefit of all of this technology is increased electrical efficiency and the ability to program more precise operation of the motor, over a wide range of HVAC system performance needs, to enhance consumer comfort.

OBJECTIVE - Temperature Rise Method

The most popular method of determining how much air is present, is by the temperature rise method. This process can be used when either a gas furnace or an electric heat section is present. The procedure requires you to run the heating system to obtain a temperature rise difference between the supply air and return air temperatures. This difference is called Delta-T ($\triangle$T). The Delta-T value will be used in a mathematical formula to establish the indoor airflow volume.

The procedure and formula for measuring airflow with gas and electric heat systems are not the same. The procedures used for both types of systems are explained in this section.

What you will need:



- ***Thermometer***
- ***Calculator***

Procedure

Gas Heating Temperature Rise Method

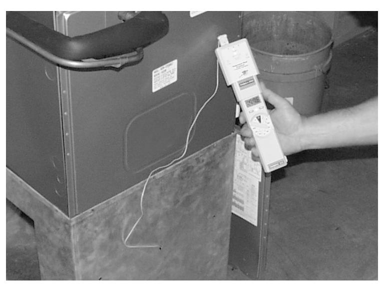
1. Give the system a Call For Heat and confirm the heating section is running. If the system is Two-Stage, make sure both stages of heat are on.

2. Establish what the heating capacity of the gas furnace in BTUH Output (reference the furnace nameplate). Record this value.

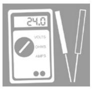
3. Run the heating system and allow time for the system temperatures to stabilize. The indoor blower should be on.

4. Measure the temperature of the return air at the furnace filter rack **(Fig. 1)**. Record this value.

Fig. 1



What you will need:



- ***Magnehelic Pressure Probe***
- ***Drill***

Procedure

Total External Static Pressure - Air Handler

1 Make an access hole at the discharge supply air outlet area of the air handler **(Fig. 1)**. Insert the HIGH pressure probe into this hole. When inserting the probe, place the tip of the probe to face into the air stream.

2 Determine if the filter is included in the air performance data chart. If the filter is included, drill a hole where return air duct attaches to the air handler. If the filter is not included, drill a hole into the blower door of the air handler in a spot where no damage will occur and where the probe when inserted will not touch anything electrical **(Fig. 2)**. Insert the LOW port probe into this hole and position the tip to face the direction of return air.

FILTER NOTE:
Manufacturer charts, when including a filter in the data, are specifying a factory installed filter, not a high efficiency add on filter! If a high efficiency filter has been added to the air handler, remove the factory installed filter and measure return air static via a hole in the air handler door.

Fig. 1

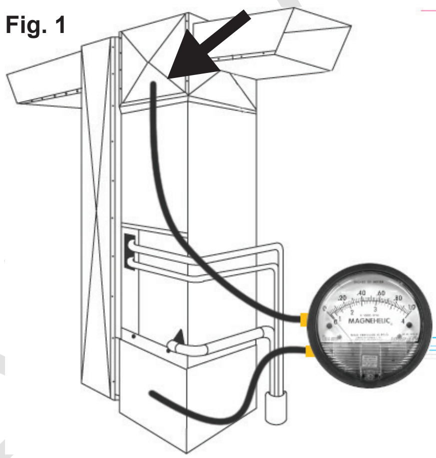
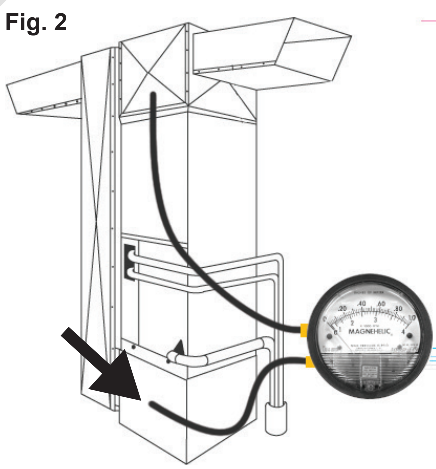
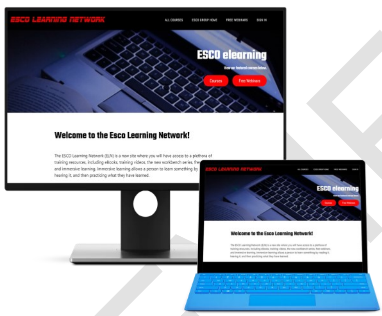


Fig. 2





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