Gas Appliance Engineers Handbook

SECTION 13B

AUTOMATIC BURNER IGNITION AND SAFETY SHUTOFF DEVICES

AUTOMATIC BURNER IGNITION AND SAFETY SHUTOFF DEVICES AND PILOT BURNERS

by Robert W. Newell - Eastern Chapter

Automatic burner ignition and safety shutoff devices and pilot burners have been designed to perform the main function of providing a safe means of igniting the gas flowing from the main burners. Simultaneously these controls provide an automatic safety check to continuously signal the main control circuit that the igniting means is ready at any time for the main gas flow to be turned on.

As defined by A.G.A.:

AUTOMATIC IGNITION. Ignition of gas at the burner(s) when the gas controlling device is turned on, including reignition if the flames on the burner(s) have been extinguished by means other than by the closing of the controlling device.

SAFETY SHUTOFF DEVICE. A device that will shut off the gas supply to the controlled burner(s) in the event the source of ignition fails to ignite the gas at the burner(s). This device may interrupt the flow of gas to the main burner(s) only, or to the pilot(s) and main burner(s) under its supervision.

PILOT. A small flame which is utilized to ignite the gas on the main burner(s).

American Standard Listing Requirements for Automatic Burner Ignition and Safety Shutoff Devices, ASA Z21.20 is considered the basic standard for safe, good performing, and long lasting pilot systems. Inherent quality and reliability must be built into the design of the components that make up the system.

TYPES OF PILOT SYSTEMS

Three basic designs are in general use that use a pilot burner:

1. Thermoelectric generation through the use of a thermocouple that operates a small electro magnet located in the pilot relay. See Figure 1.

2. Bimetal action by using the heat in the pilot flame to warp the bimetal element to operate contacts in the electric control circuit. See Figure 2.

3. Expansion of liquid on gas in a tube that in turn works against a bellows or diaphram, opening or closing contacts by the mechanical action of the bellows or diaphram.

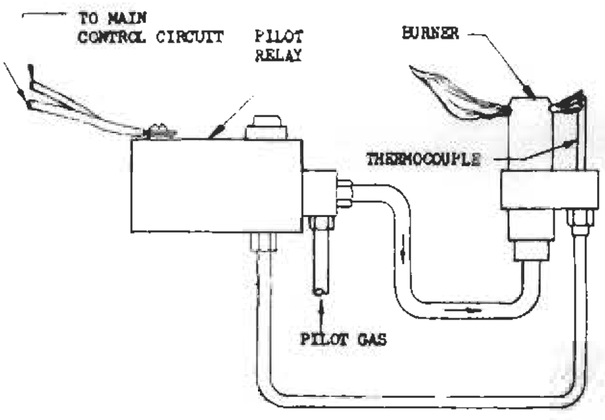

Figure 1 - Thermoelectric Generation Type Safety Shutoff Control

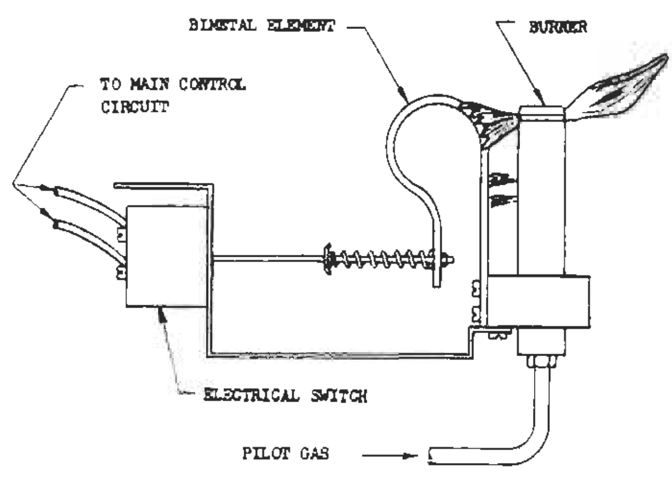

Figure 2 - Bimetal Type Safety Shutoff Control

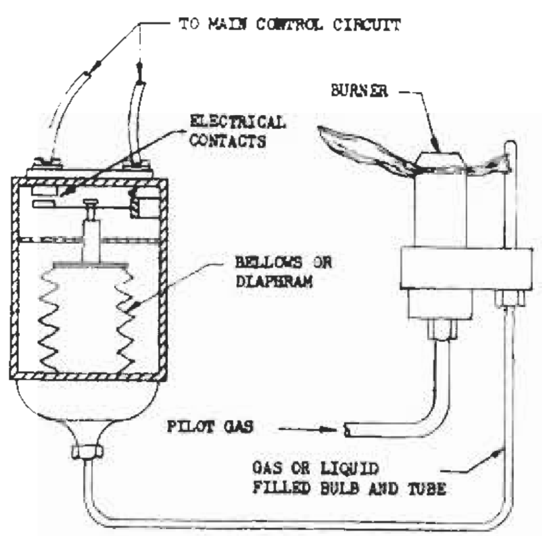

Figure 3 - Gas or Liquid Expansion Type Safety Shut-off Control

Characteristic of all three systems is the proper combustion of the gas at the pilot burner to effect:

1. Safe ignition of the main burner
2. Good flame characteristics at the burner tip to prevent lifting; flash back to the orifice, too harsh of a flame caused by too much primary air, high or low pressures at the burner causing erratic operation.

IMPORTANCE OF PILOT BURNER LOCATION

Safe ignition of the main burners depends a great deal on the proper location of the pilot burner with respect to the main burners. Considerations to be taken into account are:

1. Immediate ignition of main burner gas within requirements for the particular appliance on which the pilot is mounted.
2. Prevent impingement of main burner flame on pilot burner.
3. Causing too high ambient temperature at pilot burner with corresponding result in lazy yellow pilot flame.
4. Flame out or erratic burning pilot burner due to main burner secondary air passing around the pilot or high draft conditions experienced during shut down periods.
5. Smothering action does not take place when main burners are on. This would result from too much products of combustion and not enough air around pilot burner.
6. Proper positioning of pilot burner parts to effect ignition even though some of the parts are clogged or blocked up.
7. Proper location of safety sensing element to be effected only by the pilot flame.

The location of the pilot burner to obtain the correct pilot action is a matter of experimentation. Important points to be considered are:

1. Pilot burner location easily accessible for igniting at start up.
2. Easily accessible for cleaning and servicing.
3. Does not become erratic at ignition or extinguishing of the main burners.
4. Maintains a fixed position with respect to the main burners.

OPERATION UNDER TEST CONDITIONS

When operating under test conditions, the pilot burner must perform the following:

1. Ignite the main burners under all burner test conditions.
2. Will not go out when:
   a. Main burners are burning at 25% above normal manifold pressure.
   b. Main ignition takes place from a cold start.
   c. Changes in air adjustment are made at the main burner face.
   d. Maximum temperature conditions of the appliance are maintained.
   e. Rapid cycling and normal operation of the burners occur.
3. When the flame of the pilot is reduced by restricting the flow of gas at the "B" cock to a point just sufficient to keep the main gas valve open, ignition of the main burners must take place within four seconds from the time gas is admitted to the main burners.
4. The same test repeated at normal input and pressure with ignition of the main burners taking place within four seconds each time for 15 cycles.
5. Not exceed the maximum operating temperature recommended by the manufacturer on critical or specified component parts.
6. Meet the requirements on leakage and capacity requirements as specified by Listing Requirements for Automatic Burner Ignition and Safety Shutoff Devices ASA Z21.20.
7. After the pilot flame is ignited, the gas must be supplied to the main burners within three minutes:

Exception:

The time must not exceed 1-1/2 minutes when -

a. The safety shutoff systems require a manual force to assume the on position.

b. The safety shut off systems operate by igniting the pilot flame

8. When the pilot flame is extinguished, the gas supply to the main burner must shut off within 2-1/2 minutes.

9. The safety shutoff control system must sustain 720 hours of operation at the maximum operating temperature specified for the component parts without failure.

10. Operation of moving parts of the safety shutoff control system must withstand 20,000 complete cycles at room temperature without failure.

11. At no time during the tests is there to be any carbon deposit made by the pilot flame.

PILOT FLAME CHARACTERISTICS

Good flame characteristics are generally described as the clear blue flame of the bunsen burner type having neither a yellow tipping or a sharp, harsh shape. Factors that determine good flames are:

1. Proper selection of orifice for type of gas being used.

2. Proper pressure at orifice to obtain good gas flow and aspirating effect.

3. Lack of restrictions in the pilot line or clogging at the orifice or primary air openings.

The design of a pilot burner is considered stable if in the event of failure any of the components affecting the main control circuit, the forces acting to open the circuit shall remain effective.

A very large variety of pilot burners are available to suit a particular appliance design requirement.

THERMOELECTRIC SAFETY SHUTOFF SYSTEM

Electrical energy can be generated through the conversion of heat energy of the pilot flame by use of the thermocouple principle. See Figure 4. The current produced activates a small electromagnet. The electromagnet causes contacts to make or break in the main gas control circuit, and frequently is used to hold a valve in the pilot gas line open when the thermocouple is energized. This last phase of the pilot relay function is called "100% shut off" since it not only causes the main gas supply to be shut off by opening the electrical contacts, but also shuts off the gas supply to the pilot burner.

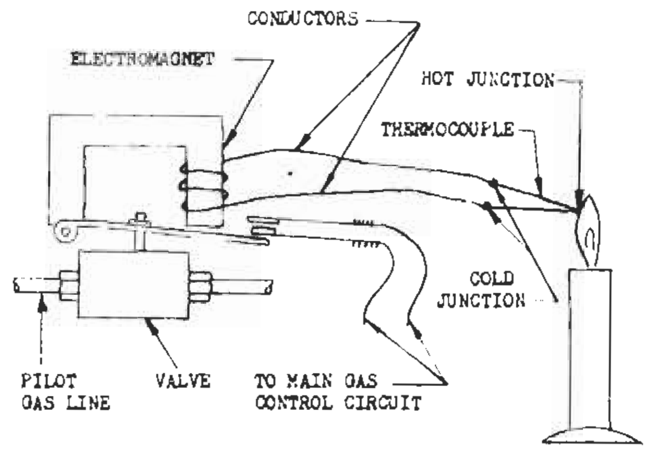

Figure 4 - Diagram Using Thermocouple Principle

The phenomenon of an electrical potential being generated when the junction of two dissimilar metals is heated has been put to a practical use in the design of safety shut off devices. To cause current to flow, the opposite ends of the dissimilar metal elements from the hot junction must be at a lower temperature and electrically isolated from each other. To complete the electrical circuit, conductors are fastened to the cold ends of the metal elements and connected through a load, in this case a small electromagnet. The armature of the electromagnet, generally through linkages, is used to open and close electrical contacts in the main control circuit and to hold open or release a valve in the pilot gas line. The current generated in the thermocouple usually is not enough for pick up of electromagnet but is quite enough for hold in properties. This principle is utilized in making sure the flame of pilot is properly ignited by required manual operation of the armature of the electromagnet until enough energy is generated to maintain a "hold in" position. Most systems when operating will have about 25 to 30 millivolts. "Drop out" of the electromagnet will occur when the potential decreases to below four millivolts.

A typical application of the thermoelectric safety shutoff system is shown in Figure 5. A cross section of a thermocouple is shown in Figure 6.

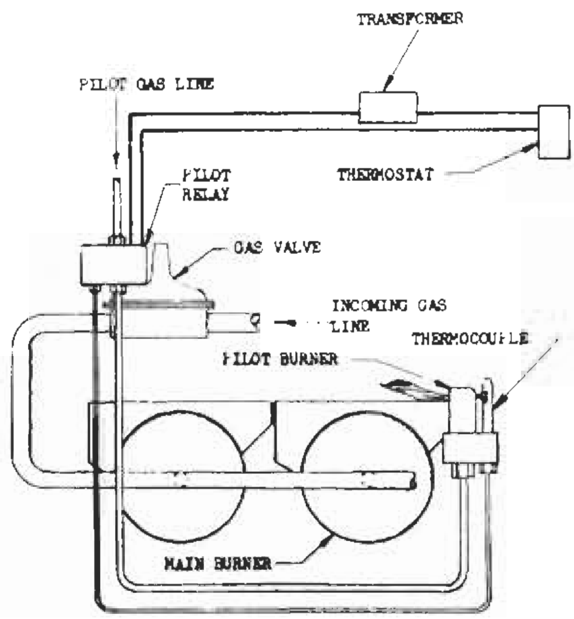

Figure 5 - Thermoelectric Safety Shutoff System

THERMOSTATIC OR BIMETAL SAFETY SHUTOFF SYSTEM

The sketch of a bimetal type safety shutoff control shown in Figure 2 is one of many designs that uses the properties of coefficients of expansion in two different metals. Instead of the "U" shape of the element, some pilot designs utilize the cantilever leaf construction with movement generally amplified through a lever system. There is one distinct advantage in the design of the "U" type shown in Figure 2 and that is the ability to compensate for ambient conditions so that the surrounding temperatures will not affect the operation of the bimetal and give continuous and consistent operation of the control.

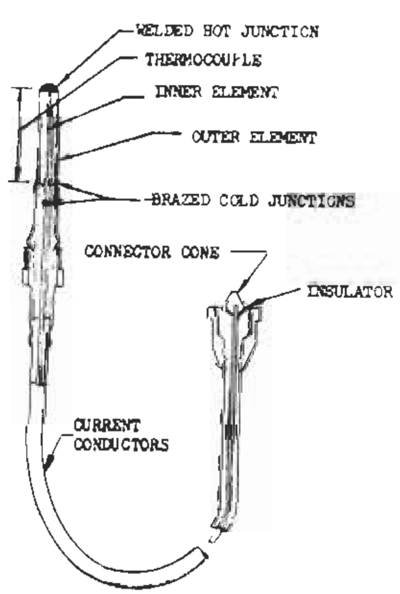

Figure 6 - Diagram of Thermocouple

The bimetal principle lies in the characteristic of metal to expand when heated and to contract when cooled down. Each metal has its own characteristic or coefficient. By firmly bonding two different metals together with different expansion coefficients and holding one end of this element securely, heating the bimetal will cause the free end to move in the direction of the metal that has the smallest expansion characteristics. See Figure 7.

Attaching a mechanism or device to the free end of the bimetal is done to utilize the work energy available to accomplish, as done in a pilot safety circuit, the making and breaking of electrical contacts. As previously mentioned to compensate for ambient conditions and obtain a consistency of movement, the bimetal element is cut at the right location in its length, one end placed upside down to the other, welded back together, and bent into a "U" shape. See Figure 8. Thus any expansion of the bimetal element caused by the temperature surrounding the bimetal

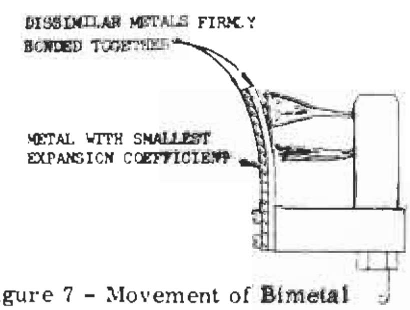

Figure 7 - Movement of Bimetal

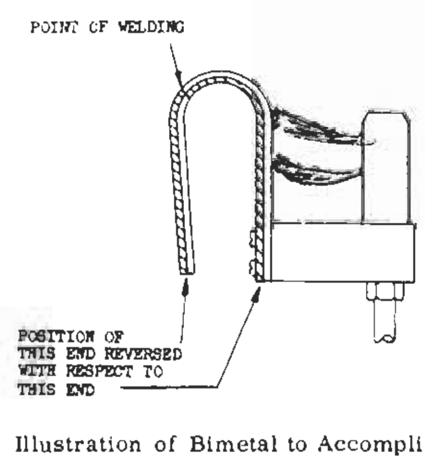

Figure 8 - Illustration of Bimetal to Accomplish Ambient Compensation

element other than that created by the flame is counteracted by the interaction movement of the metals.

Another method by which differences in coefficients of expansion is utilized is by using the same metal, usually stainless, and making two legs from the material. The pilot flame is played against one leg while the other leg is kept relatively cool. By amplifying the resultant movement of the two legs through a lever system, the making and breaking of electrical contacts can be implemented.

LIQUID OR GAS EXPANSION SAFETY SHUTOFF SYSTEM

The sketch shown in Figure 3 illustrates one of many design approaches of this system. This method takes advantage of the expansion of gas or liquid to cause a mechanical action through the movement of a bellows or diaphram. Rods or pins fastened to the diaphram or bellows actuate the contacts to make or break an electrical circuit.

Probably a liquid filled bulb is more advantageous in many respects particularly with the collapse characteristic of vapor on cool down when the gas condenses to liquid. When cool, the entire tube and bellows or diaphram cavity is filled with liquid.

When the pilot burner is ignited, the flame heats the end of the liquid filled tube. This causes the liquid in the end of the tube to boil and create gas which exerts pressure through the liquid back to the bellows or diaphram. The bellows or diaphram moves so that the contacts travel to a closed position.

Should the pilot flame go out for any reason, the end of the tube cools, the gas collapses to the liquid state causing the bellows or diaphram to move so that the electrical contacts in the control circuit are opened.

ACCESSORIES

Means other than using a match to light the pilot flame are available. Glow coils located at the pilot tip generally have an electrical current passing through a small coil of high temperature wire. Also in use is a spark type ignition of high intensity that is generated across electrodes adjacent to the pilot tip. These units can be actuated by a manual push button or through an automatic signal system depending upon the application.

Pilot burner tips are available in a wide variety of shapes and are selected for position, relationship to main burners, heating effect on sensing element, and particular space requirements.