

Title: Air/Gas ratio valves

Date issued: 26 March 2015

This version of Technical Bulletin (TB) 019 replaces the version originally published 1 April 2009, which is now withdrawn. This version has been reviewed and where appropriate revised to ensure that it remains both current and relevant.

Important: *This technical bulletin is for information purposes only and is **not** intended to be used in place of appliance manufacturer's instructions. **Always refer to appliance manufacturer's instructions for setting and adjustment requirements.***

This Technical Bulletin provides general guidance to Gas Safe registered businesses/engineers on the operation and adjustment of air/gas ratio valves and highlights the differences between these and 'standard' gas valves. It also describes some air/gas ratio valves that are commonly found on condensing boilers. Because manufacturers' specifications may change as new models are developed, this document does not include exhaustive details of all types of air/gas ratio valves which may be encountered.

Introduction

Gas Safe registered engineers will be familiar with the need to check gas valve settings by measuring the burner pressure with a manometer (e.g. 'U' gauge) and comparing the result to the values supplied by the appliance manufacturer, either by reference to the appliance data badge or the installation instructions. With many modern gas-fired condensing boilers, this procedure cannot be used because they use a different type of gas valve even though they may be similar in appearance. This Technical Bulletin describes the air/gas ratio valves that are found on many condensing boilers and highlights the differences between these and 'standard' gas valves.

Over recent years, legislation in the United Kingdom has been introduced that requires the use of high efficiency boilers both for new installations and for the majority of replacements in existing dwellings. In order to maximise the performance over the full boiler operating range, it is necessary to minimise the amount of excess air that passes through the boiler. This has resulted in the greater use of gas valves that control the ratio of gas to air. The valve has proved especially useful in modulating appliances where direct control of the fan has enabled a simple control over the gas pressure and combustion over a wide range of modulation, typically 3.5:1.

These valves are referred to by a number of different terms. Most frequently used are 'gas control valves', 'air/gas ratio valves' or simply 'gas valves'. This different terminology makes it difficult to identify which boilers may have this type of valve. Typically, SEDBUK (Seasonal Efficiency of Domestic Boilers in the UK) 2009 rated boilers will have these valves fitted, but it must not be assumed that a boiler which does not have a SEDBUK 2009 rating will not have an air/gas ratio valve.

It must be emphasised that when working on appliances with this type of valve that the appliance manufacturer's instructions **must** always be referred to.

It is imperative that registered engineers do not try and adjust air/gas ratio valves unless:

- the appliance manufacturer's instructions clearly indicate that they can be adjusted and provide the procedure to be followed;
- they have the necessary equipment in order to carry out the adjustments to the manufacturer's instructions and where necessary that equipment is calibrated regularly;
- they are competent to use that equipment and interpret any results obtained.

Important: A number of appliance manufacturers will indicate that the air/gas ratio valves are not intended to be adjusted. If this is the case then **do not** alter any of the valve settings.

If adjustments are made to an air/gas ratio valve without following the specific manufacturer's instructions, it may result in the boiler combustion being adversely affected with the possibility of high levels of carbon monoxide (CO) being generated.

Air/Gas Ratio Valves - operation

The majority of air/gas ratio valves used on new appliances operate on a similar principle. However, it is important to note that some older appliances may have air/gas ratio valves using a different design.

As in all modern boilers, a fan is used to provide the airflow to the burner. The speed of the fan is accurately controlled by the electronic boiler control. This airflow generates a pressure drop across an air restrictor or venturi and this pressure is communicated to the gas control via a 'servo' regulator. Nearly all of the air/gas ratio valves used today are termed '1:1 valves' so that if the fan gives 5mbar of air pressure then the gas valve will deliver 5mbar of gas pressure. The gas is delivered through a controlled restriction, which typically has a relatively large diameter of up to 10mm. This controlled restriction may be an orifice, traditional injector, a brass fitting or even an open calibrated pipe.

Two methods are in use in current appliances to develop the driving pressure for the gas valve servo. For ease, these are usually referred to as either positive or negative systems (see [Appendix 1, Figures 1a and 1b](#)).

In the **positive system** ([Appendix 1, Figure 1a](#)), the gas valve and pressure tapings are downstream of the fan and are therefore under positive pressure. The gas is injected into or just after the venturi to aid mixing. In the **negative system** ([Appendix 1, Figure 1b](#)), these components are upstream of the fan and under negative pressure; the gas may be injected directly into the fan.

An air pressure tube may be used to connect the valve to the venturi (see [Appendix 1, Figure 2](#)). If this tube becomes disconnected then, with either system, the air/gas ratio will be incorrect. Alternatively, the gas valve may be positioned within a sealed compartment without a connecting tube on the servo connection; in this case it is important to note that the pressures may be affected when the cover door is removed to gain access to the valve.

Valve adjustments

There are two possible adjustments that can be made to these valves: **Air/gas ratio** and **Offset**. The appliance manufacturer's instructions for specific boilers may indicate that these are factory set and must not be altered.

IMPORTANT – Before any adjustment to the valve setting is made, a check should be made to ensure that:

- The joints of the flue system comply with the manufacturer's instructions and are sound (see the current version of [TB 008^{\(1\)}](#) at: <https://engineers.gassaferegister.co.uk> - login and visit the Technical Information area; and visit the Technical Information area.
- The gas pressure at the valve inlet pressure test point is within the appliance manufacturer's specified range.

It is important that if either the air/gas ratio or the offset setting is changed then both settings **must** be checked as being correct. **Either setting should not be adjusted without checking that both settings are correct.** It is normal to adjust the air/gas ratio before the offset.

Air/gas ratio adjustment

The screw adjuster for the air/gas ratio may be referred to as a 'throttle', 'ratio adjuster', or 'flow adjuster'. It may be on the valve, the venturi, or a separate component. It can also be a 'fixed orifice' or a combination of both 'orifice' and 'throttle'.

The appliance manufacturer's instructions should be strictly followed. Some manufacturers specify and detail this adjustment but some do not, as the adjustment may either be preset and sealed by the valve manufacturer or at the factory by the boiler manufacturer.

As previously explained, the gas control delivers a set amount of gas for a set airflow. The purpose of the throttle adjustment is to increase or reduce the amount of gas for a given airflow. Changing this setting alters the carbon dioxide (CO₂) value in the combustion products.

The correct gas rate can be set by changing the valve gas rate adjustment to give the correct combination of fan speed and CO₂. The correct CO₂ value is important for the correct functioning of the appliance, otherwise ignition, flame stability and resonance problems may occur in addition to the heat input being incorrect. The manufacturer may quote a CO₂ value that corresponds to the maximum rate.

The position of this adjuster will be indicated in the appliance manufacturer's instructions. A number of commonly used air/gas ratio valves are shown in [Appendix 1](#) where the position of the throttle adjuster of the included valves is indicated.

The adjustment should be carried out carefully with the boiler normally at maximum rate and with the aid of an electronic portable combustion gas analyser (ECGA) in order to accurately set the CO₂ value to the manufacturer's recommendations; **this should not be attempted without an ECGA.**

Note 1: *The appliance manufacturer's instructions will normally describe how to set the boiler to operate at maximum rate.*

When making adjustments, turn the throttle screw slowly, 1/8 turn at a time, checking the CO₂ value after allowing sufficient time for the readings to stabilise. If the valve is in a negative pressure compartment then the combustion box door should be replaced before a CO₂ reading is taken.

Offset adjustment

The appliance manufacturer's instructions should again be strictly followed. Some manufacturers will specify and detail this adjustment but some do not as the adjustment may be preset and sealed by the valve manufacturer or at the factory by the boiler manufacturer. Some manufacturers specify that the valve is 'Factory sealed no adjustment necessary'. If in any doubt then seek further advice from the appliance manufacturer.

The purpose of the offset adjustment is to set the CO₂ value and therefore gas flow rate at the minimum of the appliance modulation range to allow for a lower or higher CO₂ value than that measured at maximum.

As stated before, a '1:1' air/gas ratio valve modulates the gas pressure to follow the air pressure. In this way, by correctly sizing orifice diameters and resistances, the air/gas ratio can be kept constant for any value of the air pressure signal. When the gas pressure is set equal to the air pressure there is said to be 'zero offset'.

An important point here is that no two installations can be alike, as every appliance will be slightly different and in the case of appliances with long flues, air throughput will differ greatly, so the correct gas pressure will be slightly different in every case.

This slight difference is important to enable these systems to effectively modulate, either deliberately or 'fortuitously' because of appliance build or a blocked flue for example. The air and gas pressures are very closely coupled to each other. To ensure that combustion remains good over the full range of potential installations and throughout the modulating range, the gas outlet pressure may be 'offset' in relation to the air pressure.

Most appliances operate with a 'negative offset' whereby the gas outlet pressure is set slightly lower than the air signal pressure. This difference is usually set between 0 and -20 Pascals (PA) (0 and -0.20mbar) relative to the air, i.e. a greater air pressure than gas pressure. This value may be given on the appliance data plate instead of the usual gas outlet pressure. When set correctly this 'offset' usually ensures that at maximum rate the CO₂ value is about 9 - 9.5% and at the minimum rate about 8.5% - 9.5%. The values for liquefied petroleum gas (LPG) are normally 1% higher than those for natural gas readings.

This adjustment is where some confusion may arise to many people who are not fully conversant with pre-mix systems and their associated controls. If the 'offset' is wound in to try to increase the burner pressure with the appliance at maximum rate then the increase in pressure measured at the outlet test point will be very small. However, at minimum rate this increase in pressure has more effect on the CO₂ value and heat input so care needs to be taken to fully understand the function of the adjustment.

If the manufacturer specifies the adjustment method and value for 'offset' then follow their instructions. In order to set the 'offset' it is necessary to run the boiler at the minimum rate. The manufacturer's instructions may describe how to put the boiler into a test mode so that it operates at the minimum rate. The 'offset' setting can then be adjusted to give the correct CO₂ value reading.

Turn the 'offset' adjustment screw slowly 1/8 turn at a time; clockwise to increase (more positive), anti-clockwise to decrease (more negative). Allow time for the readings to stabilise. If the valve is in a negative pressure compartment then the combustion box door should be replaced before a CO₂ value reading is taken.

Although setting the 'offset' by means of a CO₂ value reading is normally sufficient, individual appliance manufacturers may require the setting to be based on a pressure differential. If this is required then it will be detailed in the manufacturer's instructions. To adjust the valve by this means it is important that a 'micro-manometer' is available and that this is calibrated and operating correctly.

Use of an electronic portable combustion gas analyser (ECGA)

The valve adjustments outlined above require the use of an ECGA. It is important that the ECGA meets the requirements of BS 7927⁽²⁾ or BS EN 50379-3⁽³⁾ and has been calibrated in accordance with the ECGA manufacturer's requirements.

ECGAs are delicate instruments and should be treated with care and used and maintained in accordance with the manufacturer's instructions. Before using the ECGA it is essential to read the instruction manuals which accompany the instrument. In particular, it is important to ensure that the ECGA is operating correctly and the following should be checked:

- the batteries are correctly inserted, charged and not leaking;

- the pump is working;
- filters and water traps are clean and dry;
- the probe tubing is free from leaks or damage;
- the display is functioning correctly;
- the ECGA has a current proof of calibration;
- the ECGA is zeroed and purged in accordance with the manufacturer's instructions.

Note 2: Further information on ECGAs and their use can be found in BS 7967⁽⁴⁾.

If you do not have a suitable ECGA, or you do not fully understand how to use one, then you should not attempt to alter the settings on the air/gas ratio valve.

Commissioning

The majority of manufacturers supply their boilers with the air/gas ratio valve pre-set and therefore during the installation and commissioning process, no site adjustments should be necessary. This will ensure that the appliance is adjusted for its optimum operating conditions. If the air/gas ratio valve has to be adjusted when the boiler is commissioned then this will be made clear in the appliance manufacturer's installation and commissioning instructions (also see **TB 143**⁽⁵⁾).

The Gas Safety (Installation and Use) Regulations (GSIUR) 1998⁽⁶⁾ require that after undertaking any work on a gas appliance that the heat input or operating pressure (or where necessary both) be measured, this is a particular requirement of GSIUR regulation 26(9). With air/gas ratio valves the operating pressure (burner pressure) is not a good indicator that the boiler is operating safely. To satisfy the requirements of gas safety legislation, it is then necessary to measure the gas flow rate. This can be supplemented by a check on the combustion properties using an ECGA.

The appliance manufacturer's instructions may provide a range of CO, CO₂ or CO/CO₂ ratio values between which the boiler would be expected to operate. These values will correspond to the maximum rate of the boiler. It is therefore important that when checking the measured value of CO, CO₂ or CO/CO₂ ratio, that the boiler is operating at or near its maximum rate. The manufacturer may also provide a CO, CO₂ or CO/CO₂ ratio values corresponding to the minimum rate that the boiler will modulate down to. This again can only be reliably used if the boiler is operating at the minimum rate.

If the CO, CO₂ or CO/CO₂ ratio value reading is outside the limits set by the appliance manufacturer and the manufacturer states that the air/gas ratio valve must not be adjusted, then the manufacturer should be consulted as to what further action should be taken.

Note 4: When undertaking gas safety checks (GSIUR regulation 26(9)⁽⁶⁾) and it is not possible to measure the heat input rate (i.e. no gas meter installed) reference should be made to **TB 021**⁽⁷⁾ which can be viewed at: <https://engineers.gassaferegister.co.uk> - login and visit the Technical Information area.

Servicing

It is likely that many appliance manufacturers will recommend that during a service the CO, CO₂ or CO/CO₂ ratio values are checked.

The manufacturer may quote values of CO, CO₂ or CO/CO₂ ratio to be expected. These will correspond to specific boiler operating conditions. It is normal to quote the CO₂ value when the boiler is operating at maximum rate. As these boilers are likely to modulate in line with the heat demand and the specific installation details, it is necessary to force the boiler to operate at full rate during these measurements. The

appliance manufacturer's instructions will give guidance on this. Check the CO, CO₂ or CO/CO₂ ratio value is within the expected range for that boiler. If the manufacturer's instructions state that the air/gas ratio valve must not be adjusted and the CO, CO₂ or CO/CO₂ ratio value reading is outside the limits stated by the manufacturer, then advice should be sought from the appliance manufacturer.

If the air/gas ratio valve is to be adjusted as part of a service then this will be stated in the manufacturer's instructions. Do not attempt to change the valve setting unless the manufacturer's instructions give a clear description of how to carry this out. (see also **Note 4** (above)).

Before carrying out any adjustment, ensure that the connecting tube (if there is one fitted) between the gas valve and the air duct is free from any obstruction or clogging. A small obstruction in this tube could result in the gas valve being set incorrectly. It is also important that the connecting tube and any 'O' ring seals are sound. Any leakage could result in the CO₂ readings being diluted by air drawn in through the leaks and settings being adjusted incorrectly.

The majority of air/gas ratio valves will have an 'offset' that is negative. This means that at the lower end of the modulating range the CO₂ value will normally be less than that at the higher end.

If the appliance manufacturer's instructions indicate that the CO₂ value at minimum rate is higher than at maximum rate then the air/gas ratio valve most likely has a positive 'offset'. This is likely to be the exception and the majority of appliances are expected to use a negative 'offset'.

Valve replacement

If the air/gas ratio valve needs replacing then follow the appliance manufacturer's instructions regarding the procedure to be adopted. As with new appliances, the air/gas ratio valve may be supplied pre-set or it may require field adjustment. This will be made clear in the manufacturer's instructions that should accompany each valve. In the event that the instructions do not clearly identify whether the valve is suitable for the particular appliance and do not identify if it is pre-set or requires adjustment, then the appliance manufacturer must be consulted prior to fitting the valve.

If the valve is pre-set then no adjustment should be made. It is recommended that the CO₂ value and a CO/CO₂ ratio are measured.

If the valve is to be adjusted then the procedure used for servicing (see above) should be followed (see also **Note 4** (above)).

Note 5: *Where the CO, CO₂ or CO/CO₂ ratio reading is outside of the tolerances set by the appliance manufacturer and the manufacturer states that the air/gas ratio valve must not be adjusted, then the manufacturer should be consulted as to what further action should be taken and the appliance should be classified as At Risk (AR) in accordance with the current Gas Industry Unsafe Situations Procedure (GIUSP), until any necessary remedial work can be carried out by a competent person.*

Note 6: *The GIUSP (TB 001⁽⁸⁾) can be viewed at: <https://engineers.gassaferegister.co.uk> - login and visit the Technical Information area.*

Summary

Air/gas ratio valves are found on many new condensing boilers. These valves operate differently from conventional gas valves fitted to standard efficiency boilers over recent years. Air/gas ratio valves are also set up very differently from conventional gas valves and care must be taken to ensure the valves are set and operated correctly to avoid the risk of poor combustion performance and the production of high levels of CO.

Note 7: *For details of current gas safety legislation, building legislation and industry standards for the geographical areas covered by Gas Safe Register, see the [Legislative](#),*

Normative & Informative Document List (LNIDL)⁽⁹⁾ at:
<https://engineers.gassaferegister.co.uk> - login and visit the Technical Information area.

Note 8: For general information about the process behind the development of Gas Safe Register Technical Bulletins and the expectations for all Stakeholders, see TB 1000⁽¹⁰⁾ at: <https://engineers.gassaferegister.co.uk> - login and visit the Technical Information area.

Bibliography

- (1) TB 008 - Existing concealed room-sealed fanned-draught boiler chimney/flue systems
- (2) BS 7927: 1998 - Heating appliances for domestic applications. Portable apparatus designed to detect and measure specific combustion flue gas products – Requirements. (Now superseded by BS EN 50379-3⁽²⁾)
- (3) BS EN 50379-3: 2004 - Specification for portable electrical apparatus designed to measure combustion flue gas parameters of heating appliances. Performance requirements for apparatus used in non-statutory servicing of gas fired heating appliances
- (4) BS 7967; 2015 - Guide for the use of electronic portable combustion gas analysers for the measurement of carbon monoxide in dwellings and the combustion performance of domestic gas-fired appliances
- (5) TB 143 - CO and combustion ratio checks using an Electronic Combustion Gas Analyser (ECGA) when commissioning a condensing boiler incorporating air/gas ratio control valve technology
- (6) Gas Safety (Installation and Use) Regulations 1998 SI No. 1998: 2451
- (7) TB 021 - Measuring combustion performance to satisfy the requirements of GSIUR 1998 Certificate of Exemption No. 1 of 2008
- (8) TB 001 - The Gas Industry Unsafe Situations Procedure
- (9) LNIDL - Gas Safe Register Legislative, Normative & Informative Document List
- (10) TB 1000 – An introduction to Gas Safe Register Technical Bulletins

Note: Gas Safe Register Technical Bulletins and the Legislative, Normative & Informative Document List can be viewed at: <https://engineers.gassaferegister.co.uk> - login and visit the Technical Information area

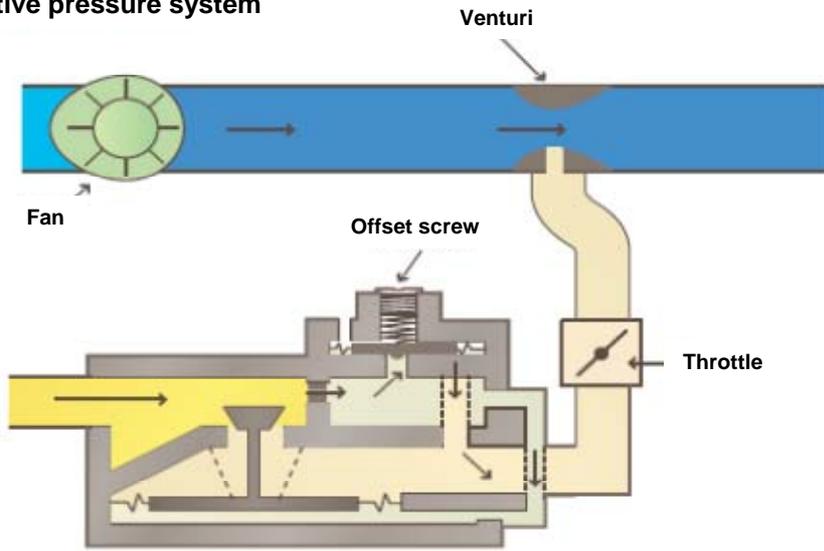
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Appendix 1

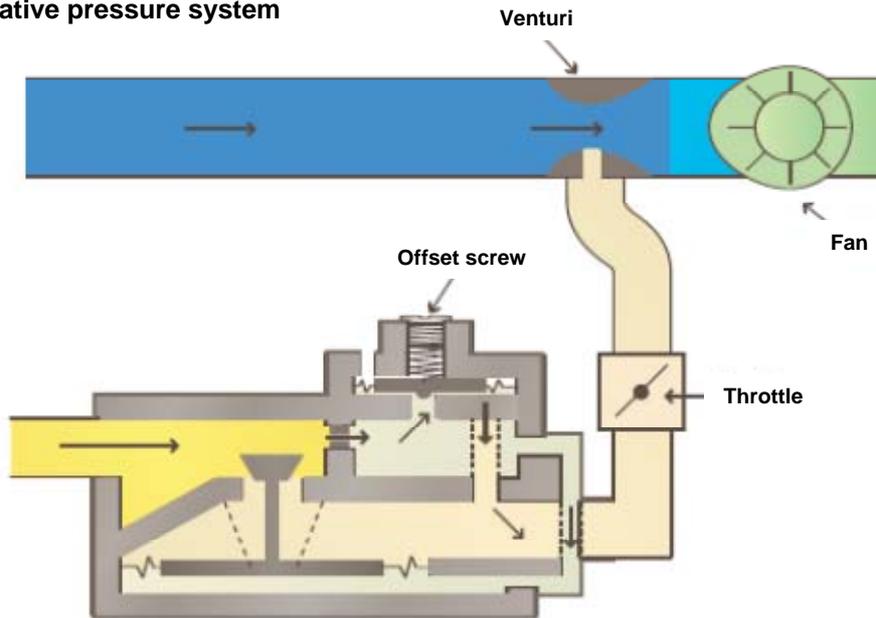
Types of Air/gas ratio valves

Figure 1: Air/gas ratio valve configurations

a) Positive pressure system

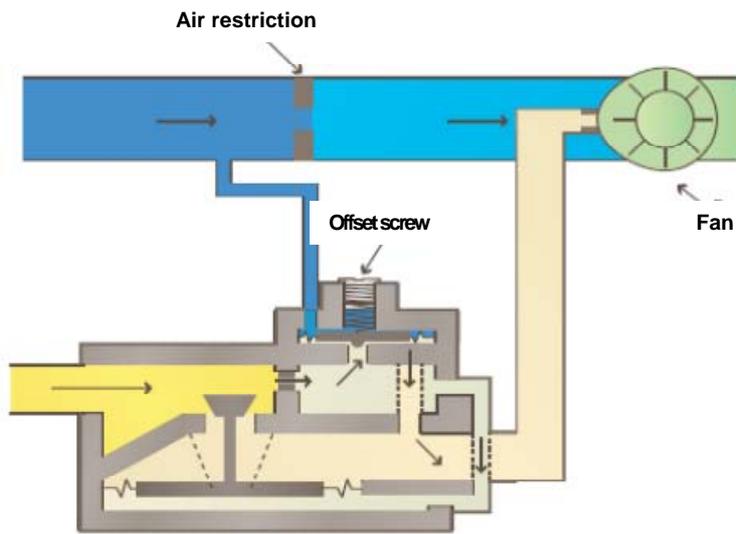


1b) Negative pressure system



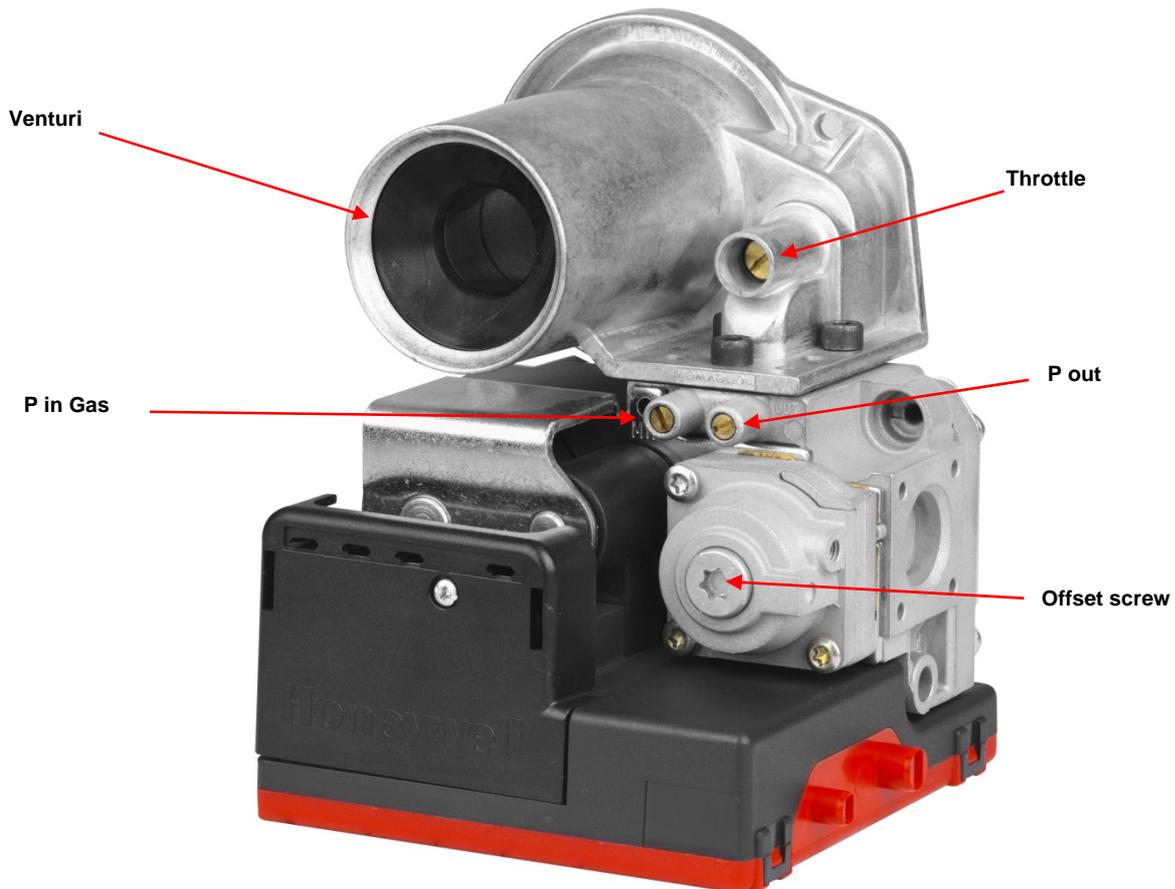
Appendix 1

Figure 2: Air/gas ratio valve configuration – use of pressure connecting tube



Specific Models of Air/Gas Ratio Valves

Figure 3: Honeywell air/gas ratio valve (integrated venturi and electronic control)



Appendix 1

Figure 4: SIT air/gas ratio valve

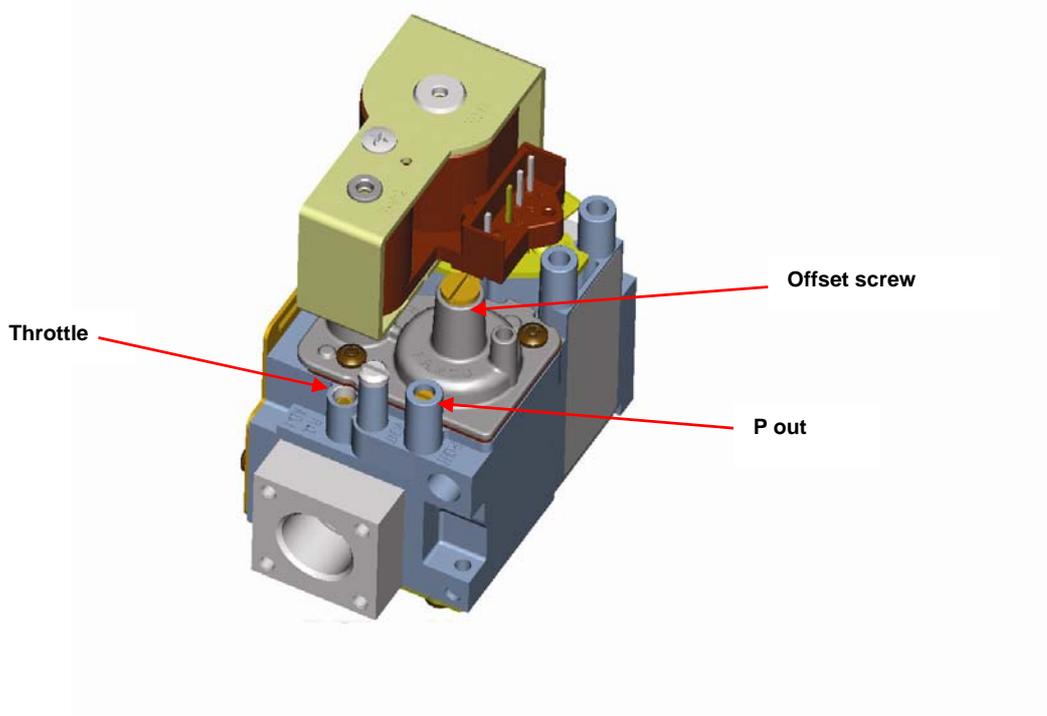
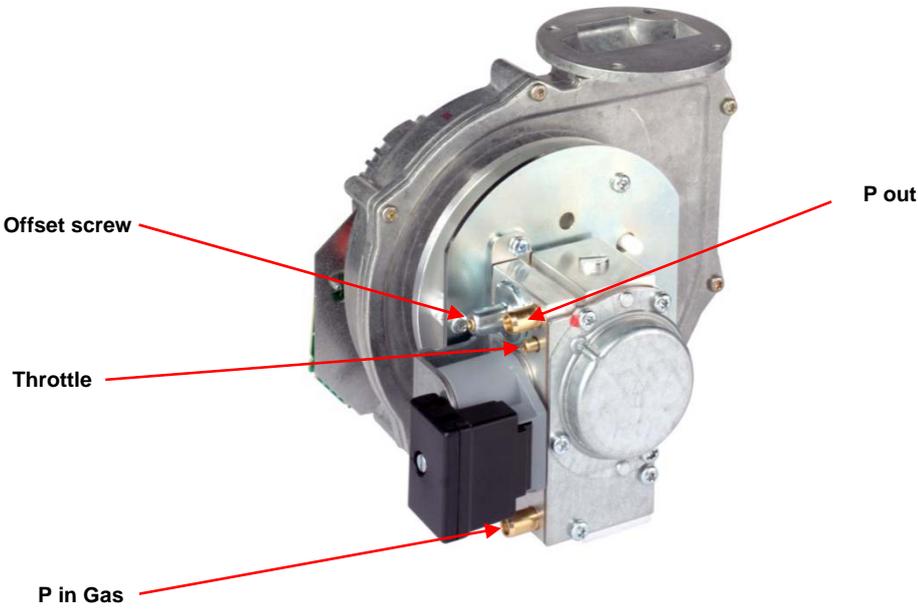


Figure 5: Dung air/gas ratio valve



Appendix 1

Figure 6: Siemens combination gas valve

