Commercial
Water Heaters

VF™

Water Heater

Design Guide

Dear Customer,

This VF Water Heater Handbook is intended to explain, simplify and help in the planning and the installation of our VF Water Heaters on your next project. However, it is important to remember that this guide is supplemental to the Installation and Operation Manual and does not contain all of the information and instructions necessary to install and operate the unit. The Installation & Operation Manual must be read in its entirety and all instructions, notices, cautions and warnings followed.

Best Regards,

A.O. Smith Product Management

Table of Contents

This Handbook will cover the 5 major elements of domestic hot water heating systems design and installation:

1. **Combustion Air**
2. **Venting**
3. **Gas**
4. **Water**
5. **Electrical and Controls**

CHAPTER 1
COMBUSTION AND VENTILATION AIR

The VF Water Heater is designed to receive combustion air by one of TWO methods. The water heater may draw combustion **air from the room** or have the **air ducted directly to the water heater** from an exterior space.

This chapter explains the methods for "air from the room". Chapter 2 explains "air ducted directly to the water heater". Again, this chapter lists several techniques to size the air openings that will deliver room air. If there are other appliances in the room requiring air, their air requirements must be included when sizing the air openings.

Provisions for combustion and ventilation air must be designed and installed in accordance with "Air for Combustion and Ventilation", of the latest edition of the National Fuel Gas Code, ANSI Z223.1, (in Canada, the latest edition of CGA Standard B149 Installation Code for Gas Burning Appliances and Equipment) or applicable provisions of the local building codes.

NEGATIVE PRESSURE IN THE EQUIPMENT ROOM

It is important to NEVER have a negative pressure in the equipment room. Exhaust fans are popular in equipment rooms to exchange the air. If the exhaust fan pulls air OUT, then a negative pressure occurs in the room. The combustion and ventilation air must be sized to supply all the equipment PLUS the air for the exhaust fan.

COMBUSTION AND VENTILATION AIR SIZING CALCULATIONS

The sizing calculations in this section are based on "free area". The louvers or grill used on the air openings must have a **net free area** equal to or greater than the value derived in the calculations. The free area in a louver or grill is defined as the open, unblocked area. The louvers, grills, mesh, blades, all will block a given amount of space in the louver's overall dimension. Consult the louver manufacturer for exact **net free area** of the louver.

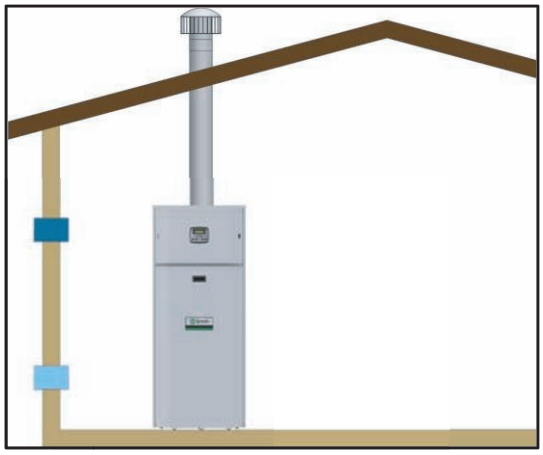
COMBUSTION AND VENTILATION AIR

1 COMBUSTION AIR FROM OUTSIDE

If air is taken directly from outside the building with no duct, provide two permanent openings to the equipment room:

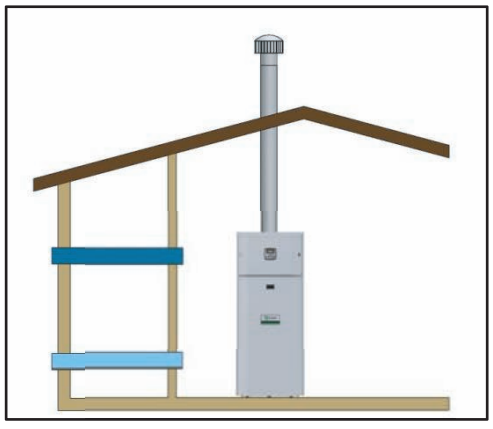
(a) Combustion air opening, with a minimum free area of one square inch per 4000 Btu/hr input (5.5 cm^2 per kW). This opening must be located within 12" (30 cm) of the bottom of the enclosure.

(b) Ventilation air opening, with a minimum free area of one square inch per 4000 Btu/hr input (5.5 cm^2 per kW). This opening must be located within 12" (30 cm) of the top of the enclosure.



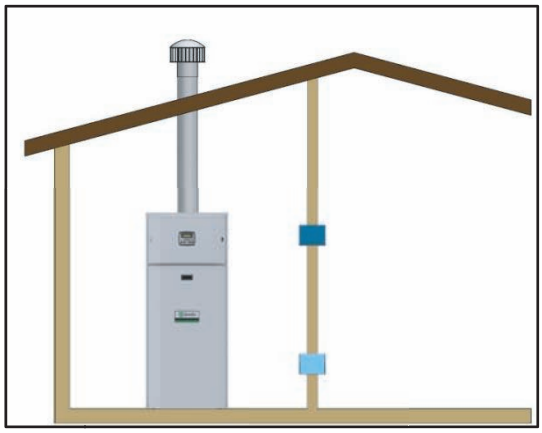
DID YOU KNOW?

THE VF™ COMES WITH LOUVER CONTACTS AS STANDARD EQUIPMENT. THE CONTACTS WILL OPEN AND CLOSE A MOTORIZED LOUVER ON EACH CALL FOR HEAT.



2 COMBUSTION AIR THROUGH DUCTS

If combustion and ventilation air is taken from the outdoors using a duct to deliver the air to the equipment room, each of the two openings should be sized based on a minimum free area of one square inch per 2000 Btu/hr (11 cm^2 per kW) of input.



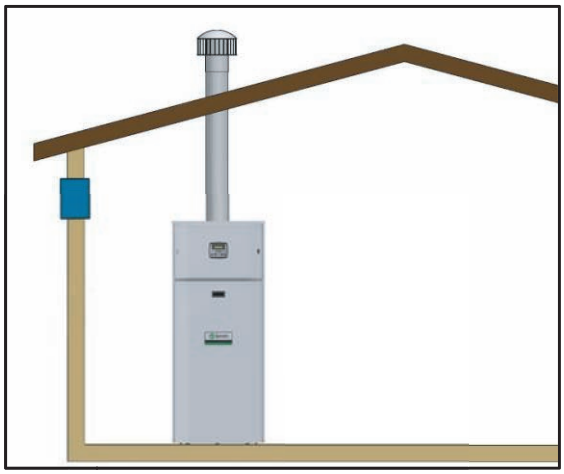
3 COMBUSTION AIR FROM INTERIOR SPACE

If air is taken from another interior space, each of the two openings specified above should have a net free area of one square inch for each 1000 Btu/hr (22 cm^2 per kW) of input, but not less than 100 square inches (645 cm^2).

COMBUSTION AND VENTILATION AIR

4 DIRECT OUTSIDE AIR, SINGLE OPENING

If a single combustion air opening is provided to bring combustion air in directly from the outdoors, the opening must be sized based on a minimum free area of one square inch per 3000 Btu/hr (7 cm^2 per kW). This opening must be located within 12" (30 cm) of the top of the enclosure.



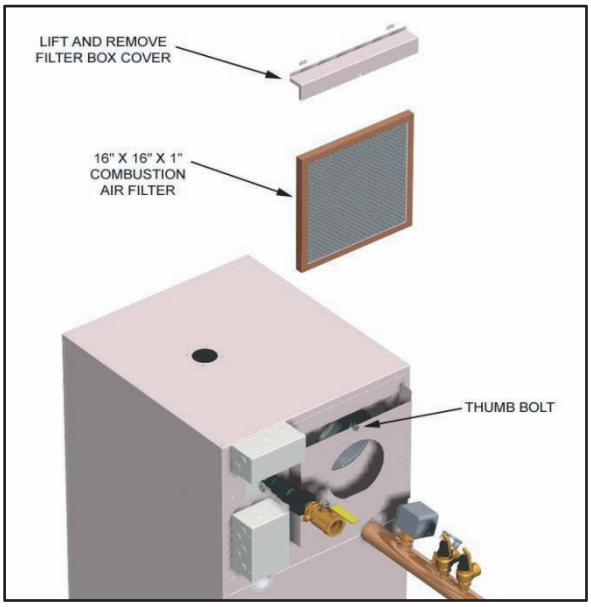
CAUTION!!

THE COMBUSTION AIR MUST BE FREE OF ANY CONTAMINANTS OR CHEMICAL FUMES. SALTS, REFRIGERANTS AND SOLVENTS INTRODUCED INTO THE COMBUSTION PROCESS WILL RESULT IN THE FORMATION OF CORROSIVE ACIDS THAT WILL DAMAGE THE APPLIANCE AND THE VENT.

COMBUSTION AIR FILTER

The VF has a built-in air filter as standard equipment. Located at the combustion air inlet, the air filter is provided to help ensure that clean air is used for the combustion process.

The filter size on models 502-1302 is 16" x 12" x 1" (40.6 cm x 30.4 cm x 2.5 cm) and on models 1501 - 2001 is 16" x 16" x 1" (40.6 cm x 40.6 cm x 2.5 cm). You can find these commercially available filters at any home center or plumbing supply store.



CHAPTER 2

CHAPTER 2
VENTING

Venting is a difficult design element for the installation of a gas-fired appliance. It has a variety of choices, it has several available vent configurations, it has the important rules and regulations that govern the installation and most important of all, it bears a requirement for human safety.

WARNING!!

SPILLAGE OF FLUE PRODUCTS AND CARBON MONOXIDE EMISSIONS PRODUCED BY THE COMBUSTION PROCESS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH.

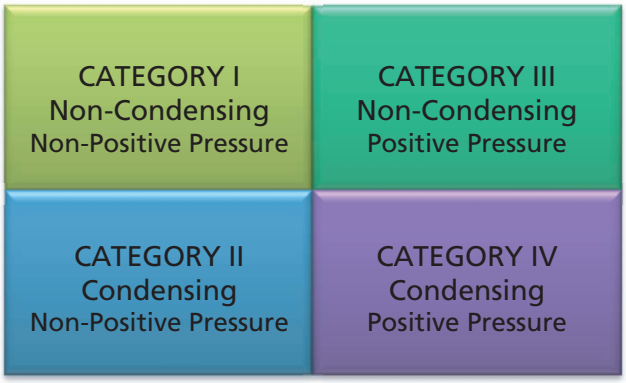
A. O. Smith offers twelve different vent configurations on the VF water heater to meet the building's requirements. There are six layouts or footprints across two different vent categories. They are...

Vertical Vent with Air from the Equipment Room	**Category II or Category IV**
Vertical Vent with Air from the Rooftop	**Category II or Category IV**
Vertical Vent with Air from the Sidewall	**Category II or Category IV**
Sidewall Vent with Air from the Equipment Room	**Category IV only**
Sidewall Vent with Air from the Rooftop	**Category IV only**
Sidewall Vent with Air from the Sidewall	**Category IV only**

That's a lot of choices. Allow me to explain.

Part 1
Vent Categories

Here is the traditional vent category diagram, standard throughout the industry.



The four basic Vent Categories are determined by two characterisitics, Condensation and Pressure.

CONDENSING VERSUS NON-CONDENSING

The possibility for condensation to form in a stack is based on the temperature of the flue products. If the temperature of the flue product remains consistantly above dewpoint, condensation will not form. If the temperature drops below dewpoint, condensation will form.

So how does condensation apply to the VF? The VF's firing rate determines the stack temperature. When firing at a high or full firing rate the VF's stack temperature is high enough to stay above the dewpoint and does not condense. However, when the unit is modulating and firing at a low or reduced firing rate, stack temperatures can drop below dewpoint and produce condensate in the vent.

Condensing – The VF Water Heater is a "Modulating" water heater that can fire a 25% to 100% firing rate. (4:1 Turndown) Temperature – When the VF Water Heater models modulate down to their lowest input rate of 25%, they produce a comparatively low stack temperature that will likely cause condensation to occur in the stack.

Condensing Pressure – The VF Water Heater models are designed with a small diameter vent connection to simplify installation and reduce vent cost. The blower ***CAN PUSH*** the flue products through a similarly sized stack therefore creating a positive pressure.

Positive Pressure – In most cases the VF Water Heater will be installed as a Category IV appliance that condenses in the vent and has a positive vent pressure.

POSITIVE VERSUS NON-POSITIVE

Positive or non-positive pressure in the vent is determined by the capacity of the appliance's blower ***AND*** the diameter of the vent in order to ***PUSH*** the flue products. If the same appliance is connected to a larger diameter stack, the blower ***CANNOT PUSH*** the flue products.

Part 2
Choose Your Vent Configuration

It's time to choose the vent configuration or system layout.

CATEGORY IV VENTING

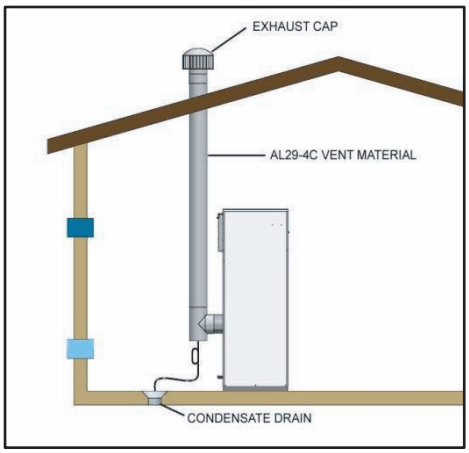
All six layouts listed on page eight can be installed as Category IV venting. The following pages offer a diagram of the six layouts, important design information and a list of the available vent kits that are required to install some of these configurations.

Vertical Vent with Air from the Equipment Room	**Category IV**
Vertical Vent with Air from the Rooftop	**Category IV**
Vertical Vent with Air from the Sidewall	**Category IV**
Sidewall Vent with Air from the Equipment Room	**Category IV only**
Sidewall Vent with Air from the Rooftop	**Category IV only**
Sidewall Vent with Air from the Sidewall	**Category IV only**

VERTICAL VENT WITH COMBUSTION AIR FROM EQUIPMENT ROOM

The flue outlet terminates on the rooftop. The combustion air is drawn naturally from the equipment room.

- Category IV vent material is required, such as AL29-4C.
- All vent joints and seams must be sealed gas-tight and may not be common vented.
- The vent must have a condensate drain with provisions to properly collect and dispose of any condensate that may occur in the vent pipe.
- All vent material for this configuration including vent termination will be obtained locally.
- The air is delivered to the equipment room by means defined in Chapter 1 of this designer's guide.
- Maximum distance – 50 equivalent feet of vent.



Model Number	Vent Size Category IV
VWH0500N	4″
VWH0750N	5″
VWH1000N	6″
VWH1500N	6″
VWH2000N	8″

TIP

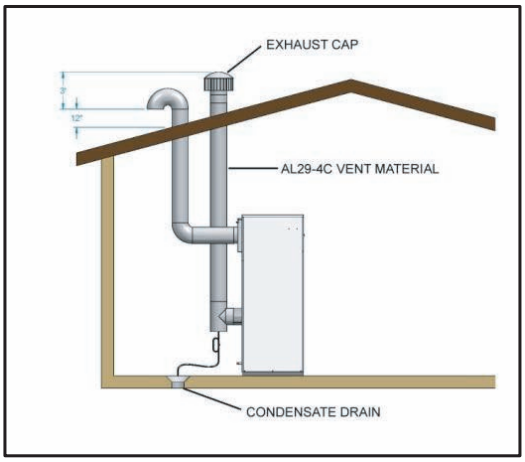
THIS CONFIGURATION MAY BE INSTALLED AS CATEGORY II. SEE PAGE 16 FOR DETAILS.

CATEGORY IV VENTING (CONT'D)

VERTICAL VENT WITH COMBUSTION AIR FROM THE ROOFTOP

The flue outlet terminates on the rooftop. The combustion air is ducted to the appliance from outdoors through the rooftop. This is true Direct Vent with the flue termination and the air inlet port in the same pressure zone.

- Category IV vent material is required, such as AL29-4C.
- All vent joints and seams must be sealed gas-tight and may not be common vented.
- The vent must have a condensate drain with provisions to properly collect and dispose of any condensate that may occur in the vent pipe.
- All vent material for this configuration including vent termination will be obtained locally.
- The air is delivered to the appliance via a separate duct. The air intake material can be galvanized pipe, PVC, CPVC or ABS and must be sealed airtight.
- Maximum distance – 50 equivalent feet of vent.
- Maximum distance – 50 equivalent feet of air intake.



Model Number	Combustion Air Inlet	Vent Size Category IV
VWH0500N	5"	4"
VWH0750N	5"	5"
VWH1000N	6"	6"
VWH1500N	6"	6"
VWH2000N	8"	8"

TIP

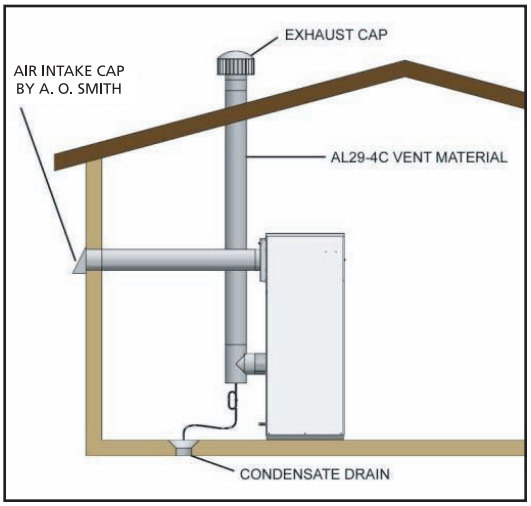
THIS CONFIGURATION MAY BE INSTALLED AS CATEGORY II. SEE PAGE 16 FOR DETAILS.

CATEGORY IV VENTING (CONT'D)

VERTICAL VENT WITH COMBUSTION AIR FROM THE SIDEWALL

The flue outlet terminates on the rooftop. The combustion air is ducted to the appliance from outdoors through the sidewall. This is not true Direct Vent with the flue termination and the air inlet port in different pressure zones.

- Category IV vent material is required, such as AL29-4C.
- All vent joints and seams must be sealed gas-tight and may not be common vented.
- The vent must have a condensate drain with provisions to properly collect and dispose of any condensate that may occur in the vent pipe.
- The Sidewall Air Intake Cap must be provided by A. O. Smith. See table below for kit part numbers. All other vent material for this configuration will be obtained locally.
- The air is delivered to the appliance via a separate duct. The air intake material can be galvanized pipe, PVC, CPVC or ABS and must be sealed airtight.
- Maximum distance – 50 equivalent feet of vent.
- Maximum distance – 50 equivalent feet of air intake.



The table also includes the kit part numbers for the sidewall exhaust caps which must be used.

Model Number	Vent Size Category IV	Combustion Air Inlet	Air Intake Cap Part Number
VWH0500N	4″	5″	9910117000
VWH0750N	5″	5″	9910117000
VWH1000N	6″	6″	9910117002
VWH1500N	6″	6″	9910117002
VWH2100N	8″	8″	9910117004

The main component in Sidewall Air Intake Kit is the Sidewall Air Intake Cap.


AIR INTAKE CAP

TIP

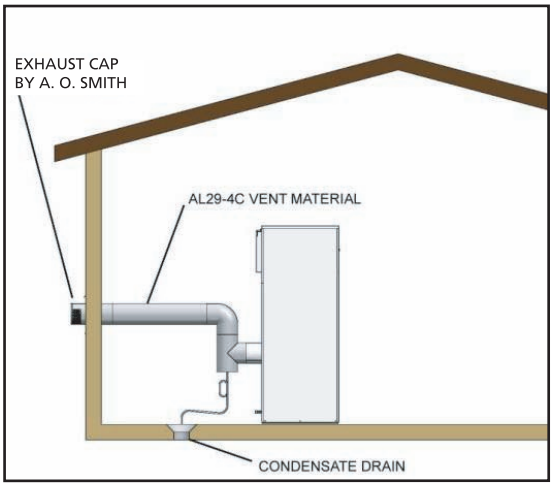
THIS CONFIGURATION MAY BE INSTALLED AS CATEGORY II. SEE PAGE 16 FOR DETAILS.

CATEGORY IV VENTING (CONT'D)

SIDEWALL VENT WITH COMBUSTION AIR FROM EQUIPMENT ROOM

The flue outlet terminates out the sidewall. The combustion air is drawn naturally from the equipment room.

- Category IV vent material is required, such as AL29-4C.
- All vent joints and seams must be sealed gas-tight and may not be common vented.
- The vent must have a condensate drain with provisions to properly collect and dispose of any condensate that may occur in the vent pipe.
- The Sidewall Exhaust Cap must be provided by A. O. Smith. See table below for kit part numbers. All other vent material for this configuration will be obtained locally.
- The air is delivered to the equipment room by means defined in Chapter 1.
- Maximum distance – 50 equivalent feet of vent.



The table also includes the kit part numbers for the Sidewall Exhaust Caps which must be used.

Model Number	Vent Size Category IV	Sidewall Exhaust Cap Part Number
VWH0500N	4"	9910118000
VWH0750N	5"	9910118001
VWH1000N	6"	9910118002
VWH1500N	6"	9910118002
VWH2100N	8"	9910118004

The main component in Sidewall Vent Kit is the Sidewall Exhaust Cap.

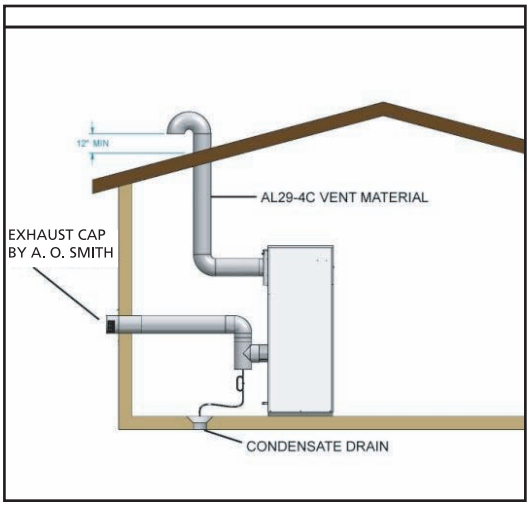

SIDEWALL VENT CAP

CATEGORY IV VENTING (CONT'D)

SIDEWALL VENT WITH COMBUSTION AIR FROM THE ROOFTOP (DUCTED AIR)

The flue outlet terminates out the sidewall. The combustion air is ducted to the appliance from outdoors through the rooftop. This is not true Direct Vent with the flue termination and the air inlet port in different pressure zones.

- Category IV vent material is required, such as AL29-4C.
- All vent joints and seams must be sealed gas-tight and may not be common vented.
- The vent must have a condensate drain with provisions to properly collect and dispose of any condensate that may occur in the vent pipe.
- The Sidewall Exhaust Cap must be provided by A. O. Smith. See table below for kit part numbers. All other vent material for this configuration will be obtained locally.
- The air is delivered to the appliance via a separate duct. The air intake material can be galvanized pipe, PVC, CPVC or ABS and must be sealed airtight.
- Maximum distance – 50 equivalent feet of vent.
- Maximum distance – 50 equivalent feet of air intake.



The table also includes the kit part numbers for the Sidewall Exhaust Caps which must be used.

Model Number	Vent Size Category IV	Sidewall Exhaust Cap Part Number
VWH0500N	4″	9910118000
VWH0750N	5″	9910118001
VWH1000N	6″	9910118002
VWH1500N	6″	9910118002
VWH2100N	8″	9910118004

The main component in Sidewall Vent Kit is the Sidewall Exhaust Cap.

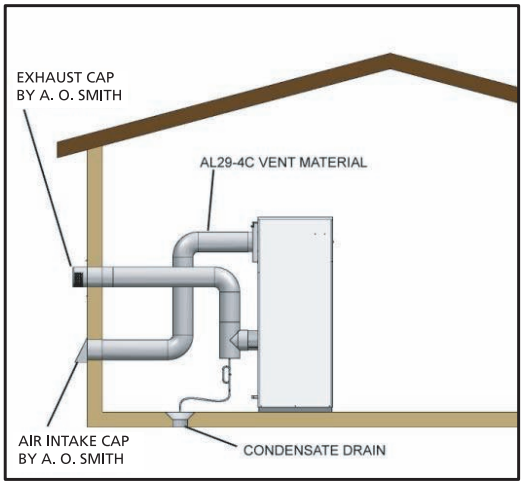

SIDEWALL VENT CAP

CATEGORY IV VENTING (CONT'D)

SIDEWALL VENT WITH COMBUSTION AIR FROM THE SIDEWALL

The flue outlet terminates out the sidewall. The combustion air is ducted to the appliance from outdoors through the sidewall. This is true Direct Vent with the flue termination and the air inlet port in the same pressure zone.

- Category IV vent material is required, such as AL29-4C.
- All vent joints and seams must be sealed gas-tight and may not be common vented.
- The vent must have a condensate drain with provisions to properly collect and dispose of any condensate that may occur in the vent pipe.
- The Sidewall Exhaust Cap and the Sidewall Air Intake Cap must be provided by A. O. Smith. See table below for kit part numbers. All other vent material for this configuration will be obtained locally.
- The air is delivered to the appliance via a separate duct. The air intake material can be galvanized steel pipe, PVC, CPVC or ABS and must be sealed airtight.
- Maximum distance – 50 equivalent feet of vent.
- Maximum distance – 50 equivalent feet of air intake.



The table also includes the kit part numbers for the Sidewall Exhaust Caps and air intake caps which must be used.

Model Number	Vent Size Category IV	Combustion Air Inlet	Part Number
VWH0500N	4"	5"	9910119000
VWH0750N	5"	5"	9910119001
VWH1000N	6"	6"	9910119002
VWH1500N	6"	6"	9910119004
VWH2100N	8"	8"	9910119006

The main component in the Horizontal Direct Vent Kit are the Sidewall Exhaust Cap and the Sidewall Air Intake Cap.

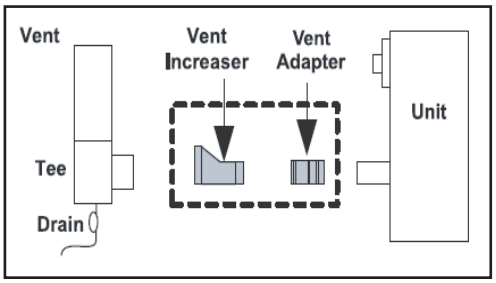

SIDEWALL VENT CAP


AIR INTAKE CAP

CATEGORY II VENTING

An important detail in the Category IV section is Category IV venting MAY NOT be common vented. Category IV is positive pressure stack and you cannot combine positive pressure stacks. This is where switching to Category II can be useful.

Converting the VF models from Category IV appliance to Category II appliance is done by increasing the stack diameter. That changes the stack pressure from positive to non-positive. (Category II – A condensing appliance with a non-positive (negative vent pressure.) With the larger vent diameter the pressure drops from positive to non-positive converting the unit from Category IV to Category II.



Of the six layouts listed on page 8, three can be installed as Category II venting. Notice that only vertical vent termination is permissible with Category II venting.

Vertical Vent with Air from the Equipment Room	**Category II**
Vertical Vent with Air from the Rooftop	**Category II**
Vertical Vent with Air from the Sidewall	**Category II**

There are ***two*** important considerations when specifying Category II venting.

1. A special vent adapter MUST be specified to convert the appliance from Category IV vent diameters to Category II vent diameters. The increase in vent diameter is crucial to change from Category IV positive pressure to Category II non-positive pressure.

2. The combined vent MUST be properly sized for the combined appliances.

The Category II kits are as follows:

Model Number	Vent Size	Category II Kit Part Number
VWH0500N	4" to 7"	9910119000
VWH0750N	5" to 9"	9910119001
VWH1000N	6" to 10"	9910119002
VWH1500N	6" to 8"	9910119004
VWH2100N	8" to 10"	9910119006

CHAPTER 3
GAS SUPPLY

Clean burning high efficiency water heaters such as the A. O. Smith VF Water Heaters need a tightly controlled air and gas mixture going to the burner in order to produce the low emissions that can meet the most restrictive air quality standards while maximizing the overall combustion efficiency of the water heater. VF Water Heaters provided with an adequate supply of gas will start smoother, run longer and perform at maximum efficiency.

The key to the gas supply is sizing the gas line properly. The VF will require less than a half a pound of pressure. The following Sizing Chart is based on less than 1/2 pound of pressure or less than 14 inches of pressure. The table is derived from the ANSI Z223.1, the National Fuel Gas Code.

Simply calculate the total linear feet of straight gas pipe. Figure each elbow is equal to five straight feet of pipe. Working down the column that matches your pipe length, find the value GREATER THAN the total Btu/hr input of the water heater or water heaters. This will identify the minimum nominal iron pipe size.

GAS PIPING SIZING CHART

Nominal Iron Pipe Size	Length of Pipe in Straight Feet													
	10	20	30	40	50	60	70	80	90	100	125	150	175	200
3/4"	369	256	205	174	155	141	128	121	113	106	95	86	79	74
1"	697	477	384	328	292	267	246	256	210	200	179	164	149	138
1 1/4"	1,400	974	789	677	595	543	502	472	441	410	369	333	308	287
1 1/2"	2,150	1,500	1,210	1,020	923	830	769	707	666	636	564	513	472	441
2"	4,100	2,820	2,260	1,950	1,720	1,560	1,440	1,330	1,250	1,180	1,100	974	871	820
2 1/2"	6,460	4,460	3,610	3,100	2,720	2,460	2,310	2,100	2,000	1,900	1,700	1,540	1,400	1,300
3"	11,200	7,900	6,400	5,400	4,870	4,410	4,000	3,800	3,540	3,300	3,000	2,720	2,500	2,340
4"	23,500	16,100	13,100	11,100	10,000	9,000	8,300	7,690	7,380	6,870	6,150	5,640	5,130	4,720

The VF features a Negative-Regulation or Neg-Reg gas combustion system. The gas is introduced upstream of the combustion blower. As the blower draws air in, the negative pressure on the inlet of the blower pulls the gas from the gas valve. The gas/air mixture is pushed through the blower into the burner. The gas/air mixture filters through the ceramic burner mesh and is ignited by the Hot Surface Igniter.

On full fire, a crisp blue flame rises off the surface of the burner. As demand decreases, the operating control reduces the blower speed. The flame is reduced and touches the burner surface. The ceramic burner material is designed to burn infra-red safely without being damaged by direct contact of the flame. Even at this reduced Btu/hr input, the gas/air mixture is balanced to provide clean, efficient combustion.

GAS SUPPLY (CONT'D)

The table below shows the gas connection size on the water heater. Logically, the gas pipe size from the meter to the water heater may be larger than the appliance connection.

Model Number	Pipe Size
VWH0500N	1"
VWH0750N	1-1/4"
VWH1000N	1-1/4"
VWH1500N	2"
VWH2000N	2"

The table below lists the Minimum and Maximum Inlet Gas Pressures.

INLET GAS PRESSURE				
Model	Natural		LP	
	Max. w.c.	Min. w.c.	Max. w.c.	Min. w.c.
500-1000	14.0	4.0	13.0	11.0
1500-2000	14.0	4.0	14.0	8.0

Maximum Inlet Gas Pressure must not exceed the value specified.
Minimum value listed is for the purposes of input adjustment.

PROPANE (L.P.) GAS MODELS

If you are specifying a model for connection to L.P. gas, make sure that is noted on your design specification. The VF must be factory trimmed for the chosen gas type and may not be field converted from Natural to L.P. gas or vice versa.

GAS PRESSURE REGULATORS

A. O. Smith recommends the use of "Lock-Up Type" gas pressure regulators on the system gas supply. A Lock-Up Type gas pressure regulator features a seat that seals the regulator orifice when the appliance is off and there is no demand for gas. The seat will seal against the orifice shutting off the flow of gas to the appliance.

A standard regulator without a Lock-Up mechanism will allow the system pressure to reach the boiler when it is off. The system pressure can "creep up" pressing against the appliance gas train with excessive system pressures. This can damage the components in the gas train.

IMPORTANT!

HIGH PRESSURE GAS REGULATORS MUST BE THE LOCK-UP VARIETY AND MUST BE INSTALLED NO LESS THAN 10 EQUIVALENT FEET FROM THE BOILER TO PROVIDE AN ADEQUATE VOLUME OF GAS FOR SMOOTH IGNITION.

CHAPTER 4
WATER

Domestic water pipe design seems easy enough. The VF water heater is connected to a storage tank. Water recirculates between the two to maintain a prescribed water temperature. Hot water is drawn off the top of the tank to supply the system. Fresh water flows in from the city. The VF fires again to maintain the temperature of the system.

However, there are other concerns, details regarding the system design that must be checked to provide the water heater with safe and comfortable operating conditions. There are temperature and water capacity demands, water chemistry and multiple unit piping and many more.

Here is a short list of important details to keep in mind as we design our system.

IMPORTANT DETAILS FOR WATER PIPING

1. ***Water Connections***
   All models have 2 1/2 inch copper sweat pipe inlet and outlet connections. Installed piping to and from the tank must be a minimum of 2 1/2 inch diameter.

2. ***Maximum Flow Rate***
   VF models VWH0500 thru 1000 have a specified flow rate of 75 GPM. The VF models VWH1500 thru 2000 models have a specified flow rate of 90 GPM.

3. ***Working Pressure***
   The appliance should not be operated at less than 12 PSIG.

4. ***Minimum Inlet Water Temperature***
   The minimum inlet water temperature returned to the appliance is 140°F (60°C).

5. ***Flow Rate***
   The appliance requires a constant flow rate through the heat exchanger. Do not vary the flow rate through the water heater during a call for heat.

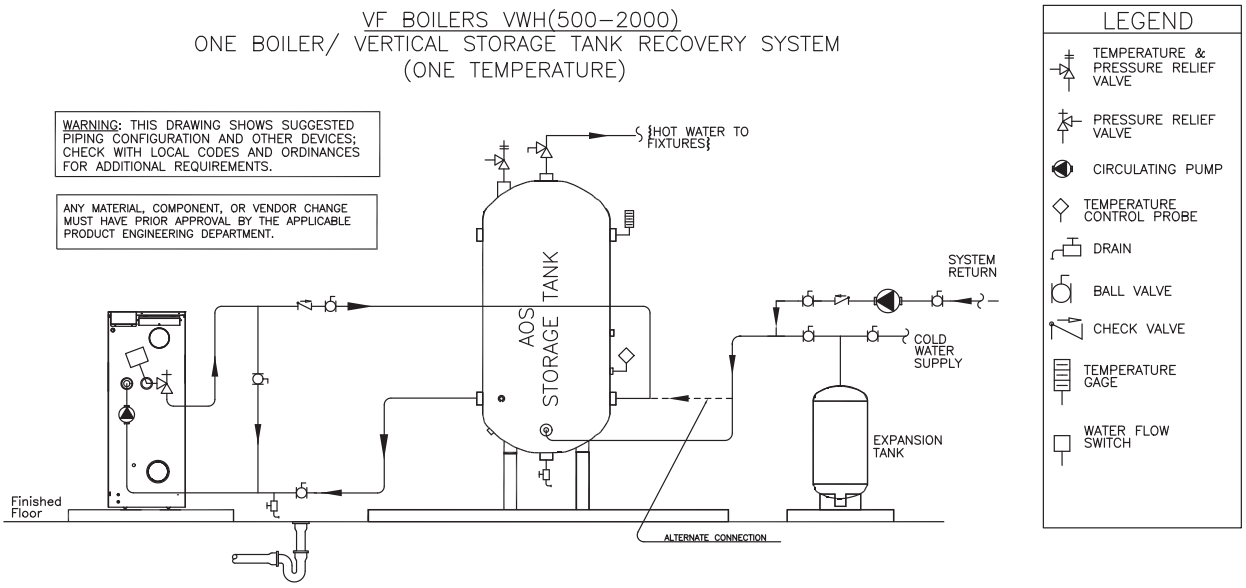
6. ***Unions and Ball Valves***
   The water piping to the tank should have unions and ball valves at the inlet and outlet of the water heater to isolate the unit for service and flow adjustment. Use only full port ball valves.

WATER (CONT'D)

SINGLE HEATER / SINGLE TANK

The most common design is for a single water heater piped to a single tank. The water flows from the water heater into the tank and then back from the tank to the heater. A factory supplied circulation pump creates the flow in this water heater loop only.

A system loop carries hot water away from the tank and the building return line is connected to the water heater loop. A field supplied circulation pump will create the flow in the system loop.



FACTORY SUPPLIED PUMP

Again, the circulation pump in the water heater loop is factory supplied. It is sized based on a given amount of pipe and so many fittings. The standard pump is based on 45 feet of straight pipe with:

6 – 90° Elbows	2 – Ball Valve
2 – Unions	1 – Cold Water Tee

DID YOU KNOW!

THE VF COMES WITH INTERMITTENT PUMP CONTACTS AS STANDARD EQUIPMENT. THE CONTACTS WILL OPERATE THE RECIRCULATION PUMP ON EACH CALL FOR HEAT AND THE PUMP DELAY TIMING IS FIELD PROGRAMMABLE.

WATER (CONT'D)

For each fitting in excess of those shown above, deduct 6.5 feet from the straight pipe. If your system exceeds this math, the pump may be increased in size to provide the necessary flow. Please consult A. O. Smith Technical Service for details.

MULTIPLE HEATERS / MULTIPLE TANKS

The second most common design is for multiple water heaters piped to multiple tanks. Multiple heaters provide water heating redundancy. Multiple tanks increase storage on capacity in easy to manage vessels.

The key element in having multiple water heaters is you have multiple pumps; multiple pumps that share common piping. When that happens, the pipe diameters MUST be increased to accommodate the increased flow.

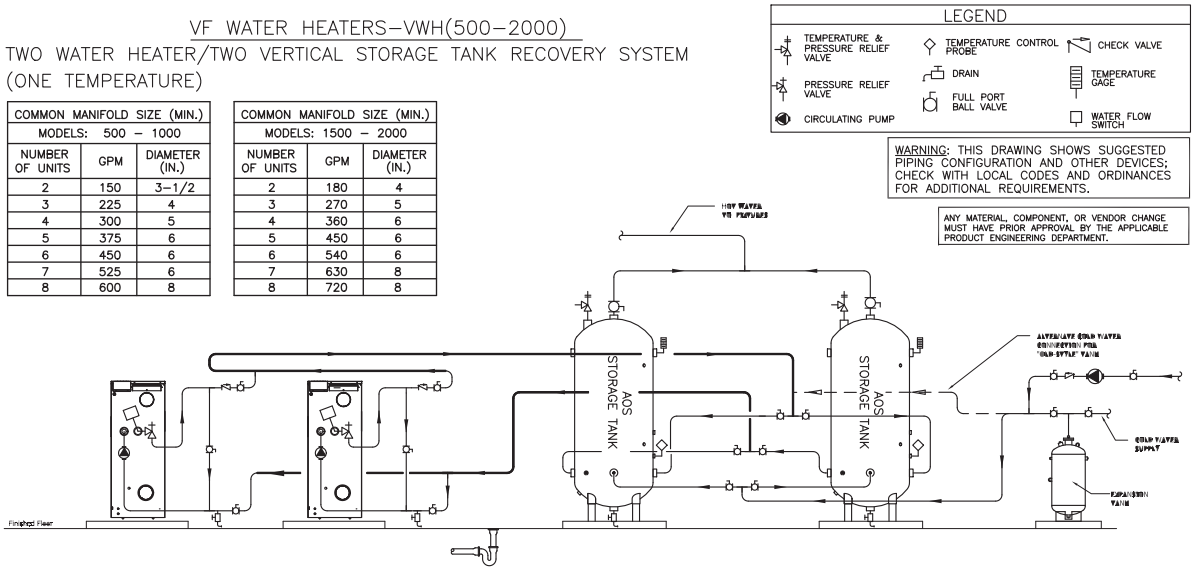
Here are the common manifold pipe sizes and the combined flow rates for the VF product family.

VF WATER HEATERS–VWH(500–2000)

TWO WATER HEATER/TWO VERTICAL STORAGE TANK RECOVERY SYSTEM (ONE TEMPERATURE)

COMMON MANIFOLD SIZE (MIN.) MODELS: 500 – 1000		
NUMBER OF UNITS	GPM	DIAMETER (IN.)
2	150	3–1/2
3	225	4
4	300	5
5	375	6
6	450	6
7	525	6
8	600	8

COMMON MANIFOLD SIZE (MIN.) MODELS: 1500 – 2000		
NUMBER OF UNITS	GPM	DIAMETER (IN.)
2	180	4
3	270	5
4	360	6
5	450	6
6	540	6
7	630	8
8	720	8



Regardless of the number of tanks, when you have more than one heater, the common pipe size must increase because the number of pumps increased. However, if you have multiple tanks but only one heater, you do not have to increase the common manifold size because you only have one pump.

TIP

REMEMBER TO SPECIFY STORAGE TANK'S RECIRCULATION TAPPINGS THAT WILL MATCH THE SIZE OF THE COMMON MANIFOLD.

WATER (CONT'D)

Now that we've seen some designs, let's consider three important concepts for designing the domestic water piping system. They are…

- ***WATER FLOW***
- ***WATER TEMPERATURE***
- ***WATER VOLUME***

Basically, a water heater or bank of water heaters have a given range of operation under these three concepts. A water heater has a water flow rate range. A water heater has a water temperature range. A water heater has a water volume range. If you design a system that lets the appliance operate within its comfort zone, it lives a long and prosperous life. If the system forces the appliance to operate outside any one of the three comfort zones, it suffers.

WATER FLOW

The flow rate concept is easy. The water MUST flow through the VF at a specified flow rate. Period.

The specified flow rate for the VF models VWH0500 thru 1000 is 75 GPM.
The specified flow rate for the VF models VWH1500 thru 2000 is 90 GPM.

The idea behind flow rate is to avoid "lime scale" buildup. All water contains minute quantities of calcium, referred to as water hardness and free floating particulate, referred to as Total Dissolved Solids (TDS).

When water is heated the calcium precipitates or boils out to become free floating particulate. This newly released calcium along with other free floating particulate can stick to the inside of the copper-finned tubes. Over time, lime scale could build up on the inside of the tubes.

This layer of lime scale can become so thick it will interfere with the heat transfer process. Normally, heat is transferred efficiently from the flame through the copper and into the water. The lime scale becomes a layer of insulation between the copper and the water. If the copper can't instantly release the heat into the water, then the copper will overheat. This leads to a failure of the copper and ultimately, the entire heat exchanger.

WARNING!!

FAILURE OF THE HEAT EXCHANGER DUE TO LIME SCALE BUILDUP IS A NON-WARRANTABLE FAILURE.

Here is why flow rate is important to lime scale. If the flow rate is too low, the calcium has a chance to adhere to the copper. But if we flow the water fast enough, the calcium doesn't get a chance to adhere to the tube. In addition, at the proper flow rate, the water creates a scouring action that tumbles along the ribbed interior of the copper tube, keeping it clear of lime scale.

Therefore, too low a flow rate is bad. Conversely, too high a flow rate can also damage the tubes. At too high a flow rate, the scouring action of the water becomes so aggressive that it chips away at the copper tube, eroding the tube and causing tube failure. That's not warrantable either.

Temperature Rise Chart Copper Heat Exchanger	
Model Number	Temp. Rise °F
VWH0500N	11
VWH0750N	17
VWH1000N	23
VWH1500N	28
VWH2000N	38

Temperature Rise Chart Copper-Nickel Heat Exchanger	
Model Number	Temp. Rise °F
VWH0500N	9
VWH0750N	14
VWH1000N	18
VWH1500N	22
VWH2000N	30

WATER (CONT'D)

COPPER-NICKEL HEAT EXCHANGERS

These flow rates will deliver the proper temperature rise for lime scale free operation in the copper-finned tubes that are standard equipment on all VF models. For water that is just outside the specified range, the VF water heaters can be factory trimmed with Copper-Nickel heat exchangers.

90% copper, 10% nickel, the Copper-Nickel finned tube is a harder alloy than pure copper. With a harder alloy, we can flow the water through the heat exchanger at a greater speed. If you have water chemistry in the following range, you can use a copper-nickel exchanger instead of a water softener. The higher flow rates for the Copper-Nickel heat exchanger are 25% faster.

WATER CHEMISTRY

While flow rate has been our main focus, there is a companion concept to mention. We return to the idea of water chemistry, the amount of calcium and Total Dissolved Solid in the water. Now, let's add Ph to the list and look at them closely.

Yes, with a specified flow rate, the VF can give you lime scale free operation. But that is based on a normal amount of material in the water. Obviously, it is possible to have so much calcium and TDS in the water that no amount of water flow can wash it away.

Based on the copper-finned tube design, the water chemistry must be in the following range:

Minimum Water Hardness:	**5 Grains**
Maximum Water Hardness:	**25 Grains**
Max Total Dissolved Solids:	**350 PPM**
Acceptable PH:	**7.2 to 7.8**

If the water is outside these parameters, water softeners or other measures must be taken to put the water chemistry inside the specified range. Failure of a heat exchanger due to bad water conditions is a non-warrantable failure.

WATER TEMPERATURE

Water temperature is also an easy concept. The water temperature delivered to the VF must be high enough to avoid condensation in the heat exchanger.

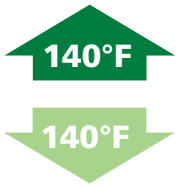
The minimum return water temperature to the VF water heater is 140°F (60°C).

Reason why? If the inlet water temperature is less than 140°F, condensate will occur on the outside of the copper-finned tube and in-between the fins. The condensate will collect particles from the flue products. The moisture and particles build up over time and ultimately will clog the fins. This leads to improper combustion, sooting, elevated temperatures and premature failure of the heat exchanger.

Since the water flowing into the water heater comes directly from the storage tank, A. O. Smith recommends maintaining a stored water temperature of 140°F or greater. That works perfectly for kitchens, laundries and other processes that use high water temperatures.

In addition, 140°F or greater water temperature will kill the bacteria that causes Legionella disease, a major concern in public water distribution systems.

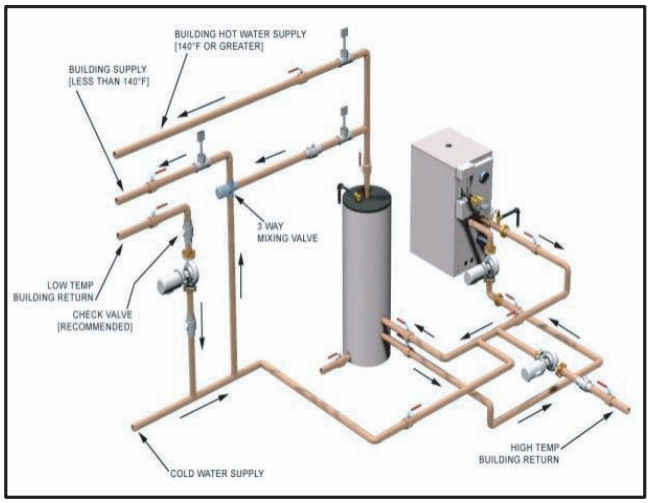
The flip side of that coin is the issue of scald. Direct contact with 140°F water will cause a scald injury. Water to public showers and sinks require lower water temperatures. Most areas of the country have safety standards for nursing homes, schools and hotels that require no more than 110°F water delivered to the customer.



So we are caught between the need to maintain a return water above 140°F and a system supply temperature below 140°F. What's a designer to do?

We strongly recommend you store your water temperature at 140°F, then use a mixing valve to deliver a lower water temperature to the system.

WATER (CONT'D)



This is a single heater, single tank diagram featuring a three way mixing valve. The valve in this illustration takes 140°F water from the tank, mixes it with the cold water from the city supply and sends mixed water below 140°F to the system.

There are a variety of choices in mixing valves. There are valves that mix at the storage tank. There are faucets and other fixtures that limit the water temperature at the point of use. Whatever method you use, consult the valve manufacturer for details on how to pipe that particular brand.

All VF Water Heater piping diagrams show a bypass between the inlet and the outlet of the water heater. If a mixing valve is not used and less than 140°F (60°C) is required for the system temperature. The bypass valve will need to be adjusted to maintain 140° (60°C) at the inlet of the water heater to prevent condensing and premature failure of the heat exchanger.

Properly sized systems maintaining a stored water temperature of 140° (60°C) or more may not require a bypass or the bypass valve may remain closed.

WATER VOLUME

The VF water heater is often misinterpreted as an instantaneous water heater. Yes, it does heat water very quickly but the water heater alone cannot react quickly enough to provide an uninterrupted flow of hot water at a prescribed temperature. A storage tank MUST be installed.

Even then, systems are often designed to rely primarily on the VF heating capacity to carry the system demand with a very small storage tank acting as a buffer. This can work but, logically, it is possible to undersize the tank. When that happens, the VF water heater suffers too low an inlet water temperature and the heat exchanger will condense.

Here's a basic calculation to determine the minimum gallon capacity of the tank. Divide the Btu/Hr input by 4000. Example: the VF 500,000 Btu/hr model would require a minimum stored gallon capacity of 125 gallons. OK, you can shave that a bit and install the TJV-120A or TJV-120M tank.

Even though the VF series has a 4:1 turndown and will fire as low as 25% of the total Btu/hr input. The tank must be sized for maximum demand and maximum firing rate. So, size for the full Btu/hr input.

Model Number	Minimum Gallon Capacity	Recommended A. O. Smith Storage Tank
VWH0500N	125	TJV-120A
VWH0750N	188	TJV-200A
VWH1000N	250	TJV-250A
VWH1500N	375	TJV-400A
VWH2000N	500	TJV-500A

CHAPTER 5
ELECTRICAL & CONTROLS

The first idea for this chapter is supplying power to the water heater. A 120 VAC, 15 Amp, 1 ph, 60 Hz circuit is required for operation of the water heater.

The appliance, when installed, must be electrically grounded in accordance with the requirements of the authority having jurisdiction, or in the absence of such requirements, with the latest edition of the National Electrical Code ANSI/NFPA No. 70. When the unit is installed in Canada, it must conform to the CAE C22.1, Canadian Electrical Code, Part I and/or local Electrical Codes.

1. All wiring between the appliance and field installed devices shall be made with type T wire [63°F (35°C) rise].
2. All voltage wire exterior to the appliance must be enclosed in approved conduit or approved metal clad cable.
3. The appliance must be provided with proper overload protection.

AMP DRAW DATA			
Model Number	Blowers and Controls	Pump FLA	Total Amps 120 VAC
VWH0500	6.7	8.8	15.5
VWH0750	6.7	8.8	15.5
VWH1000	6.7	8.8	15.5
VWH1500	6.5	8.8	15.3
VWH2000	6.5	8.8	15.3

VF'S ELECTRONIC CONTROL

The VF's Electronic Control is designed to operate all the various elements of domestic hot water heating system. The VF's Electronic Control will control temperature, operate the pump and dispense a large amount of operational data.

ELECTRICAL & CONTROLS (CONT'D)

PUMP CONTROL

The VF's Electronic Control will operate the circulator pump. The terminal strip is rated for 1 HP pumps maximum adequate to control the all-bronze pump supplied with every VF water heater. Intermittent pump operation. 30 second pump delay (programmable).

HIGH VOLTAGE TERMINAL STRIP CONNECTIONS

Alarm on Any Failure Contacts

Should the VF's Electronic Control detect a fault, it will send an alarm signal through these dry contacts to a remote control board or activate an alarm bell.

Run Time Contacts

The VF's Electronic Control will "make" dry contacts for the duration of the Main Burner.

LOW VOLTAGE TERMINAL BOARD

Every VF is equipped with a Low Voltage Terminal Board for a variety of other field connections and control features.

Tank Sensor or Tank Thermostat

The control will operate the water heater based on a signal from a tank sensor with a resistance signal or a tank thermostat with an enable / disable signal.

Louver Contacts

The control will open and close equipment room louvers on a call for heat with Louver Proving Switch for control safety.

BMS Control with 0-10 Vdc Input

The VF's Electronic Control can be activated by a Building Management System with a 0-10 Vdc signal. The signal can control either the setpoint or the modulation directly.

TIP

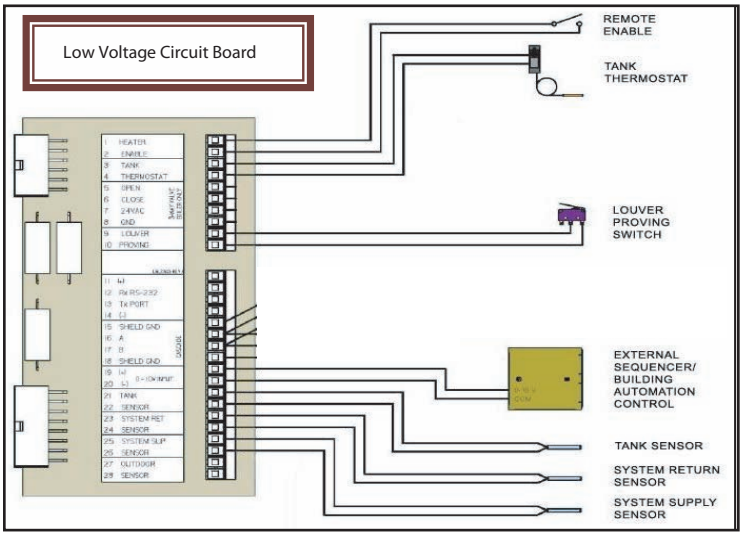
DRAW THE SENSORS AND THE SENSOR LOCATIONS INTO YOUR BUILDING AND PIPING PLANS.

VF'S ELECTRONIC CONTROL OPERATIONAL FEATURES

The following is a list of just a few of the many other operational features built-in to the control. For the complete list of features with more detailed explanations plus programming parameters, refer to the Installation & Operation Manual or the User Manual.

Clock

The VF's Electronic Control has a clock for date and time. This must be set for record keeping and night setback functions.



ELECTRICAL & CONTROLS (CONT'D)

VF'S ELECTRONIC CONTROL OPERATIONAL FEATURES (cont'd)

Freeze Protection

The control automatically monitors the water temperatures and will operate the pump and if necessary, fire the appliance to protect the heat exchanger from freezing.

Inlet Water Temperature

The control will monitor inlet water temperature and report persistent flow of water less than 130°F which will cause condensation in the heat exchanger.

Anti-Cycling

The control will monitor burn cycles and force a minimum off time to reduce short cycling.

Night Setback

The control will reduce the DHW setpoints during periods where the building is unoccupied. This is a programmable parameter.

Service Reminder

The control can display a reminder to the customer that it is time for a service call. This time frame is a programmable parameter.

AND MORE

Open / Shorted Sensor Detection
Monitoring of Safety Devices
Fan Speed Low & Fan Speed High
Ramp Delay
Flame Current Support
Run Time and Cycle Count
Flue Temperature Limiting
Temperature Rise Limiting
Outlet Temperature Limiting
High Limit Operation
Low Voltage Blocking
Low Water Cutoff Protection

CHAPTER 6

CHAPTER 6
OTHER DETAILS OF GREAT IMPORTANCE

STANDARD CODES, STANDARD CONSTRUCTION

The VF water heater is design certified to the latest edition of ANSI Z21.10.3, the water heater standard. The third party certification was performed by CSA International and the water heater bears the American Blue Star emblem and the Canadian Blue Flame emblem. The heat exchanger inside the water heater conforms to the latest edition of the ASME Boiler and Pressure Vessel Code, Section IV and the vessel bears the ASME "HLW" Stamp.

The installation of a water heater with a storage tank is governed by local boiler and water heater codes. The water heater and tank shall be installed in accordance with those installation regulations and shall be carefully followed in all cases. Authorities having jurisdiction shall be consulted before installations are made. The local code may require a feature on the water heater above and beyond the ANSI requirements. Check the list of factory installed options on page 31. Again, these options are factory installed and must be specified on the original purchase order. Review the local code especially in regard to the venting requirements.

In the absence of local codes, U.S. installations shall conform to the latest edition of the National Fuel Gas Code, ANSI Z223.1. In Canada, the installation must comply with the Canadian Gas Association Code, CAN/CGA-B149.1 and/or B149.2 and/or local codes.

CSA International
Blue Star for
United States

CSA International
Blue Flame for
Canada

ASME, Section IV
"HLW" stamp
Water Heaters

OPTIONAL CODES, ADDITIONAL CONSTRUCTION

Primarily, local building code inspectors inspect boiler installations. When reviewing water heater installations, inspectors occasionally ask for the water heaters to comply with well known boiler codes, such as CSD1, the American

Society of Mechanical Engineers Safety Code for Controls and Safety Devices for Automatically Fired Boilers. Also, they'll ask for Factory Mutual or "GE Gap", popular insurance codes that call for CSD-1 requirements.

CSD-1 is strictly a space heating boiler code. Per CSD-1 code, Section CG-130, "Exclusions", water heaters are exempt from the boiler requirements. The standard water heater built to the ANSI Z21.10.3 requirements is acceptable.

STATE CODES, ADDITIONAL CONSTRUCTION

All states have their own boiler and water heater installation codes, but some states have codes that require special equipment on the water heater itself. Currently, California, Massachusetts, Minnesota and Kentucky have state codes that require additions to A. O. Smith products. Check with your local A. O. Smith sales office or A. O. Smith Customer Service for details.

DETERMINE THE UNIT LOCATION

1. Locate the appliance so that if water connections should leak, water damage will not occur. When such locations cannot be avoided, it is recommended that a suitable drain pan, adequately drained, be installed under the unit. The pan must not restrict combustion airflow.

   Under no circumstances is the manufacturer to be held responsible for water damage in connection with this unit, or any of its components.

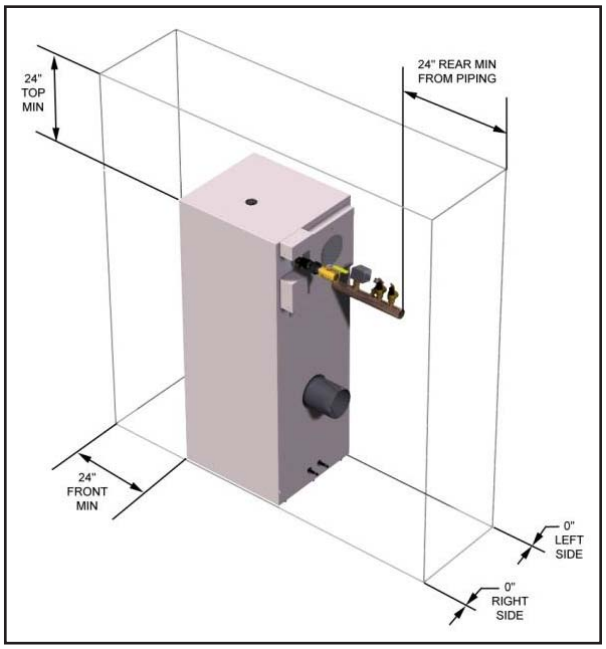
2. **DO NOT** install this appliance in any location where gasoline or flammable vapors are likely to be present.

3. The appliance must be installed on a level floor. Combustible floor locations may be used. Maintain required clearances from combustible surfaces.

4. The appliance must be installed indoors where it is protected from exposure to wind, rain, and weather.

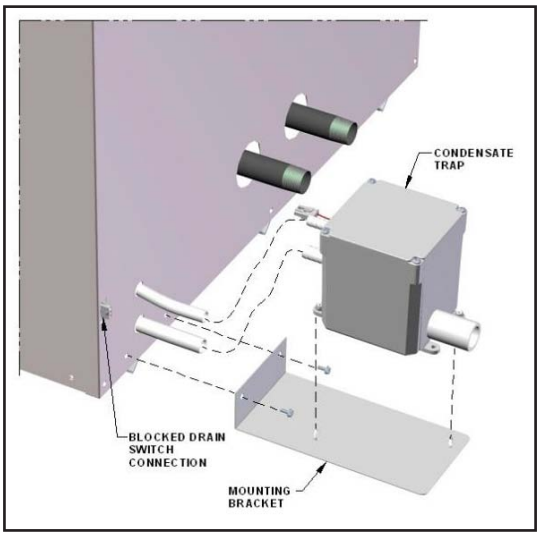
5. This appliance may condense the products of combustion if operated at water temperatures below 140°F (60°C). Ensure that the appliance is located near an acceptable drain where condensate that may form in the venting system can be properly collected and disposed.

6. Access to the rear of the appliance ***MUST*** be maintained.



CLEARANCES FROM COMBUSTIBLE CONSTRUCTION	
Right Side	Zero inches
Left Side	Zero inches
Rear	6" (Minimum 24" suggested for service to the pump and other components)
Front - Alcove*	(Minimum 24" suggested for service)
Top	6" (Minimum 24" suggested for service)
Flue	2"
Hot Water Pipes	1"

*An Alcove is a closet without a door.



CONDENSATE TRAP

The VF is fitted with a condensate trap to be field mounted on the floor behind the appliance. The trap is a requirement of the ANSI standard for any Category IV vented appliance with condensation forming in the stack.

HIGH ALTITUDE APPLICATIONS

Atmospheric pressure decreases as the height above sea level increases. At any altitude above sea level, a cubic foot contains less gas than a cubic foot at sea level. Thus, the heating value of a cubic foot of fuel gas will decrease as height above sea level increases. Therefore a recalculation of heat input rate should be performed on any appliance beginning at 2000 feet. Ratings should be reduced at the rate of 4 percent for each 1000 feet above sea level. The VF water heater must be factory trimmed for installation at an altitude range **GREATER** than 4000 feet above sea level.

FACTORY INSTALLED OPTIONAL EQUIPMENT

A. O. Smith provides the following selection of optional equipment to meet your building requirements.

Alarm Bell

Factory installed onto the inner front panel of the appliance and wired to the alarm on any failure contacts. It will sound on any failure. A silencing switch is provided. Alarm on any failure contacts are standard on every VF water heater for connection to a remote alarm bell or Building Management System.

High & Low Gas Pressure Switches with Manual Reset

The switches are mounted just inside the upper front chamber. The High Gas Switch will interrupt the call for heat should high gas pressure be sensed in the gas line. The Low Gas Switch will interrupt the call for heat if the gas pressure supplied to the appliance is too low to achieve a safe burner flame. Both switches require manual reset to restart the appliance. The High and Low Gas Pressure Switches with Manual Reset is part of the Factory Mutual, GE Gap or CSD1 option packages. Per CSD-1's exemption of the water heater, the Gas Pressure switched may be ordered by name individually and not as part of CSD-1 code package.

Low Water Cut-Off, Probe Type with Manual Reset

The electronic board is mounted in the control panel with a sensing probe mounted in the top header of the heat exchanger. The LWCO is set to interrupt the call for heat if a low water condition is sensed. The LWCO requires manual reset to restart the appliance. This is offered for many local codes that do not accept the standard-equipped flow switch as a low water cut off device. Check with local code authorities for acceptance of the standard flow switch as a low water cut off device.

Cupro-Nickel Heat Exchanger

90% copper, 10% nickel, the Copper-Nickel Heat Exchanger is a harder alloy than the standard copper-tubed heat exchanger and is suggested for chemically treated water and for hard water conditions.

Relief Valve

The standard relief valve offered on the VF water heater is a 125 psi temperature & pressure ASME relief valve. The VF can be factory trimmed with a temperature & pressure relief valves with a different pressure rating of your choosing.

APPENDIX A

WATER HEATER PIPING DIAGRAMS

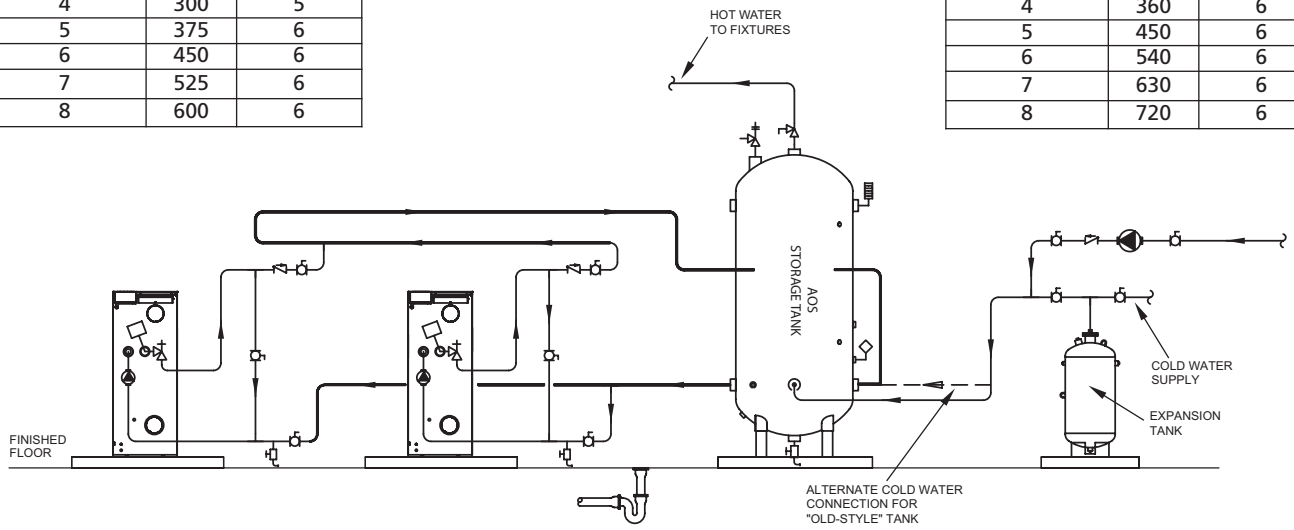
The illustration is for concept only and should not be used for actual installation without engineering or technical advice from a licensed engineer. All necessary system equipment may not be illustrated.

WATER HEATER PIPING DIAGRAMS

VF WATER HEATERS VWH (500-2000)
TWO WATER HEATERS/VERTICAL STORAGE TANK RECOVERY SYSTEM (ONE TEMPERATURE)

COMMON MANIFOLD SIZE (MIN.)		
MODELS: 500-1000		
NUMBER OF UNITS	**GPM**	**DIAMETER (IN.)**
2	150	3-1/2
3	225	4
4	300	5
5	375	6
6	450	6
7	525	6
8	600	6

COMMON MANIFOLD SIZE (MIN.)		
MODELS: 1500-2000		
NUMBER OF UNITS	**GPM**	**DIAMETER (IN.)**
2	180	4
3	270	5
4	360	6
5	450	6
6	540	6
7	630	6
8	720	6



NOTES:

1. *Preferred piping method.*
2. *The temperature and pressure relief valve setting shall not exceed pressure rating of any component in the system.*
3. *Service valves are shown for servicing water heater. However, local codes shall govern their usage.*
4. *A. O. Smith piping method is based on 50 equivalent feet of piping. Water heater placement shall be as close as practical to the storage tank. Applications in excess of these recommendations shall require a licensed engineer for design assistance.*
5. *Temperature control probe (quad thermistor probe, P/N 9006905005) must be installed onto the tank, and connected to each water heater.*

WARNING: *This drawing shows suggested piping configuration and other devices, check with local codes and ordinances for additional requirements.*

Any material, component or vendor change must have prior approval by the applicable product engineering department

LEGEND

TEMPERATURE & PRESSURE RELIEF VALVE	PRESSURE RELIEF VALVE	CIRCULATING PUMP	TEMPERATURE CONTROL PROBE	DRAIN	FULL PORT BALL VALVE	CHECK VALVE	TEMPERATURE GAUGE	WATER FLOW SWITCH
								

WATER HEATER PIPING DIAGRAMS

VF WATER HEATERS VWH (500-2000)
THREE WATER HEATERS/VERTICAL STORAGE TANK RECOVERY SYSTEM (ONE TEMPERATURE)

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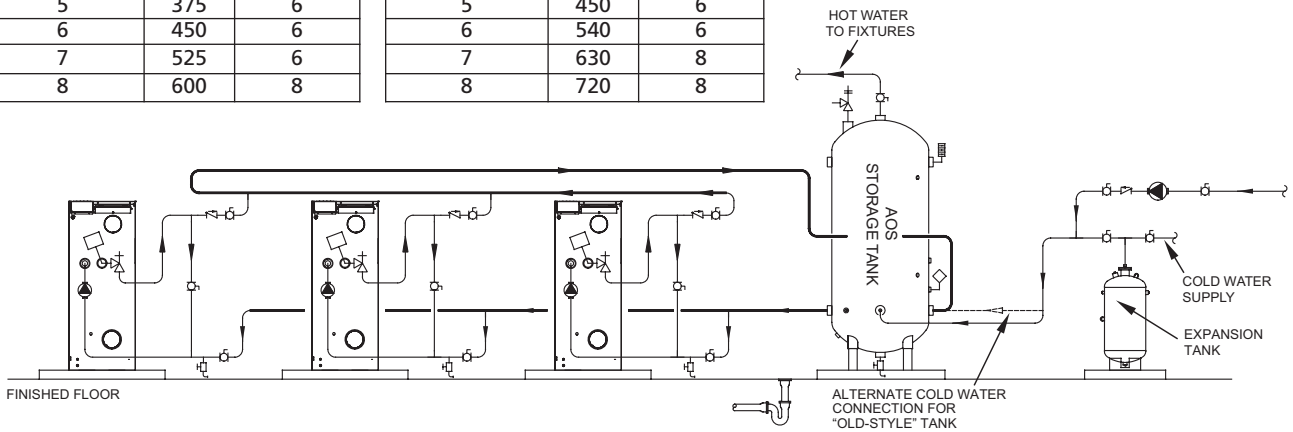

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LEGEND

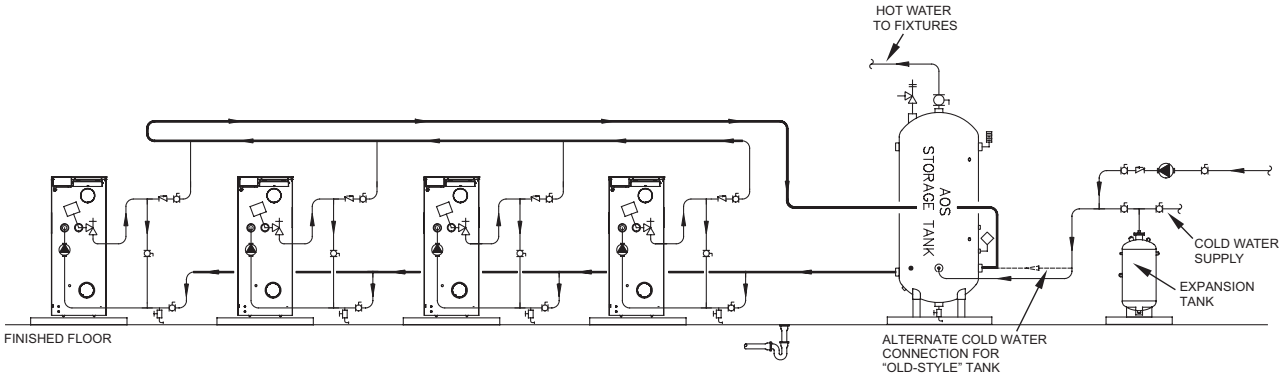
TEMPERATURE & PRESSURE RELIEF VALVE	PRESSURE RELIEF VALVE	CIRCULATING PUMP	TEMPERATURE CONTROL PROBE	DRAIN	FULL PORT BALL VALVE	CHECK VALVE	TEMPERATURE GAUGE	WATER FLOW SWITCH
								

WATER HEATER PIPING DIAGRAMS

VF WATER HEATERS VWH (500-2000)
FOUR WATER HEATERS/VERTICAL STORAGE TANK RECOVERY SYSTEM (ONE TEMPERATURE)

COMMON MANIFOLD SIZE (MIN.)		
MODELS: 500-1000		
NUMBER OF UNITS	**GPM**	**DIAMETER (IN.)**
2	150	3-1/2
3	225	4
4	300	5
5	375	6
6	450	6
7	525	6
8	600	8

COMMON MANIFOLD SIZE (MIN.)		
MODELS: 1500-2000		
NUMBER OF UNITS	**GPM**	**DIAMETER (IN.)**
2	180	4
3	270	5
4	360	6
5	450	6
6	540	6
7	630	8
8	720	8



NOTES:

1. *Preferred piping method.*
2. *The temperature and pressure relief valve setting shall not exceed pressure rating of any component in the system.*
3. *Service valves are shown for servicing water heater. However, local codes shall govern their usage.*
4. *A. O. Smith piping method is based on 50 equivalent feet of piping. Water heater placement shall be as close as practical to the storage tank. Applications in excess of these recommendations shall require a licensed engineer for design assistance.*
5. *Temperature control probe (quad thermistor probe, P/N 9006905005) must be installed onto the tank, and connected to each water heater.*

WARNING: *This drawing shows suggested piping configuration and other devices, check with local codes and ordinances for additional requirements.*

Any material, component or vendor change must have prior approval by the applicable product engineering department

LEGEND

TEMPERATURE & PRESSURE RELIEF VALVE	PRESSURE RELIEF VALVE	CIRCULATING PUMP	TEMPERATURE CONTROL PROBE	DRAIN	FULL PORT BALL VALVE	CHECK VALVE	TEMPERATURE GAUGE	WATER FLOW SWITCH
								

APPENDIX B

TECHNICAL DATA AND WATER HEATER COMPONENT BREAKDOWN

VF – the components, the design

1. **Heat exchanger**
   The heat exchanger allows system water to flow through specially designed tubes for maximum heat transfer. The glasslined headers and copper finned tubing are encased in a jacket that contains the combustion process.

2. **Heat exchanger access cover**
   The heat exchanger access cover is a stainless steel door which allows access for service, maintenance, and removal of the heat exchanger from inside the combustion chamber.

3. **Blower**
   The blower pulls in air and gas through the venturi (see item 5) and injects the fuel/air mixture into the burner, where they burn inside the combustion chamber.

4. **Gas valve**
   The gas valve allows the proper amount of gas to pass into the burner for combustion. The gas valve on the VF works under a negative pressure so gas should only be pulled through the valve when the blower is in operation.

5. **Venturi**
   The venturi attaches to the inlet (or suction) side of the blower and generates the negative pressure needed by the gas valve.

6. **Flue sensor**
   The flue sensor is mounted in the exhaust collar of the unit and monitors the flue gas temperature. If the temperature in the stack exceeds the maximum temperature the unit will shut down to prevent a hazardous condition. The flue sensor helps to control the amount of modulation to prevent condensation in the stack.

7. **Outlet temperature sensor**
   This sensor monitors the outlet water temperature. If selected as the controlling sensor, the appliance will maintain set point by adjusting the firing rate of the unit according to this sensor.

8. **Inlet temperature sensor**
   This sensor monitors inlet water temperature. If selected as the controlling sensor, the appliance will maintain set point by adjusting the firing rate of the unit according to this sensor.

9. **Temperature and pressure gauge**
   The temperature and pressure gauge monitors the outlet temperature of the appliance as well as the system water pressure.

10. **Electronic display**
    The electronic display consists of 7 buttons and a dual line 32-character liquid crystal display used to monitor the operation of the heater as well as enter and view the programming of the main control board.

11. **Burner**
    The burner is made of a woven fabric over steel screen construction. The burner uses pre-mixed air and gas and provides a wide range of firing rates.

12. **Water outlet (supply)**
    The water outlet is a 2 1/2" pipe connection that supplies water to the system with connections for a flow switch (see #28), a relief valve (see #25).

13. **Water inlet (return)**
    The water inlet is a 2 1/2" pipe connection that receives water from the tank and delivers it to the heat exchanger.

VF – the components, the design (cont'd)

14. Gas connection pipe
The gas pipe connection on this appliance is 1", 1-1/4", or 1-1/2" NPT. To deliver the correct amount of gas volume to the appliance it may be necessary to have a larger gas line and reduce to the appliance connection size at the appliance. Please reference the National Fuel Gas Code charts for more details.

15. VF's Electronic Control Module
The Control Module is the main control for the appliance. This module contains the programming that operates the blower, gas valve, and pumps in addition to other programmable features.

16. Air intake
The air intake pipe allows fresh air to flow directly to the appliance. The air inlet is part of the filter box assembly where air filtration is accomplished with a standard filter.

17. Line voltage terminal strip
The line voltage terminal strip provides a location to connect all of the high voltage (120 VAC) contact points to the unit, such as the contacts to control the recirculation pump.

18. Low voltage connection board
The low voltage connection board provides a location to tie in all of the low voltage contacts to the appliance. This is where most of the external safety devices are connected to the unit such as the tank thermostat or tank sensor.

19. Condensate trap
The condensate trap is designed to prevent flue gases from escaping the appliance through the combustion chamber drain.

20. Access cover - front
The front access cover provides access to the gas train as well as the blower and other key components for service and maintenance.

21. Hot Surface Igniter (HSI)
The hot surface igniter is a device that is used to ignite the air/gas mixture as well as monitor the performance of the flame during operation. This device also acts as a flame sense electrode.

22. Flame inspection window (sight glass)
The flame inspection window is a quartz glass window that allows a visual inspection of the burner and flame during operation.

23. Gas shut off valve (downstream test cock)
The downstream test cock is provided in the gas train to ensure complete shut off of the gas to the burner in case of maintenance, inspection, or testing of the valve.

24. High limit sensor
A device that monitors the outlet water temperature to ensure safe operation. If the temperature exceeds its setting (field adjustable), it will break the control circuit, shutting the appliance down.

25. Relief valve
The relief valve is a safety device that ensures the maximum pressure of the appliance is not exceeded. Water heaters receive 125 PSI Temperature & Pressure Relief Valves.

26. Power switch
The power switch is used to engage and disengage power to the appliance on the 120 VAC circuit.

VF – the components, the design (cont'd)

27. Air pressure switch

The air pressure switch is a safety device which ensures proper blower operation. The air pressure switch is wired in series with the low voltage control circuit in such a way that if the fan does not engage or shuts down prematurely the device will break the control circuit and the unit will shut down.

28. Flow switch

The flow switch is a safety device that ensures flow through the heat exchanger during operation. This appliance is low mass and should never be operated without flow. The flow switch makes contact when flow is detected and allows the unit to operate. If flow is discontinued during operation for any reason the flow switch will break the control circuit and the unit will shut down.

29. Drain port(s)

Location from which the heat exchanger can be drained.

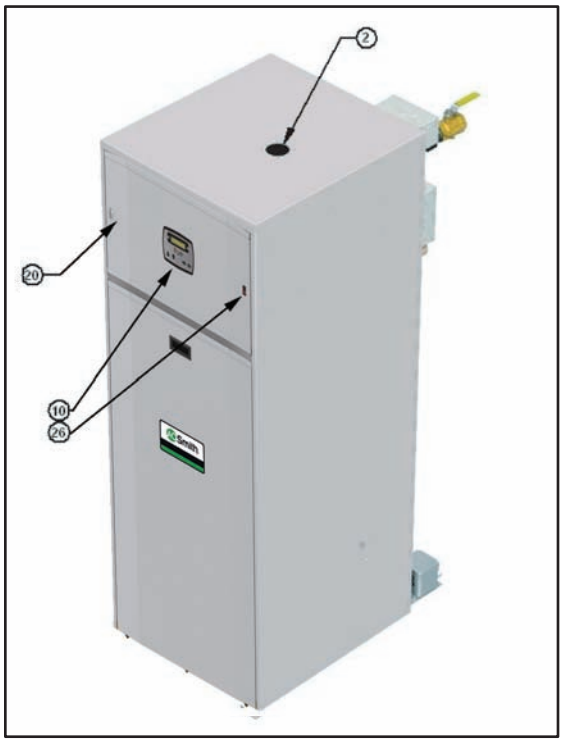
30. Ventilation fan

Provides air circulation around the controls inside the unit.

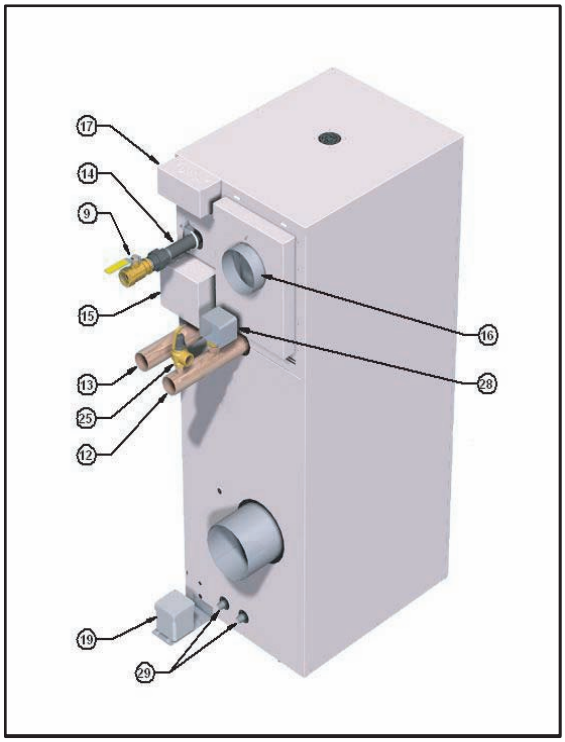
31. Manual shutoff valve

Manual valve used to isolate the unit from the gas supply.

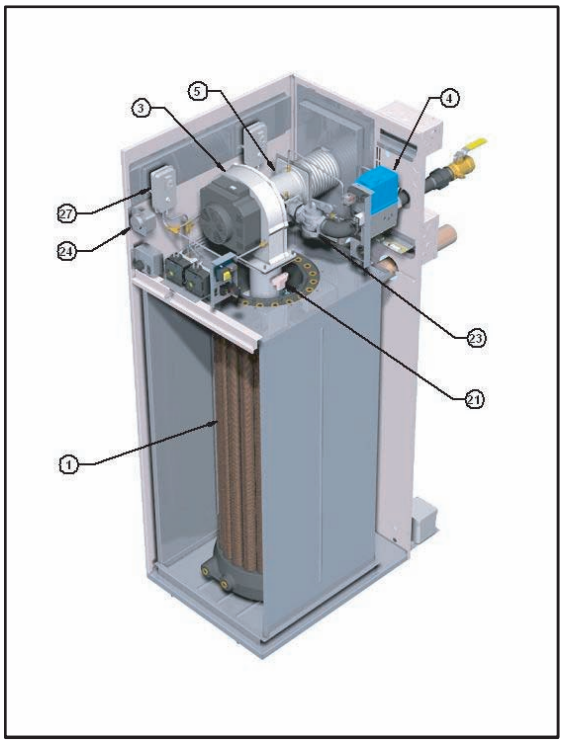
VF models VWH0500 thru 1000



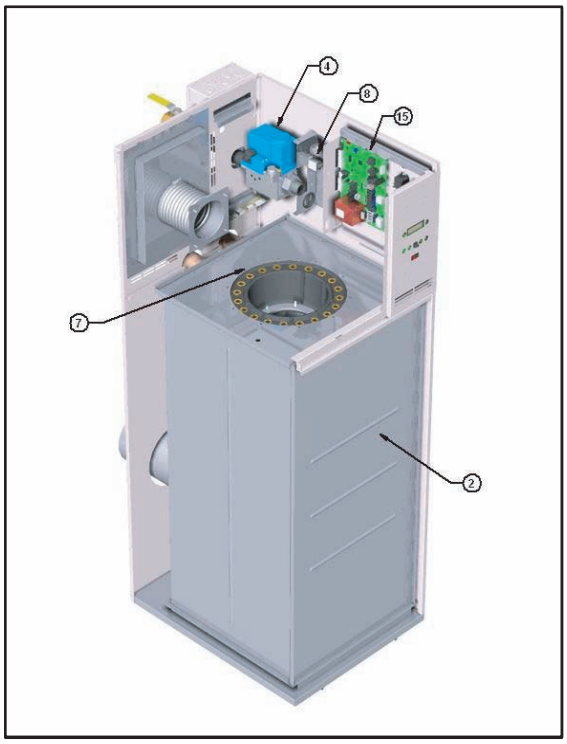
Front View



Rear View

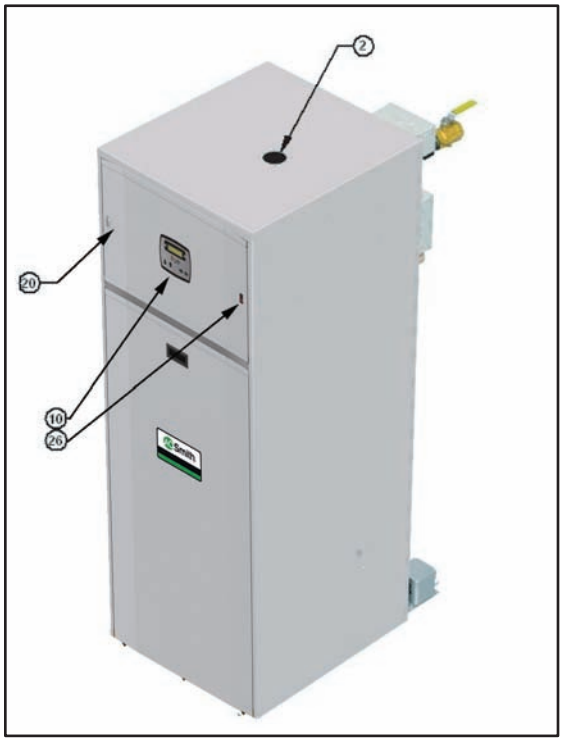


Right Side (inside view)



Left Side (inside view)

VF models VWH1500 and 2000



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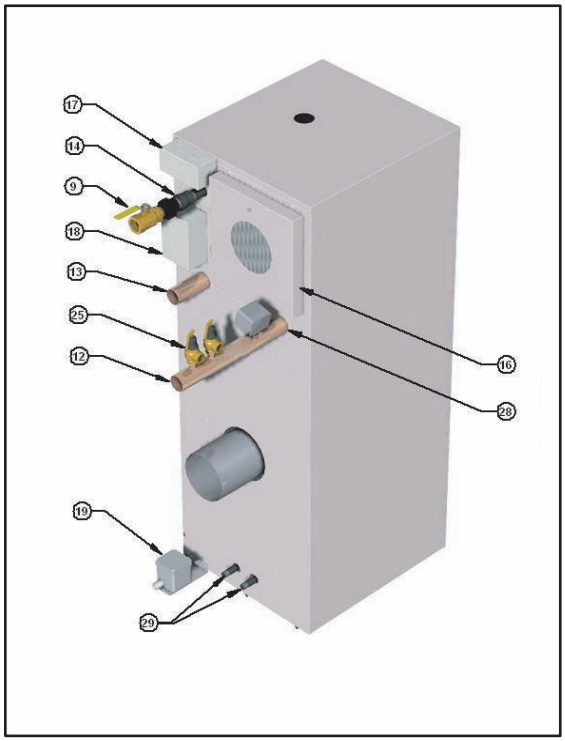

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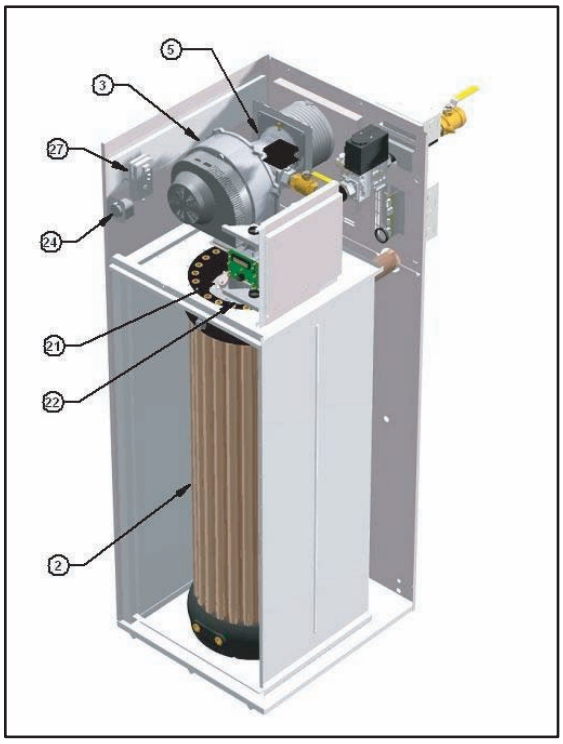
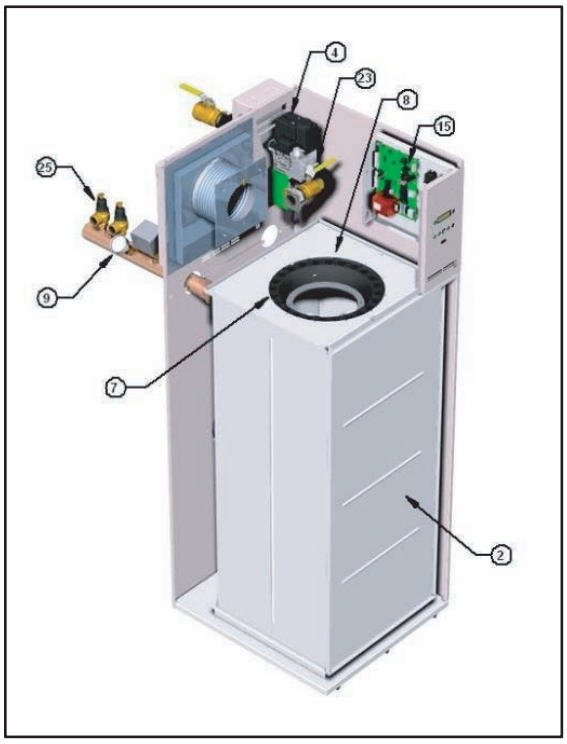


Right Side (inside view)



Left Side (inside view)

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