404 SERVICE WATER HEATING SYSTEMS

Overview

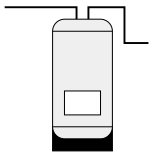
DESIGN CONSIDERATIONS

Compliance with Section 404 of the 90.1 Code is based on the application of some basic, cost-effective, design practices: (see Figure 404A).

- Minimize standby losses with heat traps, thermal insulation, and temperature controls.
- Reduce distribution losses with thermal insulation and system temperature controls or eliminate through point-of-use heaters.
- Reduce hot water waste with flow limiting or metering terminal devices.
- Increase overall system performance with high efficiency sources.

Although compliance with the 90.1 Code assures a minimum level of water heating system performance, the designer is encouraged to view the code as a starting point and investigate designs that exceed these requirements. Application of heat recovery, solar energy, or high efficiency equipment can create a system that is more efficient than the 90.1 Code requires *and* one that exhibits an excellent return on investment. Examples of measures which exceed the code include:

- Specifying low-flow shower heads which exceed the requirements of the code
- Extending the public restroom flow requirements to all restrooms
- Specifying low-water usage or low-temperature appliances, including residential and commercial clothes washers and dishwashers
- Recovering heat from gray water



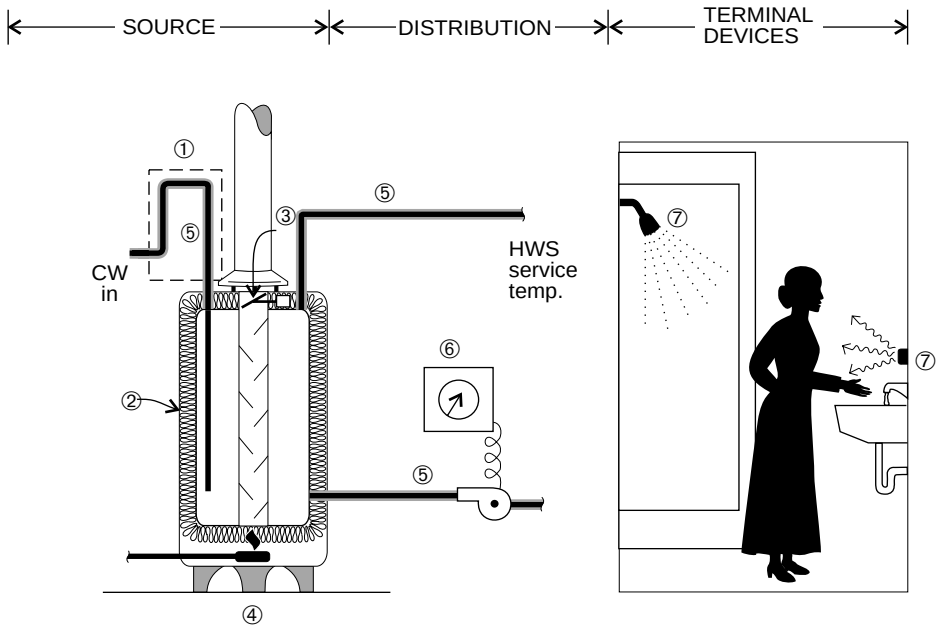
SCOPE

Section 404 of the 90.1 Code contains the requirements for service water heating equipment. These requirements apply to equipment used to produce and distribute hot water for:

- Restrooms
- Showers
- Laundries
- Kitchens
- Pools and spas
- Defrosting of sidewalks and driveways
- Car washes, beauty salons, and other commercial enterprises
- Living units in high-rise residential buildings and hotels

The requirements of this chapter are for service water-heating equipment and systems only; however, the principles presented could apply to energy-efficient process water-heating systems and equipment as well. Space-conditioning boilers and distribution systems are covered under the requirements of Section 403. The service water-heating portion of combined space-conditioning and water-heating systems must meet the requirements of this chapter as well.

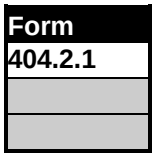
Figure 404A Elements Covered By Section 404 of the 90.1 Code



① Heat traps to reduce standby losses
② Insulated tanks to reduce standby losses
③ Automatic flue damper to reduce standby losses
④ High efficiency sources
⑤ Pipe insulation to reduce distribution and standby losses
⑥ Circulation loop temperature controls to reduce distribution losses
⑦ Flow limiting devices such as low flow shower heads and occupant sensors to reduce waste

CHAPTER ORGANIZATION

The Service Water Heating Systems Summary form, annotated in Figure 404B, provides an organizing element for this chapter. The form itemizes each requirement and provides a place to reference where on the drawings compliance with each requirement is documented. This form is filled out by the permit applicant and is then used by the plan's examiner and the field inspector to verify energy code compliance. The text of this chapter follows the order of the Summary form. As each requirement is addressed, an icon of the Summary form appears in the margin highlighting the appropriate 90.1 Code reference on the form.

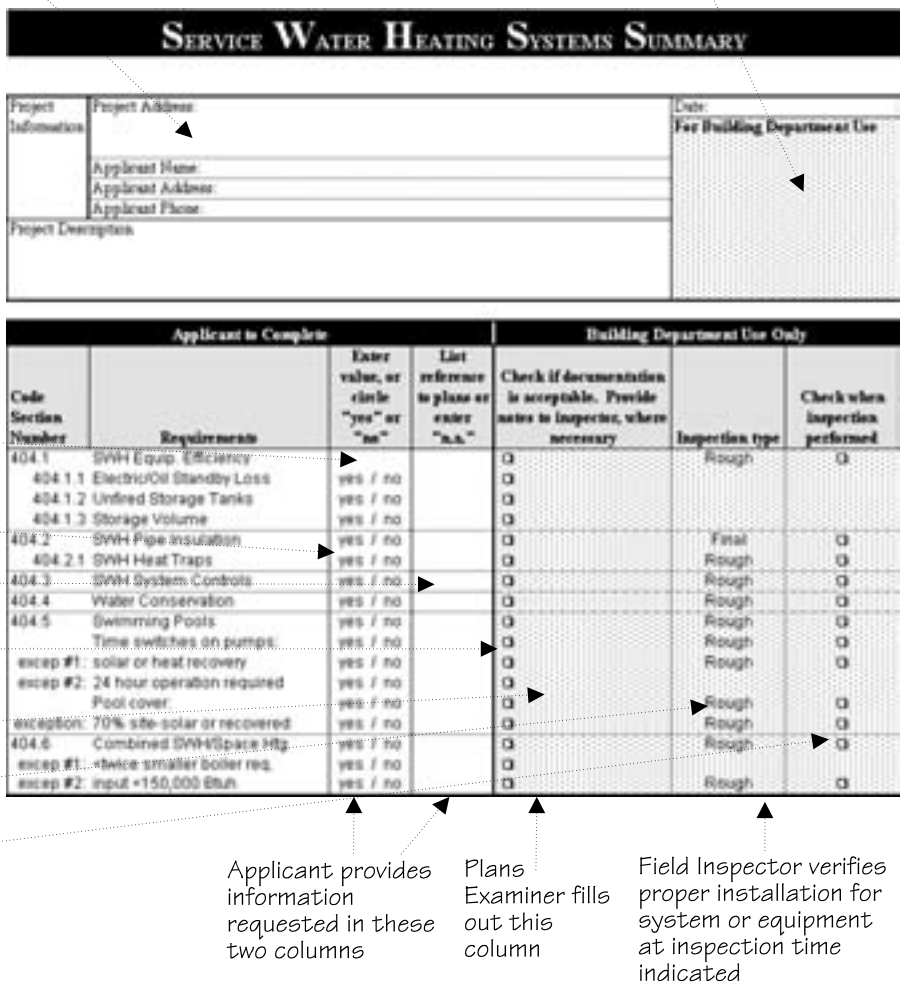


The Compliance and Enforcement section of this chapter describes how to fill out this form in more detail. It will be helpful for the reader to refer to the form as each requirement is addressed below. A blank copy of the form is found in Appendix D.

Figure 404B Annotated Service Water Heating Systems Summary Form

Applicant completes this basic information

Building department may require applicant to certify here that plans comply with the code



SERVICE WATER HEATING SYSTEMS SUMMARY

Project Information	Project Address:	Date:
	Applicant Name:	For Building Department Use
	Applicant Address:	
	Applicant Phone:	
Project Description:		

Applicant to Complete				Building Department Use Only		
Code Section Number	Requirements	Enter value, or circle "yes" or "no"	List reference to plans or enter "n.a."	Check if documentation is acceptable. Provide notes to Inspector, where necessary	Inspection type	Check when inspection performed
404.1	SWH Equip. Efficiency			☐	Rough	☐
404.1.1	Electric/Oil Standby Loss	yes / no		☐		
404.1.2	Unfired Storage Tanks	yes / no		☐		
404.1.3	Storage Volume	yes / no		☐		
404.2	SWH Pipe Insulation	yes / no		☐	Final	☐
404.2.1	SWH Heat Traps	yes / no		☐	Rough	☐
404.3	SWH System Controls	yes / no		☐	Rough	☐
404.4	Water Conservation	yes / no		☐	Rough	☐
404.5	Swimming Pools	yes / no		☐	Rough	☐
	Time switches on pumps	yes / no		☐	Rough	☐
except #1:	solar or heat recovery	yes / no		☐	Rough	☐
except #2:	24 hour operation required	yes / no		☐		
	Pool cover	yes / no		☐	Rough	☐
exception:	70% site-solar or recovered	yes / no		☐	Rough	☐
404.6	Combined SWH/Space Htg.	yes / no		☐	Rough	☐
except #1:	<twice smaller boiler req.	yes / no		☐		
except #2:	input <150,000 Btuh	yes / no		☐	Rough	☐

Section numbers and requirements follow the order of the 90.1 Code

Enter appropriate values in blank spaces

Circle "yes" if the requirement has been met or if "no", circle "yes" to the exception that applies

Write page number(s) or location of drawings where information is identified

Check box if compliance documentation has been reviewed and is acceptable

Note any special features that should be checked in the field

Verify in the field during suggested time of inspection

Check box when relevant inspection has been completed

Applicant provides information requested in these two columns

Plans Examiner fills out this column

Field Inspector verifies proper installation for system or equipment at inspection time indicated

Requirements

Following is a discussion of the service water heating system requirements in the order that they appear in the 90.1 Code.

SERVICE WATER HEATING EQUIPMENT EFFICIENCIES

Form
404.1

Table 404.1 of the 90.1 Code presents the minimum required efficiencies for service water-heating equipment. Equipment is required to have a minimum heater efficiency (thermal efficiency), and/or a maximum standby loss. Smaller equipment, which falls under NAECA[1], is required by the federal government to meet the efficiency requirements given in Table 404.1 of the 90.1 Code before it can be sold. This minimum *energy factor* is a combined measure of thermal efficiency and standby loss. NAECA-covered water heating equipment includes:

- Electric heaters of all types with input ratings less than 12 kW
- Fuel-fired storage heaters at or below 75,000 Btuh input for gas, or 105,000 Btuh input for oil
- Fuel-fired instantaneous heaters at or below 200,000 Btuh input for gas, or 210,000 Btuh for oil
- All fuel-fired pool and spa heaters

The efficiency requirements for non-NAECA equipment are summarized in Table 404A. Equipment in the table is classified by type (instantaneous gas, storage electric, etc.), capacity (input rating), and storage size (V_T). Data from nationally recognized programs using standard DOE/ANSI[2] test procedures can be used to demonstrate compliance with these requirements.

In cases where gas water heaters draw either their combustion air and/or air for draft hood dilution from a conditioned space, automatic vent or flue dampers are required (see Figure 404C). These dampers are beneficial because they reduce standby losses by eliminating convective heat loss through the flue when the water heater is not firing. Vent dampers must meet ANSI standards and be installed in accordance with manufacturer's instructions. The installation of the vent damper shall not require an electrical connection unless the water heater has an available electrical supply. An integral vent or flue damper that is supplied with the equipment by the manufacturer will meet these criteria.

[1]National Appliance Energy Conservation Act

[2]American National Standards Institute

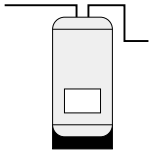


Table 404A Minimum Efficiency Requirements of Non-NAECA Service Water Heating Equipment

Form
404.1.1
404.1.2
404.1.3

Type	Input Rating	V_T	Input/V_T Btuh/gal	Thermal Efficiency Et%	Standby Loss %/hr
Storage Electric	≥ 12 kW	ALL	N/A	N/A	≤ 0.30+27/V_T
All Gas/Oil	≤ 155,000 Btuh	ALL	< 4,000	≥ 78	≤ 1.3+114/V_T
	> 155,000 Btuh	ALL	<4,000	≥ 78	≤ 1.3+95/V_T
	ALL	< 10	≥ 4,000	≥ 80	N/A
	ALL	≥ 10	≥ 4,000	≥ 77	≤ 2.3+67/V_T
Unfired Storage Tanks	N/A	ALL	N/A	N/A	≤ 6.5 Btuh/ft^2

Note that "V_T" in this table is the storage volume, in gallons, determined during the appropriate test procedure. The rated volume provided by the manufacturer can be used for determining the standby loss requirements by assuming that the test volume is equal to no less than 95% of the volume shown on the rating plate for gas and oil water heaters, and no less than 90% of the volume shown on the rating plate for electric water heaters.

Example 404A Equipment Efficiency Requirements – Electric Resistance Water Heater

Q An 82-gallon electric-resistance storage heater with a 15 kW element has a GAMA-certified standby loss of 0.55%/hr. Does it comply?

A Since the input rating of this model is 15 kW, it is not subject to the NAECA efficiency requirements. Furthermore, V_T for this unit is equal to 0.90*V, or 73.8 gallons. Table 404A requires that the standby loss of this unit is less than or equal to:

$$SL_{max} = 0.30 + (27/VT) = 0.30 + (27/73.8) = 0.67\%/hr$$

This heater complies.

Example 404B Equipment Efficiency Requirements – Gas-Fired Split System

Q A split water system consists of a gas-fired heater, circulation pump, and storage tank. The heater is rated at 1,825,000 Btuh input and 1,497,000 Btuh output. The heater storage capacity is 45 gal, and its standby losses are 4%/hr. The storage tank is 400-gal capacity and a standby loss of 6 Btu/h-ft^2. Does the system comply?

A As the storage tank is unfired and has a standby loss that is less than 6.5 Btu/h-ft^2, it complies with the code . The heater thermal efficiency and input-to-volume ratio are given by:

$$E_t = \frac{Q_{out}}{Q_{in}} = \frac{1{,}497{,}000}{1{,}825{,}000} = 82\%$$

$$\text{Input-to-Volume Ratio} = \frac{Q_{in}}{V_{heater}} = \frac{1{,}825{,}000\text{Btu}}{\text{hr - 45gal}} = 40{,}556\frac{\text{Btu}}{\text{hr - gal}}$$

Table 404A sets the following requirements for the heater: the minimum allowable thermal efficiency is 77% and the maximum allowable standby loss is given by:

$$\text{Maximum allowable standby loss} = 2.3 + \frac{67}{V_T} = 2.3 + \frac{67}{45} = 3.79\ \%/\text{hr}$$

The storage tank complies. The heater thermal efficiency complies. The heater needs additional thermal insulation to reduce its standby loss below 3.79%/hr to comply. As it is impractical to blanket this unit in the field, the designer should request a model with more insulation from the manufacturer or select another unit that complies.

Example 404C Equipment Efficiency Requirements – Condensing Gas Water Heater

Q An instantaneous condensing gas water heater has the following characteristics: 1,000,000 Btuh input; 23 gal storage; 93% thermal efficiency; and, 5.2%/hr standby loss. Does it comply?

A The water heater's input-to-volume ratio is given by:

$$\frac{Q_{in}}{V_{heater}} = \frac{1{,}000{,}000\text{Btu}}{\text{hr - 23gal}} = 43{,}478\text{Btu / hr - gal}$$

Table 404A sets the following requirements for the water heater: the required minimum efficiency is 77% and the required maximum standby loss is given by:

$$2.3 + \frac{67}{V_t} = 2.3 + \frac{67}{23} = 5.21\%/\text{hr}$$

The water heater complies.

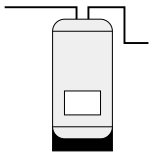


Figure 404C Gas Water Heater with Automatic Flue Damper

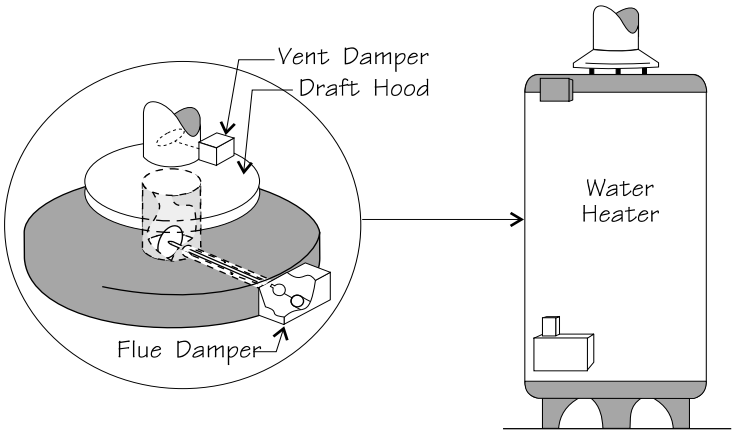
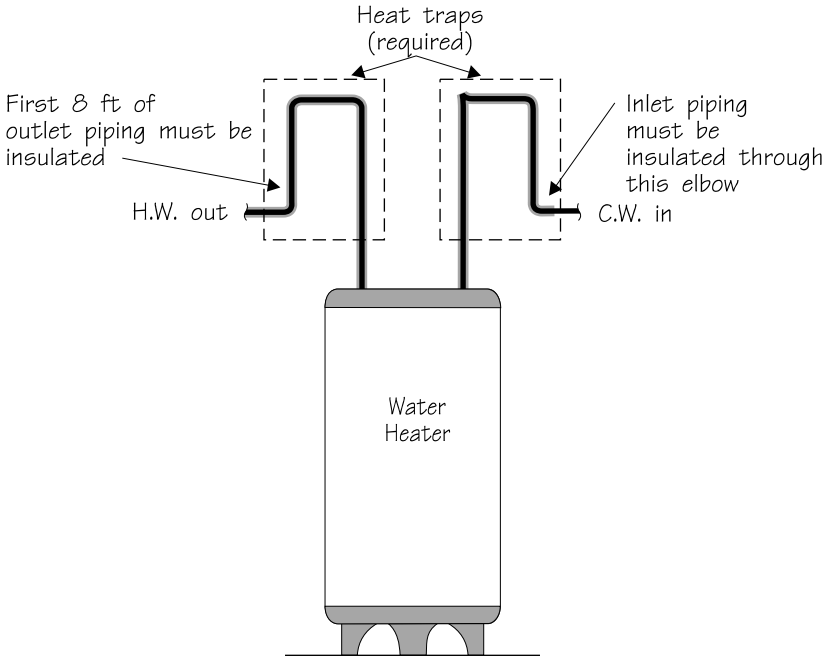


Figure 404D Heat Trap and Insulation Requirements for Non-circulating Systems



SERVICE HOT WATER PIPE INSULATION

Form
404.2

Distribution losses impact building energy use both in the energy required to make up for the lost heat, and in the additional load that can be placed on the space cooling system if the heat is released to air conditioned space. These losses can be limited by insulating the hot water storage vessel and pipes. The requirements of the 90.1 Code differ for circulating and non-circulating systems.

Circulating Systems

In circulating systems, the hot water is exposed to loss throughout the entire distribution system as long as the water is circulating. For these systems, the entire hot water supply and return piping system must be insulated to the requirements of Table 403.2.9.1 of the 90.1 Code. These requirements are summarized in Table 404B. Note that systems which operate below 105°F and systems that do not heat water through the use of fossil fuels or electricity do not have to meet these requirements.

The range of piping insulation conductivities specified by the 90.1 Code is restricted to between 0.24 and 0.28 Btu-in/(h-ft^2-°F). Most pipe insulation products used for service water distribution have conductivities within this range; however, equivalent thicknesses for piping insulation of different conductivities can be calculated from the following formula, when necessary:

$$T = R_{out} \times [(1 + \frac{t}{R_{out}})^{\frac{K}{0.24}} - 1]$$

where

T = minimum required insulation thickness for proposed material (in.)

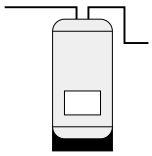
R_{out} = actual outside pipe radius (in.)

t = minimum insulation thickness (in.) specified in Table 403.2.9.1 for a conductivity of 0.24 Btu-in./(h-ft^2-°F)

K = conductivity of proposed material (Btu-in./(h-ft^2-°F)) @ 100°F

Table 404B Minimum Pipe Insulation Thicknesses for Service Hot Water Systems

	Minimum Pipe Insulation Thickness (in.)
Conductivity at 100 °F [Btu-in/(h-ft^2-°F)]	**0.24 to 0.28 (typ. of closed-cell foam or high performance rigid preshaped fiberglass)**
Nominal Pipe Diameter	
Runouts up to 2 in. (<12 ft length)	0.5
2 in. and less	1.0
2.5 in. and larger	1.5



Non-circulating Systems

Form
404.2.1

Storage hot water tanks with vertical risers in non-circulating systems are required to have either integral heat traps or external heat traps on both the inlet and outlet piping located as close as practical to the water heater. A heat trap is a device or an arrangement of piping that keeps the buoyant hot water from circulating through a piping distribution system through natural convection. Integral heat traps are designed into the water heater by the manufacturer. Heat traps are not required on tanks without vertical risers; however, systems without heat traps, regardless of whether they have circulation pumps, must meet the insulation requirements for circulating systems.

Figure 404E Heat Traps on a Tank with Connections on the Bottom

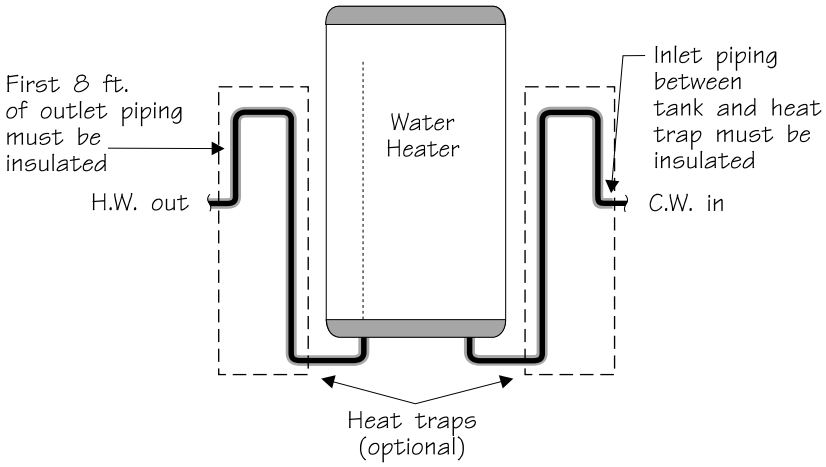


Figure 404F Heat Traps on a Tank with Connections on Sides

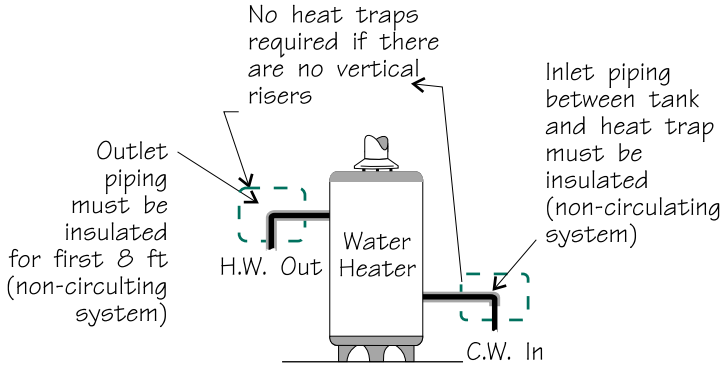
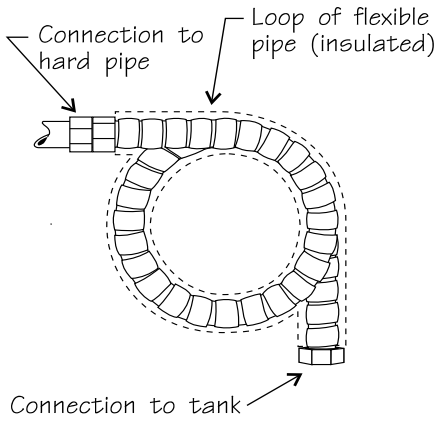


Figure 404G Heat Trap through a Flexible Pipe Loop



The first eight feet of outlet piping and the inlet piping between the storage tank and a heat trap (including the heat trap) of a non-circulating distribution system must be insulated according to the requirements specified above for circulating systems. The remainder of the distribution piping for these systems is not required to be insulated. Again, both systems which operate below 105°F systems that do not heat water through the use of fossil fuels or electricity do not have to meet these requirements.

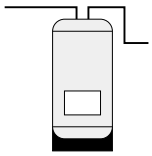
Example 404D Calculation of Required Insulation Thickness

Q A designer wants to use an insulation that has a conductivity of 0.15 Btu-in/(h-ft^2-°F) at 100°F. What thickness of insulation is required for a 3 in. copper (1.625 in. outside radius) hot water supply line?

A As the conductivity is out of the range of Table 404A, the required thickness will have to be calculated. The value of *t*, the insulation thickness from Table 404A, is 1.5 in.

$$T = 1.625 \text{ in.} \times \left[\left(1 + \frac{1.5 \text{ in.}}{1.625 \text{ in.}}\right)^{\frac{0.15}{0.24}} - 1\right]$$
$$= 0.82 \text{ in.}$$

The insulation on the hot water supply line must be 0.82 in. (roughly 13/16 in.) or thicker.



SERVICE WATER HEATING SYSTEM CONTROLS

Form
404.3

Water-heating systems are required to have controls which are adjustable down to a 90°F setpoint. An exception is made for residential units which must adjust down to a 110°F setpoint. These features should be provided by the manufacturer of the water heaters; the designer's responsibility is to specify a complying unit. Both standby and distribution losses will be minimized by designing a system to provide hot water at the minimum temperature required. Table 404C summarizes the recommended hot water design temperatures from the ASHRAE HVAC Systems and Applications Handbook (1987). Note that the 90.1 Code requires that the outlet temperature of hot water in public facility lavatories not exceed 110 °F.

When the distribution piping is heated to maintain usage temperatures, such as in circulating hot water systems or systems using heat tape, the system is required to have automatic time switches or other controls that can be set to turn off the system. The simplest of these devices is an automatic time clock. Most automatic time clocks allow the operator to enter different operating schedules for each of the seven days of the week. Thus, unnecessary pipe heating is not performed during hours of inoperation. More sophisticated devices, such as combination time and temperature controls and demand controls also comply with the 90.1 Code.

WATER CONSERVATION

Form
404.4

The 90.1 Code requires that all shower heads and lavatories be labeled as meeting the requirements of the National Energy Policy Act (PL 102-486). This means that these devices must meet the requirements of ANSI and ASME[3], and must not have flow rates greater than 2.5 gallons per minute.

Table 404C Recommended Service Water Temperatures

Use	Temperature °F
Lavatory	
Hand washing	105
Shaving	115
Showers and Tubs	110
Therapeutic Baths	95
Commercial and Institutional Laundry	180
Residential Dish Washing and Laundry	140
Surgical Scrubbing	110
Commercial Spray Type Dish Washing as Required by N.S.F.	
Rack type	>150 wash 180 to 195 final rinse
Single tank conveyor type	>160 wash 180 to 195 final rinse
Multiple tank conveyor type	>150 wash >160 pumped rinse 180 to 195 final rinse
Chemical sanitizing type (see manufacturer for actual temp. required)	140 wash >75 rinse

Source - ASHRAE HVAC Systems and Applications Handbook (1987)

[3]American Society of Mechanical Engineers

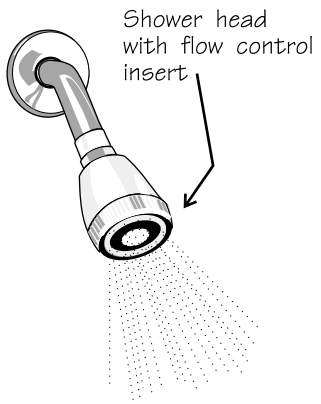
In addition to the above requirements, lavatories in public facility restrooms must be equipped with flow metering devices, such as occupancy sensors or foot switches. In lavatories that are not intended for physically handicapped persons, volume control devices can be used in place of flow metering devices. Volume control devices must limit the flow of hot water to 0.25 gal/cycle for circulating systems, and 0.50 gal/cycle for non-circulating systems. Handicap facilities must comply with the 90.1 Code by using flow metering devices and not volume control devices.

Table 404D summarizes the flow control requirements of the 90.1 Code. Figures 404G-J provide examples of complying volume control devices. Note that the shower head uses an insert to meet the flow restriction requirements. The ANSI and ASME standards require that this insert must be integral to the design of the shower head so that it is disabled when the insert is removed.

Table 404D Summary of Required Flow Controls

	Hot Water Flow Limits	Total Flow Control Type and Limits	Distribution System Type
Public Lavatories (shall have controls which limit outlet temperature to 110 °F; shall meet the requirements of the National Energy Policy Act)			
Handicap	N/A	Foot Switch, Occupancy Sensor, or Similar Device	ALL
Non-Handicap with Occupancy Controls	N/A	Foot Switch, Occupancy Sensor, or Similar Device	ALL
Non-Handicap with Volume Controls	0.25 gal/cycle 0.50 gal/cycle	N/A N/A	Circulating Systems Non-Circulating Systems
Other Lavatories	N/A	2.5 gal/min.	ALL
Showers	N/A	2.5 gal/min.	ALL

Figure 404H Complying Shower head (with insert)



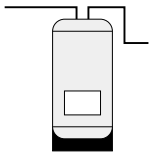


Figure 404I Complying In-line Flow Control Device

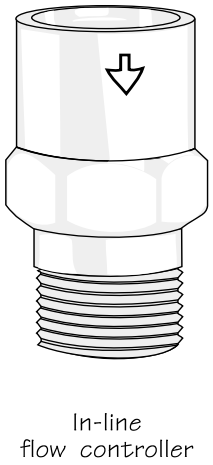


Figure 404J Lavatory Faucet with Complying IR Occupant Sensor

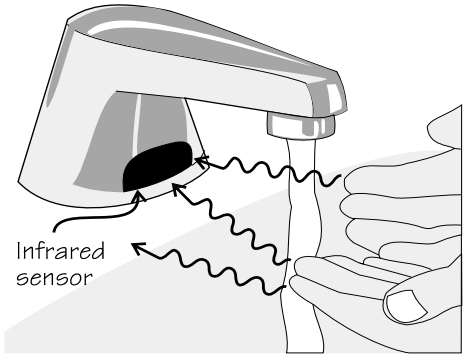
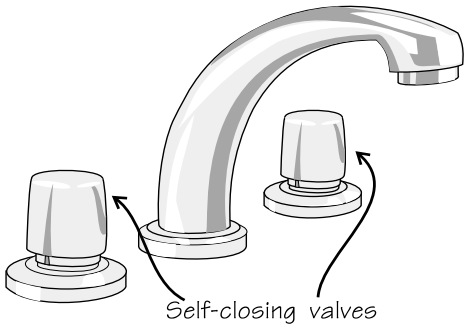


Figure 404K Lavatory Faucet with Self-closing Valves



SWIMMING POOLS

Form
404.5

All pool heaters must meet the efficiency requirements for service water heating given in of Table 404.1 of the 90.1 Code. Smaller equipment is covered under NAECA. The efficiency requirements for non-NAECA equipment are summarized in Table 404A. Note that if efficiency requirements are not given for a specific heater type, the use of that heater is not prohibited by the 90.1 Code. All pool heaters must be equipped with a readily accessible on-off switch to encourage occupants or maintenance personnel to turn off the heater when it is not needed. Electric pool heaters and pumps must also be installed with time switches so that they can shut down during periods of peak utility electrical demand. Exceptions include pumps that use solar or waste heat recovery to heat the pool and pumps that must operate continuously to meet public health standards.

All indoor and outdoor heated pools must be equipped with pool covers, unless the pools receive over 70% of their annual operating energy from either waste heat recovery or site-solar energy. Note that the 70% figure refers to the heating required by the pool and is not an indication of the efficiency of the heating source. Pool covers significantly reduce both evaporative and convective heat loss, which account for the majority of energy losses in pools.

COMBINED SERVICE WATER HEATING AND SPACE HEATING EQUIPMENT

Form
404.6

Combined service water heating and space heating devices are allowed by the 90.1 Code only if they meet either of the following two requirements:

1) The combined system capacity (input rating or storage volume) is less than twice that of the smaller of the separate heaters required in a system with separate space and water heating.

2) The heater input rating of the combined system is less than 150,000 Btu/h.

Service water-heating equipment used in combination systems must satisfy the minimum efficiency requirements given in Table 404.1 of the 90.1 Code. Space-heating equipment used in combination systems must satisfy the applicable minimum performance requirements of Section 403 of the 90.1 Code. The distribution piping, pumps, controls, and terminal devices for service hot water in combination systems must meet all of the requirements of this section.

Example 404E Selection of Self-closing Valves – Public Lavatory

Q A designer plans to use spring-loaded, self-closing valves for a lavatory in a public restroom. The hot water is provided by an instantaneous heater. The manufacturer offers two valves, a 0.25 gal/cycle valve and a 0.4 gal/cycle valve. Which one can be used for compliance?

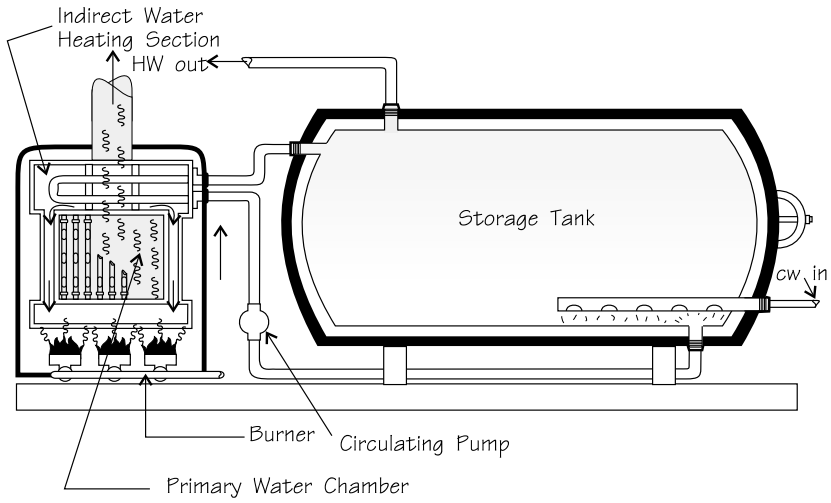
A Either valve will comply. Since the hot water is provided in a non-circulation system, self-closing valves with capacities up to 0.50 gal/cycle are allowed.

Example 404F Heat Recovery for Pools – Cogeneration

Q If 85% of a pool's annual heating energy is provided from a cogeneration system, are pool covers required?

A No, since more than 70% of the pool's annual energy is obtained through heat recovery. However, a pool cover is recommended in this installation as it could significantly reduce operation of the cogeneration system.

Figure 404L Indirect Service Water Heating from Boiler



SUMMARY FORMS AND WORKSHEETS

A summary form and checklist (one page front and back) is provided to assist with the calculations and documentation necessary in showing compliance with the service water heating systems requirements of the 90.1 Code. A blank copy of this form is included in Appendix D of this manual. The Case Study section of this chapter provides an example of a completed form. A general description of the form is provided below.

The front page of the form contains basic project information; the back lists information to be put on drawings submitted for a plumbing permit. The applicant completes the top and left hand side of the front page, and refers to the appropriate plan page on the drawings for each item on the checklist.

The plans examiner then compares this information with the drawings, requests corrections from the applicant, notes any features which merit special attention by the inspector, and forwards it to the inspector.

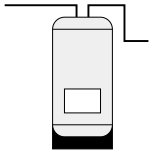
The inspector verifies all categories where there is an inspection check box, unless the applicant has written in "NA" and the plans examiner has concurred. After the inspections, the final version of the form can be filed with the building permit drawings as a record of construction.

PERMIT APPLICANT'S RESPONSIBILITIES

At permit application, the goal of the applicant is to provide all the necessary information to show compliance with the 90.1 Code. If the plans examiner is able to verify compliance with one review, then the permit can be issued and construction started without delay. To assist in submitting the permit application, the applicant should review not only the following information specific to the applicant but also the subsequent two sections that review responsibilities of the plans examiner and the inspector. The following section addresses the two common problems with permit applications: (1) missing information, or (2) incorrect information.

Information may be missing because the applicant is not aware of all of the code requirements or because the required information is located on the specifications but not on the plans. Note that building departments generally approve plans, but not specifications. The Checklist on the back of the Service Water Heating Systems Summary Form provides a detailed list of the type of information that needs to be on the plans. This information can then be provided in a number of ways:

- *On the drawings.* Provide service water heating layout with equipment location, pump type and location, control diagrams indicating type of control and the units that it controls.
- *In schedules.* For instance, list service water heating equipment capacity and efficiency, pipe insulation thickness, flow rates for lavatory fixtures in public restrooms.
- *Through notes and call outs.* For instance, indicate that showerheads and lavatories meet the requirements of the National Energy Policy Act.
- *Through supplementary worksheets or calculations.* Provide calculations where required, such as to use the exception for combined service water heating and space heating equipment.



Information may be incorrect if the code has changed since the applicant's last project. Some features to note are:

- Combination service water heating/space heating systems are generally not allowed unless the input to the boiler is less than 150,000 Btu/h.
- Piping for service water heating systems without a circulating pump must still be insulated as if it had a pump unless there is a heat trap in the piping. In addition, piping close to the tank must be insulated regardless.

PLANS EXAMINER'S RESPONSIBILITIES

The plans examiner must review each permit application for 90.1 Code compliance before a permit is issued. By letting the designer and contractor know what's expected of them early in the process, the building department can help assure that the approved drawings comply with the code. This helps the inspector to avoid the headache of correcting a contractor who is following drawings that do not meet the code requirements.

The biggest challenge for the plans examiner is often determining where the necessary information is and whether the drawings are complete. The plans examiner should make sure that the applicant includes the Service Water Heating Systems Summary and Checklist forms in this manual as part of the submittal package. The information provided on these forms makes the job easier and reduces plan review time.

A complete building service systems and equipment plan review covers all of the requirements in Section 404 (space heating, space cooling, and ventilation is included in Section 403). For Section 404, first review the comments for the applicant above for a general sense of key requirements, then:

- Check that there is a service water heating equipment schedule with the correct efficiencies for both peak load and for part load (as applicable).
- Check that there is a vent damper for all gas-fired water heaters not equipped with a flue damper and that it uses indoor air for combustion and is installed in a conditioned space.
- Check that piping insulation thickness is on the drawings and complies with the code. A note should be on the drawings indicating a heat trap for all systems without a pump unless the piping is to be fully insulated.
- Check that temperature controls are provided to allow storage temperature adjustment to a temperature compatible with the intended use. A note should be on the drawings indicating that the outlet temperature of lavatories in public facility restrooms is limited to 110°F.
- Check that there is a note indicating that shower heads and lavatories meet the requirements of the National Energy Policy Act and are to be so labeled.
- Check that lavatories in public facility restrooms are equipped with a foot switch, occupancy sensor, or limit hot water delivery to 0.25 gal/cycle for circulating systems and 0.50 for noncirculating systems.
- Check that all pool heaters have an on-off switch.
- Check that time switches are installed on electric water heaters and pumps. If one of the exceptions is claimed, ask for supporting documentation and a note on the drawings.

- Check that heated pools have a cover. If the exception is claimed, ask for supporting documentation and a note on the drawings.
- Check that a single piece of equipment is not used to provide both space heating and service water heating unless the input to the combined boiler is less than 150,000 Btu/h. If exception 1 is claimed, ask for supporting documentation and a note on the drawings.

Remember that good plan review is important. It is much easier to change a number on a drawing than to remove equipment after it has already been installed.

FIELD INSPECTOR'S RESPONSIBILITIES

The inspector's task is to make sure that the project is constructed in accordance with the approved plans. Be aware that a number of requirements will vary from project to project. Consequently, while some requirements may be learned once, others will necessitate on-site checking of the approved plans.

The primary challenge for the inspector may be educating the contractors about any changes in the code requirements so that installations are performed correctly, not simply the way they may have been routinely done in the past.

For this code, some of the most important items are listed below. As a start, review the responsibilities for the applicant and plans examiner in the previous two sub-sections to get a general sense of key requirements.

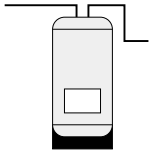
For the rough-in (okay to cover) inspection:

- Verify service water heating equipment efficiencies.
- Verify vent damper for all gas-fired water heaters not equipped with a flue damper and that use indoor air for combustion and are installed in a conditioned space.
- Verify a heat trap for all systems unless the piping is to be fully insulated.
- Check that temperature controls are provided to allow storage temperature adjustment to a temperature compatible with the intended use.
- Verify that shower heads and lavatories are labeled as meeting the requirements of the National Energy Policy Act.
- Verify that lavatories in public facility restrooms are equipped with a foot switch, occupancy sensor, or limit hot water delivery to 0.25 gal/cycle for circulating systems and 0.50 for noncirculating systems.
- Verify that all pool heaters have an on-off switch.
- Verify that time switches are installed on electric water heaters and pumps unless drawings allow an exemption.
- Verify that a single piece of equipment is not used to provide both space heating and service water heating unless the input to the combined boiler is less than 150,000 Btu/h or the drawings allow an exemption.

Inform contractor of any missing items or corrections to be made.

For the final inspection:

- Verify piping insulation thicknesses.



- Verify that heated pools have a cover unless drawings allow an exemption.
- Verify that problems noted at the rough-in inspection have been addressed.

Case Study – Office Building

The following case study demonstrates the recommended procedure for documenting compliance with the service water heating systems requirements given in Section 404 of the 90.1 Code. Requirements that must be documented include: equipment efficiency, piping insulation, temperature controls, conservation devices, swimming pool covers and time switches, and combined service water/space heating equipment size.

This case study includes a completed version of the Service Systems Summary form. A complete set of building plans would include a service systems equipment schedule, and, in larger projects, a service systems diagram For this case study, an equipment schedule is given below; however, no drawings have been included.

BUILDING DESCRIPTION

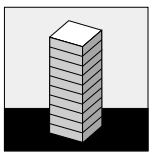
The building used in this case study is a new single story office to be constructed in Chattanooga, Tennessee. A single, 19 gallon, electric water heater is used to provide hot water to four public restroom lavatories, and one lunchroom sink. The water heater is located in a janitorial closet adjacent to the restrooms. The inlet and outlet piping of the water heater is located at the top of the tank. The outlet and inlet piping immediately above the tank consists of flexible loop heat traps like those shown in Figure 404F of this chapter. All hot water piping has a nominal diameter of 0.5 inches.

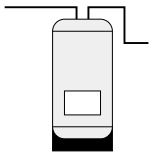
Equipment Schedule

The following service hot water equipment schedule was taken from the plans for this building. The information included in the equipment schedule is as follows:

- ID - A number or letter that references the equipment to the building plans.
- Make & Model - The manufacturer's name and the equipment's model number. This information is used by the plans examiner to verify equipment efficiencies.
- Fuel Type - Gas, oil, or electric. This is used to determine which efficiency requirement of the 90.1 Code applies to the given equipment.
- Input Rating - The power consumption of the equipment under full load conditions. Again, this is used to determine which efficiency requirement of the 90.1 Code applies to the given equipment.
- Capacity - This is the volume of storage water heaters. This too is used to determine which efficiency requirement of the 90.1 Code applies to the given equipment.
- Efficiency - This is the rated efficiency determined by the appropriate test procedure. Typically, this value is obtained from the equipment manufacturer.

A service water heating equipment schedule might also include a vent damper description and a controls description if appropriate. Vent dampers are usually integrated components of fossil fuel-fired water heating equipment. All water heaters are usually equipped with a temperature control. The water heater in this case study building is covered by the requirements of the National Appliance Energy Conservation Act (NAECA). This means that the water heater must meet the





efficiency requirements specified in the 90.1 Code before it can be sold. As a result, no test procedure has been listed with the equipment efficiency. For non-NAECA covered equipment, the test procedure that was used to determine the equipment efficiency should be referenced in the equipment schedule.

Table 404E Service Water Heating Equipment Schedule

ID	Make & Model	Fuel Type	Input Rating	Capacity	Efficiency
SW-1	A.O. Smith DSE-020-*	Electric	12 kW	19.0 Gallons	EF = 0.93

Service Water Heating System Notes

In addition to the above schedule, the following information was taken from the plans for this case study building:

- All terminal devices shall comply with the National Energy Policy Act of 1992 (EPAct).
- The specified water heating equipment shall have a temperature control which allows the tank setpoint temperature to be lowered to 90°F, and which limits the setpoint to a maximum of 110°F.
- Infrared occupancy sensors shall be installed on all public restroom lavatories that limit the flow of hot water to periods in which the lavatory is in use.
- Flexible loop heat traps shall be installed at the inlet and outlet of the service hot water storage tank.
- The first 8 feet of outlet piping from the service hot water tank, including any heat traps, and the inlet piping between the hot water storage tank and the heat trap shall be insulated with 1 in. of closed-cell foam insulation.

COMPLIANCE DOCUMENTATION

The Service Systems Summary form is used to document compliance with the Service Water Heating Systems requirements of the 90.1 Code. The form addresses each element of the 90.1 Code as they appear in the text of the code. Completion of the form is very straightforward This text describes the procedure that was used to complete the Service Systems Summary form for the case study building. The responsibilities of the plans examiner and the building inspector are listed in the Compliance and Enforcement section of this chapter.

Service Systems Summary Form

404.1 Equipment Efficiency

Water heating equipment must meet or exceed the efficiencies specified in Table 404.1 of the code. Equipment covered by NAECA cannot be sold unless it complies with the 90.1 Code, so it meets the efficiency requirements by default. The water heating equipment in this case study building consists of a 19 gallon, 12 kW, electric water heater. The energy factor (EF) obtained from the manufacturer for this unit is 0.92. This value is listed on the Service Systems Summary form. “See schedule” is also entered as a reference for the plans examiner. The plans examiner can use the information in the equipment schedule to verify that this is a NAECA-covered appliance, and therefore complies with the efficiency requirements of the 90.1 Code.

404.2 Service Hot Water Pipe Insulation

Flexible loop heat traps are specified above in the Service Water Heating System Notes on both the inlet and the outlet of the water heater storage tank. The 90.1 Code requires that the first 8 feet of outlet piping from a constant temperature, non-circulating water heater with heat traps must be insulated in accordance with Table 403.2.9.1 of the 90.1 Code. Similarly, any inlet piping between the tank and a heat trap must be insulated. The designer of this system intends to insulate these portions of the outlet and inlet piping with 1 in. thick, closed-cell foam insulation. This insulation meets the requirement listed in Table 403.2.9.1 for the specified pipe diameter. "Yes" is circled to indicate that the insulation requirements of the Code have been met, and to indicate that heat traps have been included. "See notes" is entered as a reference to the plans examiner.

404.3 Service Hot Water System Controls

Commercial water heating systems must be equipped with controls that allow the storage temperature of the water heater to be adjusted down to 90°F. Similarly, the outlet temperature of public restroom lavatories must be limited to 110°F. The Service Water Heating System Notes listed above indicate that the water heater in this case study building is equipped with a temperature control that allows the tank temperature to be adjusted from 90°F to 110°F. Thus, the system complies with the 90.1 Code. "Yes" is circled on the summary form to indicate that the water heater in this building is equipped with the appropriate temperature controls. "See notes" is entered as a reference for the plans examiner.

404.4 Water Conservation

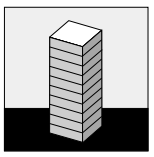
Lavatory faucets must meet the requirements of the National Energy Policy Act (EPAct). Lavatories in public facility restrooms must also be equipped with a foot switch, occupancy sensor, or similar device, or, in other than lavatories for physically handicapped persons, limit hot water delivery to 0.25 gal/cycle for circulating systems and 0.50 gal/cycle for non-circulating systems. The restroom lavatories in this building are equipped with infrared occupancy sensors. All new lavatories sold in the United States meet the EPAct requirements. This information is documented in the Service Water Heating System Notes listed above. "Yes" is circled on the Service Systems Summary form to indicate that the water conservation requirements of the 90.1 Code have been met. "See notes" is listed as a reference to the plans examiner.

404.5 Swimming Pools

The 90.1 Code requirements for swimming pools are outlined in this chapter. No swimming pools have been included in this case study building, so "no" has been circled on the Service Systems Summary form and page A2, the site plan, is listed as a reference. The plans examiner can easily verify that no swimming pools are intended for this building.

404.6 Combined SWH/Space Heating

The space heating requirements of this building are served by unitary equipment that is not combined with the service hot water equipment. "No" is circled on the Service Systems Summary form to indicate that the service system and the space heating system are separate. Page M2, the HVAC floor plan, is listed as a reference. The plans examiner must review this plan page to verify that the service hot water system and the space heating system are not combined.



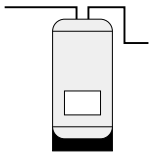


Figure 404M Service Hot Water Systems Summary Form

Case Study – Restaurant

The following information is provided as an exercise. The service hot water system details are given for a new building to be constructed in the midwestern United States. Enough information is provided to complete the required service system compliance forms.

BUILDING DESCRIPTION

The building used in this example is a new, single story restaurant that will be constructed in Columbus, Ohio in the immediate future. A single, 125 gallon, gas water heater is used to provide service hot water. A 45 kW booster heater is used as a supplement to the main water heater to provide 180°F water to a commercial dishwasher. The above grade, cold water supply piping to the water heater has a nominal diameter of 1.50 inches. The main hot water supply piping also has a nominal diameter of 1.50 inches. The recirculation loop piping has a nominal diameter of 0.75 inches. Hot water is recirculated through the entire system by a one-quarter horsepower pump. Hot water is provided to several locations in the bar and kitchen area, and to five lavatories which are accessible to the patrons of the restaurant. These terminal devices are supplied by either 0.75 inch or 0.50 inch nominal diameter runouts.

Equipment Schedule

The following service water heating equipment schedule was taken from the plans for this building:

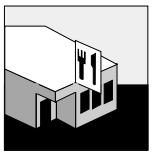
Table 404F Service Water Heating Equipment Schedule

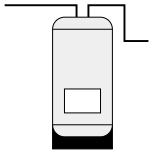
ID	Make & Model	Fuel Type	Input Rating	Capacity	Efficiency
WH-1	A.O. Smith BTP-125-540	Gas	540,000 Btu/h	123 gal.	RE=80%, SL=2.82%
BH-1	A.O. Smith CMD-45	Electric	45 kW	Instantaneous	E_t=99.9%

Service Water Heating System Notes

In addition to the above equipment schedule, the following information was taken from the plans for this building:

- WH-1 shall have been tested by the equipment manufacturer in accordance with ANSI test method Z21.10.3-1990.
- WH-1 shall be equipped with an integral flue damper, supplied and installed by the appliance manufacturer.
- All hot water piping shall be insulated with PPG Industries CertainTeed Saint Gobain snap-on insulation, or with Johns-Manville Micro-Loc. Insulation of the following thicknesses shall be applied: for piping with a nominal diameter of 1.00 in. or smaller, the insulation thickness shall be no less than 1.00 in. For





piping with nominal diameters between 1.25 and 6.00 in., the insulation thickness shall be no less than 1.50 in.

- WH-1 shall be equipped with a temperature control device supplied by the manufacturer that allow the hot water storage temperature to be adjusted from a maximum of 140°F to a minimum of 90°F.
- WH-1 and the recirculation pump shall be controlled by a timeclock device that turns both units off during unoccupied hours.
- All faucets shall comply with the requirements of the National Energy Policy Act of 1992 (EPAct).
- Infrared occupancy sensors shall be installed on all public facility restroom lavatories. The output temperature of these lavatories shall not exceed 110°F.