Supplement
to
TESTING STANDARD

Method to Determine
PERFORMANCE OF
INDIRECT-FIRED WATER HEATERS
March 2003 Edition

[NOTE: This supplement incorporates testing and calculations to determine heat source friction loss for indirect-fired water heaters.]

3.1 NOMENCLATURE

dP_{eh} Pressure drop of external heat source piping, ft w.c.
dP_h Heat source friction loss, ft w.c.
L_{in} Length of external heat source piping between pressure gauge port and the inlet to the indirect-fired water heater, ft (minimum 6 inches)
L_{out} Length of external heat source piping between the indirect-fired water outlet and the gauge port, ft (minimum 25 pipe diameters)
P_{iht} Pressure at heat source inlet with flow, ft w.c.
P_{ihs} Pressure at the heat source inlet with no flow, ft w.c.
P_{oht} Pressure at the heat source outlet with flow, ft w.c.
P_{ohs} Pressure at the heat source outlet with no flow, ft w.c
W_{hf} Heat source water flow during friction loss test, gallons per minute

4.3 PRESSURE

4.3.1 Pressure gauges used to perform the Heat Source Friction Loss test shall have an error no greater than ± 2%. These gauges shall have minimum graduations of 0.5 ft w.c.

4.3.2 Pressure gauges used in the other tests shall be calibrated so that the error is not greater than ±1 pound per square inch.

5.0 APPARATUS

The apparatus described below is used in conjunction with Indirect-Fired Water Heaters during the testing.

5.1 PIPING

See Figure 1 for a conceptual piping arrangement. Provisions shall be made to assure constant supply water temperature and pressure to the unit. Figure 2 contains a conceptual piping arrangement for an Indirect-Fired Water Heater that uses a mixing valve as determined by 5.5. Figure 3 shows a piping arrangement for measuring the heat source friction loss.

6.0 TEST CONDITIONS

6.1 INSTALLATION

6.1.2 HEAT SOURCE PIPING

During conduct of the continuous draw test, the connecting pipe between the thermocouple and the Indirect-Fired Water Heater shall be metal pipe up to the thermocouple and the balance of the piping may be as specified by the testing laboratory (see Figure 1).

6.1.2.2 For the heat source friction loss test, install pressure gauges on the heat source inlet and outlet connections as shown in Figure 3a. Each gauge shall be located in a tee in straight section of piping having the same nominal size as the indirect water connection and a minimum length of 25 diameters plus 6 inches. Maintain at least 25 diameters of straight pipe upstream of each gauge and at least 6 inches downstream of each gauge. As an alternate to installing two pressure gauges as requested above, a single pressure gauge may be installed the common port of a three way valve with the other two ports connected to the inlet and outlet of the heat source piping at the locations called out above. See alternate piping in Figure 3b.

6.2 AIR AND WATER

6.2.1 WATER SUPPLY

6.2.1.2 HEAT SOURCE WATER SUPPLY

During all of the draw tests, the water supplied to the water heater's heat exchanger inlet, T, shall be 180°F ±2.5°F. During the heat source friction loss test, the water supplied to the heat source inlet connection shall be between 58°F and 80°F.

7.0 TEST PROCEDURE

7.5 HEAT SOURCE FRICTION LOSS TEST

7.5.1 INDIRECT-FIRED STORAGE AND INSTANTANEOUS WATER HEATERS

Set up the indirect water heater as shown in Figure 3 and with the pressure gauge connections described in 6.1.2.2. Fill the test set-up with water and purge the system of air. Pressurize the system so that a readable amount of pressure is present on both gauges with no water flowing through the indirect water heater. Start the pump and adjust the throttling valve so that the heat source flow rate W_{hf}, is within ± 0.25 GPM of the nominal value established in 7.3.1. Record the pressure on the inlet pressure gauge, P_{int}, and outlet pressure gauge, P_{oht}. Shut down the pump and record the pressure gauge reading at the inlet and outlet with no heat source flow through the indirect water heater (P_{ihs} and P_{ohs}, respectively). If a single pressure gauge and three way valve is used then the pressure at the inlet and outlet with no flow does not need to be recorded.

7.5.2 DATA

Record the following measurements:

Length of the external heat source piping between the pressure gauge port and the inlet to the indirect-fired water heater in feet, L_{in}

Length of the external heat source piping between the indirect-fired water heater outlet and the pressure gauge port in feet, L_{out}

The Following readings shall be recorded during the test:

Measured heat source water flow rate during friction loss test, W_{hf}

Pressure at heat source inlet with flow, P_{iht}

Pressure at heat source outlet with flow, P_{oht}

Pressure at heat source inlet with no flow, P_{ihs} if two pressure gauges are used

Pressure at heat source outlet with no flow, P_{ohs} if two pressure gauges are used

8.0 DATA TO BE RECORDED

Water volume determination values are to be recorded on form **IWH-V-1**

Standby heat loss data is to be recorded on form **IWH-ST-1.** Data logger output may be substituted if the required data and times as shown on form **IWH-ST-1** are included in the printout.

Continuous draw data is to be recorded on form **IWH-CD-1**.

First draw data is to be recorded on form **IWH-FD-1**.

The calculated values are to be recorded on the report form **IWH-R-1**.

The summary information is to be included on form **IWH-S-1**

Heat source friction loss test data is to be recorded on form IWH-FL-1

9.0 CALCULATIONS

9.6 HEAT SOURCE FRICTION LOSS

9.6.1 Determine the friction factor for the external heat source piping from Table 4 for the diameter of the piping at the nominal heat source water flow rate established in 7.3.1, P_d in feet water column per foot of piping.

9.6.2 Calculate the pressure drop of the external heat source piping, dP_{eh} in feet w.c.

$$dP_{eh} = (L_{in} + L_{out}) \times P_d$$

Where:

L_{in} = Length of external heat source piping between pressure gauge port and the inlet to the indirect-fired water heater, ft (minimum 6 inches)
L_{out} = Length of external heat source piping between the indirect water heater outlet and the pressure gauge port, ft (minimum 25 pipe diameters)
P_d = Friction factor as determined in 9.6.1

9.6.3 Calculate the Heat Source Friction Loss, dP_h, expressed in feet water column and defined as:

When two pressure gauges are used.

$$dP_h = [(P_{iht} - P_{ihs}) - (P_{oht} - P_{ohs})] \times (W_h/W_{hf})^2 - dP_{eh}$$

When one pressure gauge and a three way valve is used

$$dP_h = (P_{iht} - P_{oht}) \times (W_h/W_{hf})^2 - dP_{eh}$$

Where :

W_{hf} = Measured heat source water flow rate during friction loss test, GPM
W_h = Nominal heat source water flow rate established in 7.3.1, GPM
P_{iht} = Pressure at heat source inlet with flow, ft w.c.
P_{oht} = Pressure at heat source outlet with flow, ft w.c.
P_{ihs} = Pressure at heat source inlet with no flow, ft w.c.
P_{ohs} = Pressure at heat source outlet with no flow, ft w.c.
dP_{eh} = Pressure drop of external heat source piping, ft w.c.

Note: If the data obtained yields a value for dP_h of less than zero, the value of dP_h shall be set at zero

Table 4a Steel

Pressure Drop in Feet of Water Column per Foot of Pipe Length								
GPM	1/2""	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"
0.5	0.004	0.001						
1.0	0.014	0.003	0.001					
1.5	0.029	0.007	0.002	0.001				
2.0	0.048	0.012	0.004	0.001				
2.5	0.071	0.019	0.006	0.001				
3.0	0.100	0.026	0.008	0.002	0.001			
3.5	0.126	0.035	0.011	0.003	0.001			
4.0	0.160	0.045	0.014	0.003	0.002			
4.5	0.205	0.056	0.017	0.004	0.002			
5.0	0.250	0.068	0.020	0.005	0.002			
5.5	0.300	0.075	0.023	0.006	0.003			
6.0		0.093	0.028	0.007	0.003	0.001		
6.5		0.105	0.031	0.008	0.004	0.001		
7.0		0.120	0.036	0.009	0.004	0.001		
7.5		0.130	0.040	0.011	0.005	0.001		
8.0		0.145	0.046	0.012	0.005	0.002		
8.5		0.165	0.050	0.013	0.006	0.002		
9.0		0.180	0.056	0.015	0.006	0.002		
9.5		0.205	0.061	0.016	0.007	0.002		
10.0		0.220	0.068	0.017	0.008	.0.002	0.001	
10.5		0.240	0.071	0.019	0.009	.0.003	0.001	
11.0		0.260	0.078	0.020	0.010	0.003	0.001	
11.5		0.280	0.090	0.022	0.011	0.003	0.001	
12.0		0.300	0.094	0.023	0.012	0.003	0.001	
12.5			0.100	0.025	0.012	0.004	0.001	
13.0			0.107	0.027	0.013	0.004	0.001	
13.5			0.115	0.030	0.014	0.004	0.002	
14.0			0.123	0.033	0.015	0.004	0.002	
14.5			0.132	0.036	0.016	0.005	0.002	
15.0			0.142	0.038	0.017	0.005	0.002	0.001
15.5			0.152	0.040	0.018	0.005	0.002	0.001
16.0			0.163	0.042	0.019	0.006	0.002	0.001
16.5			0.173	0.044	0.020	0.006	0.003	0.001
17.0			0.183	0.047	0.022	0.007	0.003	0.001
17.5			0.194	0.049	0.023	0.007	0.003	0.001
18.0			0.204	0.051	0.024	0.07	0.003	0.001
18.5			0.214	0.054	0.026	0.007	0.003	0.001
19.0			0.225	0.057	0.027	0.008	0.004	0.001
19.5			0.235	0.060	0.028	0.008	0.004	0.001
20.0			0.244	0.063	0.029	0.008	0.004	0.001

Table 4b Copper

GPM	1/2”	5/8”	3/4”	1”	1-1/4”	1-1/2”	2”	2-1/2”
0.5	0.008	0.003	0.002					
1.0	0.024	0.009	0.004	0.001				
1.5	0.049	0.018	0.008	0.003	0.001			
2.0	0.080	0.031	0.014	0.004	0.003			
2.5	0.120	0.044	0.020	0.006	0.003			
3.0	0.160	0.062	0.028	0.008	0.004			
3.5	0.210	0.080	0.036	0.010	0.004			
4.0	0.250	0.100	0.048	0.014	0.005			
4.5	0.300	0.125	0.057	0.017	0.006			
5.0		0.150	0.070	0.020	0.007			
5.5		0.175	0.080	0.023	0.009			
6.0		0.205	0.095	0.027	0.010			
6.5		0.240	0.110	0.031	0.012	0.005		
7.0		0.270	0.125	0.036	0.014			
7.5		0.300	0.140	0.040	0.015			
8.0			0.155	0.045	0.017			
8.5			0.170	0.050	0.019			
9.0			0.190	0.055	0.021			
9.5			0.210	0.061	0.023			
10.0			0.230	0.067	0.025			
10.5			0.250	0.074	0.027			
11.0			0.270	0.082	0.029			
11.5			0.290	0.090	0.031			
12.0			0.310	0.098	0.033			
12.5				0.106	0.035			
13.0				0.114	0.038			
13.5				0.122	0.041			
14.0				0.130	0.044			
14.5				0.138	0.047			
15.0				0.146	0.050			
15.5				0.154	0.053			
16.0				0.162	0.056			
16.5				0.170	0.059			
17.0				0.178	0.062			
17.5				0.186	0.065			
18.0				0.194	0.068			
18.5				0.203	0.072			
19.0				0.212	0.076			
19.5				0.221	0.080			
20.0				0.230	0.084			

Form IWH-FL-1 Rev. 1/04

Mfr.:_____
Model No.:_____
Date:_____
Completed by:_____

INDIRECT-FIRED WATER HEATER
HEAT SOURCE FRICTION LOSS TEST LOG

Nominal heat source water flow rate W_h = _____ gpm

Measured heat source water flow rate W_{hf} = _____ gpm

Pressure at tank heat source inlet with flow P_{iht} = _____ft w.c.

Pressure at tank heat source outlet with flow P_{oht} = _____ft w.c.

Pressure at tank heat source inlet with no flow * P_{ihs} = _____ ft w.c.

Pressure at tank heat source outlet with no flow* P_{ohs} = _____ft w.c.

Length of inlet piping from gauge port to tank L_{in} = _____ ft

Length of outlet piping from tank to gauge port L_{out} = _____ ft

Calculate the pressure drop of the external heat source piping, dP_{eh} in feet of w.c.

$dP_{eh} = (L_{in} + L_{out}) \times P_d$

dP_{eh} = (_____ ft + _____ ft) x _____ ft w.c. / foot = _____ ft w.c.

Calculate the Heat Source Friction Loss, dP_h, expressed in feet water column and defined as:

When two pressure gauges are used.
$dP_h = [(P_{iht} - P_{ihs}) - (P_{oht} - P_{ohs})] \times (W_h/W_{hf})^2 - dP_{eh}$

dP_h = [(_____ ft w.c. - _____ ft w.c.) – (_____ ft w.c. - _____ ft w.c.)]
X (_____ gpm / _____ gpm)^2 - _ _____ ft w.c. = _____ ft w.c.

When one pressure gauge and a three way valve is used
$dP_h = (P_{iht} - P_{oht}) \times (W_h/W_{hf})^2 - dP_{eh}$

dP_h = (_____ ft w.c. - _____ ft w.c.)
X (_____ gpm / _____ gpm)^2 - _____ ft w.c. = _____ft w.c.

*** If a single pressure gauge and a three way valve is used these values do not need to be recorded**

Indirect-Fired Water Heater Report Sheet IWH-R-1 Rev 2/04

Company Name _____
Indirect-Fired Water Heater Model Number_____ Nominal Size_____
Potable Water in Tank ☐ or Coil ☐, Indirect Fired Storage Heater ☐, Instantaneous Indirect Fired Heater ☐
Other (e.g. materal, insulation)

Heat Source Manufacturer _____ Model No. _____
Btuh Output_____ Btuh Input _____
General Specifications & Description

General	Test Number		
	Test Date		
Water Volume	Heater Dry Weight (W_t)	lbs	
	Weight of Heater Filled with Potable Water (W_p)	lbs	
	Weight of Heater Filled with Potable and Heat Source Water (W_{ph})	lbs	
	Water Temperature Used to Fill Heater (T_c)	ºF	
	Water Density (ρ), (see table 3)	lbs/gal	
	Potable Water Volume (V_p)	gal	
	Heat Source Water Volume (V_h)	gal	
Standby Loss	Uncorrected decay rate (DR_u)	ºF/Hr	
	Average Water Temperature (T_c)	º F	
	Mean Tank Water Temperature Decay Rate (DR)	ºF/Hr	
	Heat Loss (Q)	Btuh	
Continuous Draw	Heat Source Water Flow Rate ($w_{h,avg}$)	Gpm	
	Average Outlet Water Temperature to Heat Source ($T_{oh,avg}$)	º F	
	Average Inlet Water Temperature from Heat Source ($T_{ih,avg}$)	ºF	
	Heat Source Input (Q_h)	Btuh	
	Average Potable Water Inlet Temperature (T_i)	º F	
	Potable Water Outlet Temperature (T_o)	ºF	
	Potable start weight or volumetric meter reading	lbs or gal	
	Potable final weight or volumetric meter reading	lbs or gal	
	Volume or Weight of Potable Water Drawn (V_c or W_c)	gal or lbs	
	Density of Water at Average Water Temperature (ρ)	lbs/gal	
	Continuous Draw Rating (V_{cd})	gal/hr	
First Draw	Maximum value of the mean tank temperature (T_s)	ºF	
	Potable outlet water maximum temperature ($T_{o(max)}$)	ºF	
	Potable outlet water stop temperature (T_{omax} – 25F or –65F or 110F)	ºF	
	Potable start weight or volumetric meter reading (WT_t or V_t)	lbs or gal	
	Potable final weight or volumetric meter reading ($WT_{(end)}$ or $V_{(end)}$)	lbs or gal	
	Net weight divided by ρ or gallons of water drawn (W_d or V_d)	gal	
First Hour Rating	First Hour Rating (V_f)	gal/hr	
Heat Source Friction Loss	Heat Source Water Flow Rate (W_{hf})	gal/min	
	Friction Loss (dP_h)	feet water column	

Laboratory Location	Test Conducted by

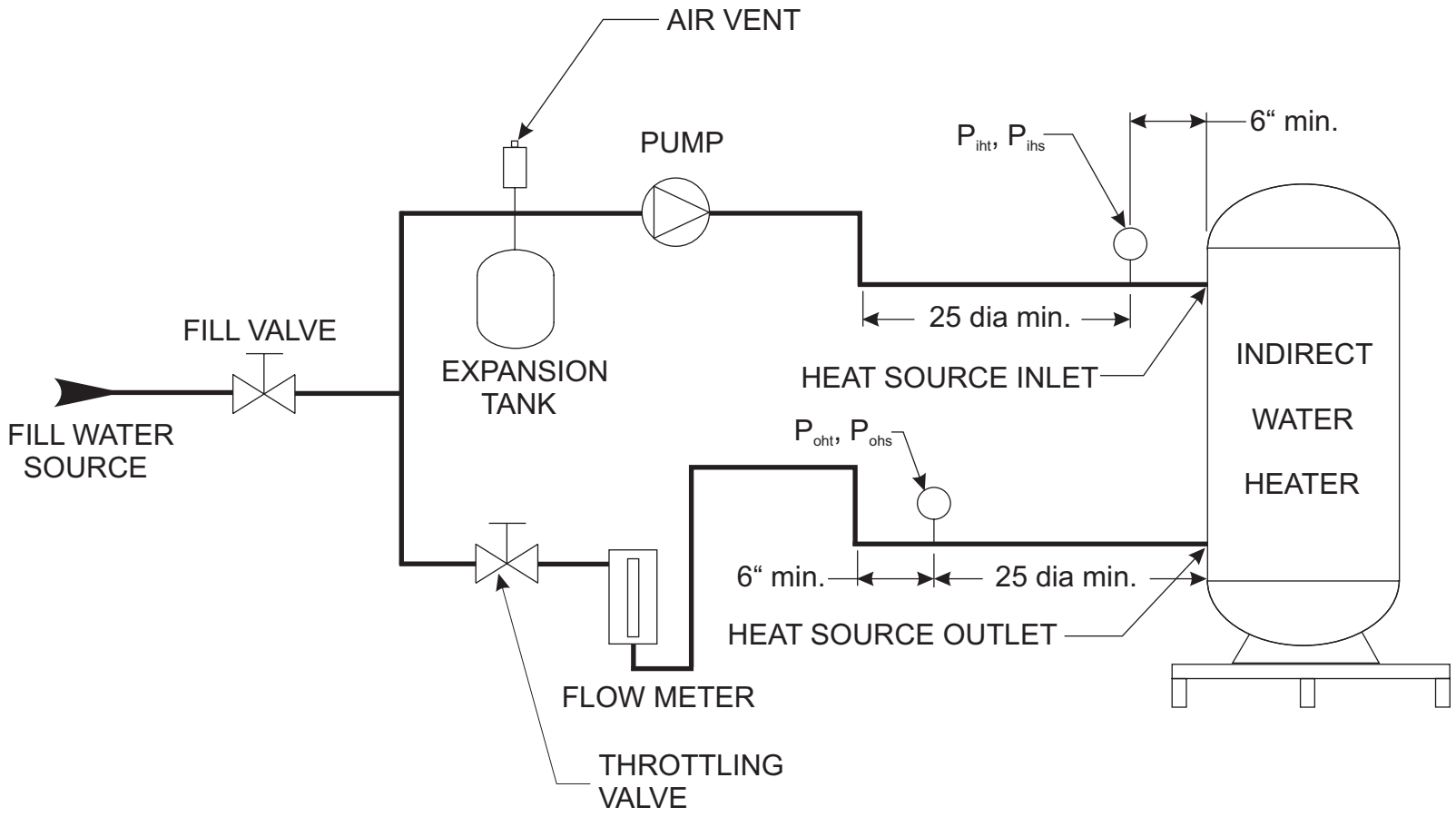

FIGURE 3a: EXAMPLE OF HEAT SOURCE FRICTION LOSS TEST SETUP (2 GAUGES)

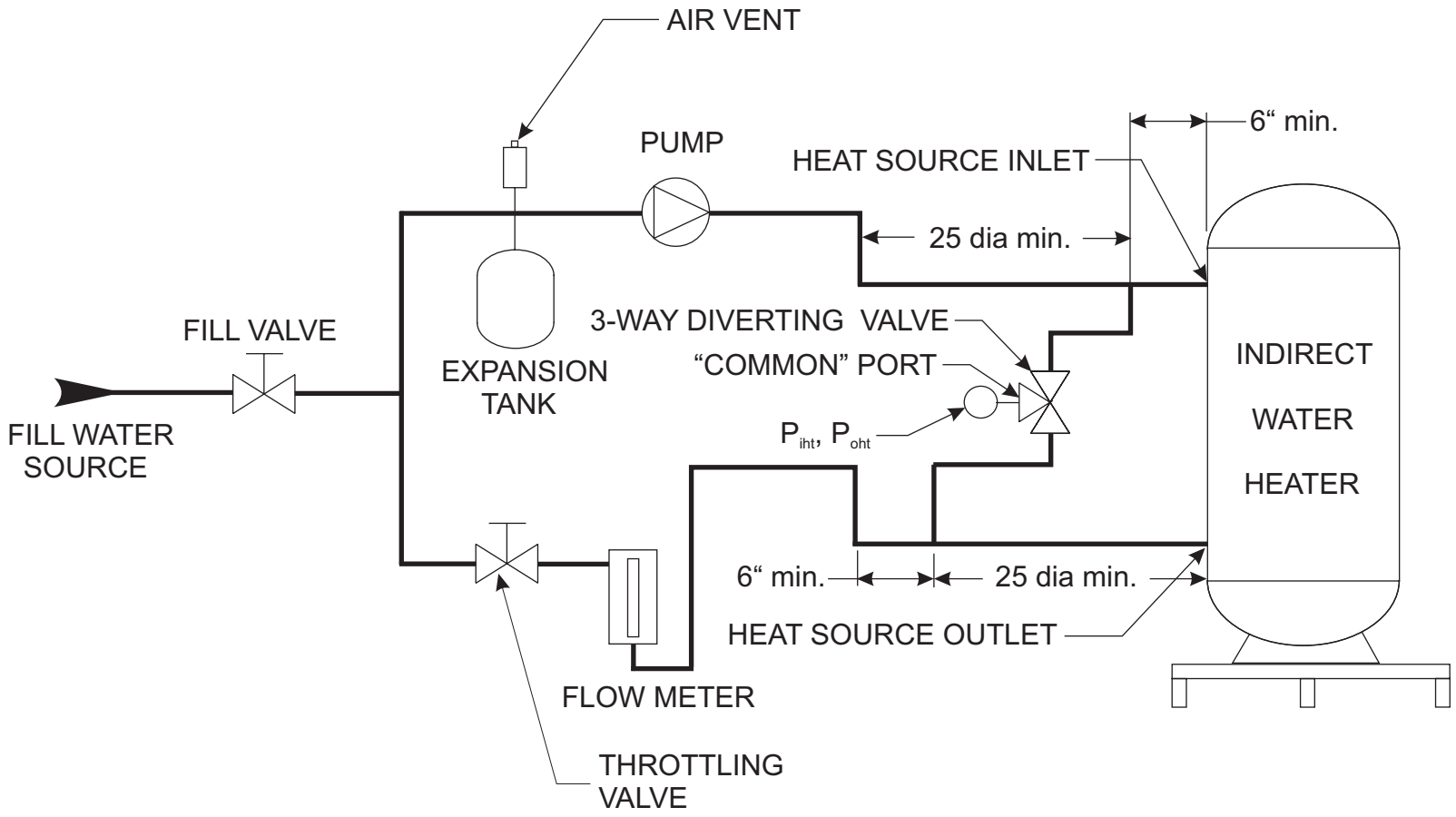

FIGURE 3b: EXAMPLE OF HEAT SOURCE FRICTION LOSS TEST SETUP
(1 GAUGE + 3-WAY VALVE)