Leaking Shower Diverters

Summary

If a diverter valve leaks in shower mode, the water flowing out of the bathtub spout goes straight down the drain, wasting both water and the energy used to heat that water. It's like pouring money down the drain!

Background Information

A diverter is used in combination bath/shower units to direct flow either to the bathtub spout or to the showerhead. There are two primary classes of diverters: diverter valves and plate diverters.

Diverter valves like the one shown in Figure 1 use a valve to direct the flow to the showerhead or the tub spout. These diverters can either be part of a three-handle shower valve assembly, or they can be a separate valve installed above the valves that control the water.

Plate diverters like those shown in Figure 2 use a plastic or metal plate to stop the water from flowing out of the tub spout. The water gets diverted to the showerhead instead. Plate diverters can be used with single-handle valves or two-handle valves, and the diverter can be located on the tub spout or on the valve body. Also, some plate diverters are held in place by water pressure alone, while others have an integral spring. If the diverter is located on the tub spout, it is called a tub spout diverter.

Figure 1: A diverter valve as part of a three-handle shower valve

When a diverter valve is working properly, water only flows out of either the tub spout *or* the showerhead. However, diverters very often leak significantly, allowing water to flow out of the tub spout even when in shower mode, as shown in Figure 3. This leakage goes directly down the drain without being available to the person taking a shower. Both the water and the energy used to heat the water are wasted.

Figure 2: Examples of plate diverters. From left to right: a lift on the tub spout diverter with a two-handle valve; a pull-down ring on the tub spout diverter with a single-handle valve; a button on the valve plate with a single-handle valve; and a sliding lever on the valve plate with a single-handle valve.

Prevalence and Savings Potential

We surveyed approximately 130 apartments and houses, which collectively had 120 combination bath/shower units with diverters. We found that 34% of the diverters leaked more than 0.1 gallons per minute (gpm). The largest leak we saw was 3.0 gpm, and the average of all leaks greater than 0.1 gpm was 0.8 gpm.

Further testing we performed showed that when a leaking diverter is fixed, some of the water that had been leaking out the tub spout is forced out of the showerhead. If a diverter is fixed and some of the water that had been leaking now comes out of the showerhead, this fraction of the water will not contribute to water or energy savings. However, even if we can only claim partial savings for fixing leaking diverters, the savings can still be substantial enough to justify the cost of the repair.

Figure 3: A leaking diverter allows water to flow out both the showerhead and the tub spout simultaneously.

In order to understand the savings potential of fixing leaking diverters, we compared savings from fixing leaking diverters to installing low-flow showerheads. We calculated the amount of savings that could be achieved by installing low-flow showerheads in our dataset of 130 homes. In those homes, approximately 18% of the showerheads had a measured flow of 2.5 gpm or more. If these showers were used for 10 minutes per day, and we installed 2.0 gpm low-flow showerheads, the sum of all the potential water savings would be approximately 79,000 gallons of hot water per year. In the same dataset, 34% of the diverters leaked more than 0.1 gpm. Again assuming that the showers were used 10 minutes per day, and assuming a savings factor of 0.7 for fixing the leaking diverters, per the results of our research, the sum of the potential water savings would be approximately 89,000 gallons of hot water per year. In other words, for the sample of homes we studied, savings from fixing diverters were higher than savings from installing low-flow showerheads! This is not to say that low-flow showerheads should not be installed, but rather to say that the potential savings from fixing diverters is very high.

One note about our calculations above: Our testing showed that in general, low-flow showerheads provide less water than their rated flow, no matter what the static pressure of the system is. Our low-flow showerhead savings calculation above was based on measured existing flows and the assumption that the new flow was 2.0 gpm.

Methods

In addition to surveying more than 130 apartments and houses to determine the extent of the problem, we also constructed the test rig shown in Figure 4 to test how the flows through the showerhead and tub spout interact in various scenarios. (Please see Appendix A for a diagram of our rig.) We focused our testing on tub spout diverters and performed the three tests described below.

We installed three showerheads on our test rig to allow for easy switching between showerheads of various flows. We were also able to simulate a higher showerhead flow by opening two showerheads at once. We used a pressure reducing valve (not shown in Figure 4) at the main water supply for the building to vary the system pressure. Finally, for Test 1 and Test 2, we installed a ball valve in place of the tub spout diverter. This allowed us to simulate various leak flows.

Test 1 – To determine a savings factor that accounts for the amount of additional water that is forced through the showerhead when a leaking diverter is fixed.

For this tech tip, we define "savings factor" as a number between 0 and 1.0 by which an auditor can multiply an existing flow from a leaking diverter to estimate the savings in gpm that can be achieved by fixing that diverter.

In Test 1, we measured the flow through the showerhead and the flow of the leak, and then we also measured the flow through the showerhead when the leak was eliminated. We performed these measurements for each showerhead at six system static pressures and 5 to 10 leak flows per static pressure. Each flow measurement was taken for 60 seconds.

Test 2 – To determine the interaction between fixing a leaking diverter and installing a low-flow showerhead at the same time.

For this test, we measured the flow through a showerhead with a rated flow greater than 2.25 gpm and through the tub spout at a variety of leaks, and then measured the flow again through a showerhead rated at 2.25 gpm with no leak through the tub spout. We repeated the measurements across six system static pressures.

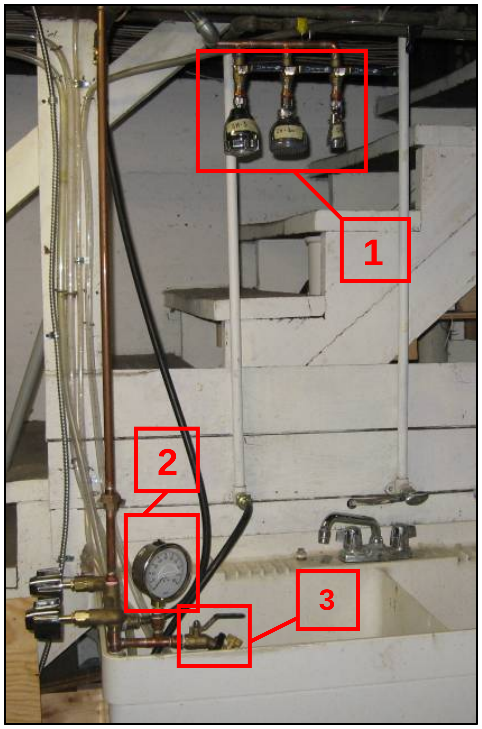


Figure 4: Test rig with (1) multiple showerheads, each with their own shutoff valve; (2) a pressure gauge; and (3) a throttling valve to simulate various tub spout leak sizes

Test 3 – To determine the most robust type of tub spout diverter in order to make recommendations about which kind should be installed as leaks are fixed.

We acquired 18 tub spout diverters and installed each one on our test rig. We measured the leak through each spout at a minimum of three static pressures.

Results

Test 1

Our primary goal for this project was to determine a savings factor for energy auditors to use in order to calculate achievable savings from replacing a leaking diverter. Test 1 focused on determining the savings factor through tests. We found that in general, at a given system pressure, the savings factor decreased as the size of the original leak got larger. (See Figure 5.) We also found that the savings factor was almost always greater than 0.7, regardless of the showerhead, system pressure, or leak flow.

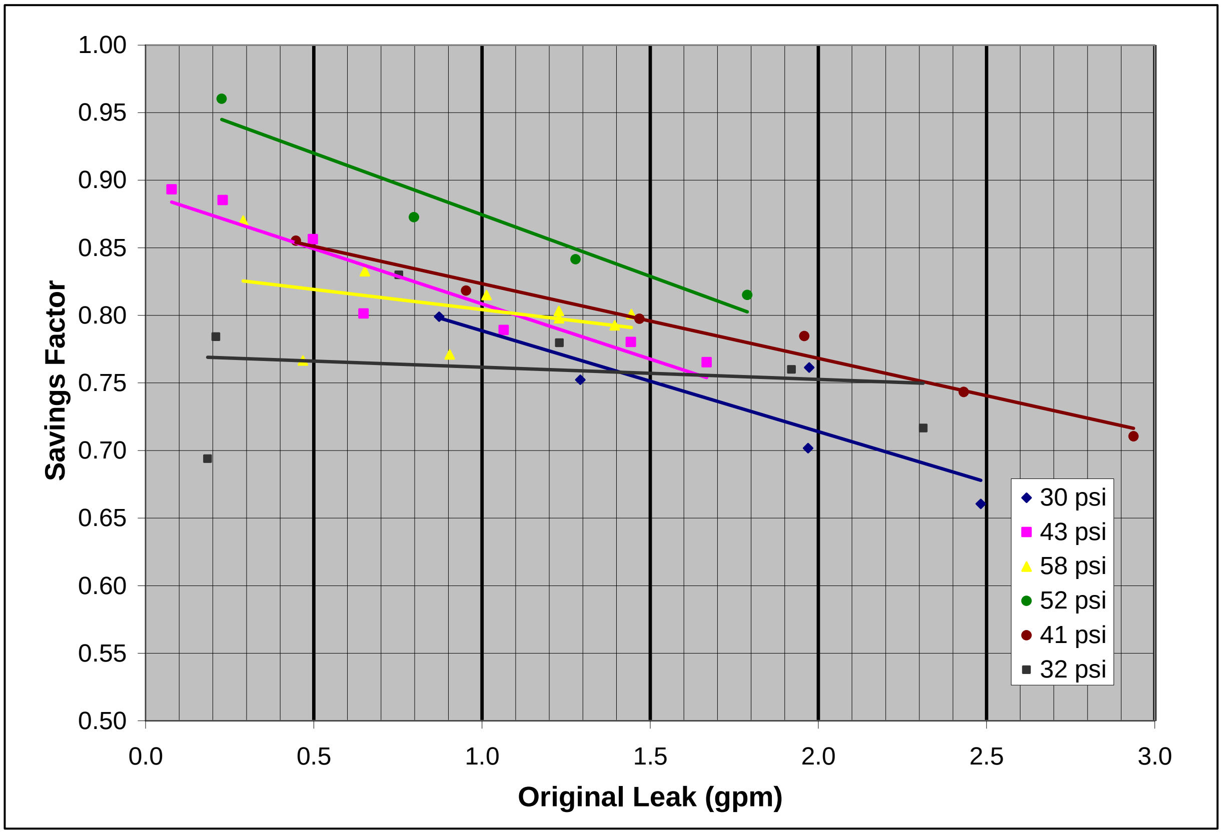


Figure 5: Calculated savings factor for SH-1 at various leaks and system static pressures

Test 2

In Test 2, we investigated the interaction between installing a low-flow showerhead and fixing a leaking diverter at the same time. We found that when we estimated savings from installing the low-flow showerhead based on the rated flow of the new showerhead, our calculated savings were lower than the achieved savings. This is because in all cases, the flow through the showerhead was less than the rated flow. (See Table 1.)

We also found in Test 2 that a savings factor is not needed if you are replacing the showerhead and fixing a leaking diverter. It is sufficiently conservative to estimate savings by taking the difference between the existing showerhead flow and the rated new showerhead flow and adding the diverter leak flow.

Test 3

In Test 3, we investigated the different types of tub spout diverters available on the market. Our research was by no means exhaustive – we tested only 18 different spouts, and only one of each model. (Please see Appendix B for a list of the tub spouts we tested and how much they leaked.) Note that we labeled each tub spout with a unique identifier, starting with TS-1 and ending with TS-20.

TS-3 and TS-16 were old diverters, and their leak rates are therefore not included in the following analysis. We found three patterns worth noting:

First, the amount of the leak through almost all of the tub spouts increased as the system pressure decreased. This is because all of the tub spouts we tested use water pressure to create the seal that prevents water from continuing to flow out of the tub spout when the diverter is in shower mode. Table 2 summarizes our results. Because the water pressure in buildings varies greatly, we have presented the number of showerheads that leaked less than a given leak rate at *all* pressures. TS-2, -6, -7, and -20 leaked less than 0.01 gpm at all pressures.

Second, many of the tub spouts leaked significantly even though they were newly purchased. Table 3 is a bin analysis of how many spouts leaked for five different leak brackets. These results are reflective of *each* static pressure. That is, each spout is counted once for each pressure.

Showerhead Tag	Rated Flow (gpm)	Static Pressure (psi)	Measured Flow (gpm)
SH-1	2.2	15	0.9
		30	1.2
		40	1.2
		50	1.3
		58	1.6
		70	1.7
		80	1.8
SH-2*	2	30	1.7
		40	1.9
		50	1.9
		86	1.9
SH-1+2	4.2	15	1.7
		30	2.1
		40	2.5
		50	2.7
		60	3.7
		70	3.9
		80	4.0
*Rated flow not marked on showerhead. Flow presumed to be 2 gpm.			

Table 1: Showerhead flows at various system pressures

Finally, we originally hypothesized that tub spout diverters with a pull-down ring (see an example in Figure 2) would leak less than lift-type tub spout diverters. This type of diverter has a spring that holds

the diverter open; perhaps the spring would help the diverters leak less. We tested two of this style diverter (TS-13 and TS-14). When we ranked the tub spouts in order of smallest leak to largest leak, we saw that

TS-13 performed better than most of the spouts across all pressures, while the performance of TS-14 varied greatly by system pressure. (See Table 4.)

Although the pull-down ring diverters did not perform as well as we had hoped, TS-20 performed better than all of the other tub spouts we tested at every static pressure. At a system static pressure of 25 psi, it dripped only a few times per minute, and at higher static pressures, it didn't leak at all. Although several of the other diverters had low leaks, especially at high static pressures, none of the other diverters performed so consistently well across all pressures.

As discussed above, TS-20 performed the most consistently, but TS-2, -6, and -7 also performed quite well across all system pressures. TS-2, -6, and -7 are standard models; we can identify no design feature that would make them perform better than any of the other spouts we tested. TS-20, however, has a different design.

TS-20 is the Positive Action Shut-off Mixet diverter by BrassCraft. Instead of pulling up on a lift to engage the diverter, one pulls straight out, in line with the tub spout. (See Figure 6.) Like the pull-down ring type diverters, a spring holds the diverter plate in the open position. When the water is turned on and the lift is pulled, water pressure causes the diverter to stay in the closed position. According to the product literature available from BrassCraft, the internal configuration of the spout was designed to make the seal very effective even at low pressures.

		System Static Pressure	
Leak Flow (gpm)	~25 psi	~50 psi	~75 psi
0< and <0.01	28%	44%	72%
0.01< and <0.02	28%	22%	0%
0.02< and <0.05	22%	17%	11%
0.05< and <0.1	11%	11%	17%
>0.1	11%	6%	0%

Table 2: Summary of all tub spout tests

Leak (gpm)	% of Spouts that Leaked Less than Stated Leak at ALL Pressures
0.01	20%
0.02	45%
0.05	65%
0.10	75%

Table 3: Percent of tub spouts that leaked a given flow at each static pressure

System Pressure	Leak Rank	
	TS-13	TS-14
~25 psi	6th	14th
~50 psi	5th	7th
~75 psi	6th	2nd

Table 4: Performance of pull-down ring diverters when leak sizes are ranked from lowest to highest

Conclusions and Recommendations

Test 1

A large majority of the measurements we took in Test 1 showed a savings factor greater than 0.7. We therefore recommend that auditors use a savings factor of 0.7 to estimate the achievable savings from fixing a leaking tub spout diverter. We feel that this savings factor will result in a conservative estimate of savings without understating the savings to the point where the measure will become not cost effective.

Test 2

Based on our results for Test 2, we conclude that auditors do not need to worry about overestimating the savings when replacing a showerhead and fixing a leaking diverter in the same bathroom. We recommend estimating the achievable savings by taking the difference between the existing measured showerhead flow and the proposed rated showerhead flow, and adding the total diverter leak flow. It is not necessary to multiply the leak by a savings factor.

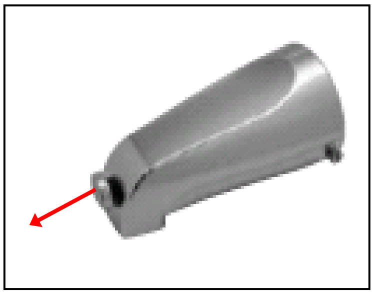


Figure 6: TS-20, the Positive Action Shut-off Mixet tub spout diverter by BrassCraft

Test 3

We recommend using the BrassCraft Positive Action Shut-off Mixet tub spout diverter, or a diverter with similar functionality, where possible. This spout is currently available from several sellers on the internet, and its price (approximately $20) is in line with the other spouts we tested. It is available in both threaded and slip-on configurations, in two lengths, and with a variety of finishes.

If for some reason the Positive Action Shut-off Mixet is not available or appropriate for a given installation, we recommend the following performance standard for replacement tub spouts. We recommend testing any replacement spout after it is installed, and accepting it only if it leaks less than 0.02 gpm. If it leaks more than that, the spout should be returned to the manufacturer as faulty and a new spout should be installed.

Calculating Energy Savings and Payback

Using our results above, it is easy for an auditor to calculate the annual savings that can be achieved by fixing a leaking diverter. (See "Calculating Potential Energy Savings" in the Resources section, below, for conversion factors, reasonable assumptions, and a step-by-step description of the calculations.) Once an auditor has calculated annual dollar savings, they must determine if the savings justify the cost of installing the new diverter. A new tub spout diverter costs approximately $20. If the installation is straightforward (see "Fixing Leaking Diverter Valves," below, for a discussion of some of the potential difficulties in installation), it should take a plumber less than one hour to install a new tub spout diverter. We therefore estimate a total installed cost of between $50 and $100 per tub spout.

It was outside the scope of this project to determine how long a new diverter lasts before it starts to leak. Anecdotal evidence suggests that older tub spout diverters leak more than newer ones. In general, it makes sense to install an energy conservation measure only if the replacement will save more than the installed cost over the lifetime of the replacement. We estimate a lifetime of between 15 and 20 years for a tub spout diverter. See Table 5 for sample savings and payback results.

Other Benefits

Comfort

When you fix a leaking diverter valve, more water is available for the person taking a shower. In the case of a very badly leaking diverter valve, the increase in water pressure may be noticeable, leading to a more comfortable shower.

Persistence of Energy Savings

Low-flow showerheads are frequently removed by tenants who dislike how low the new flow is. We predict that this will not be a problem for new diverters both because a non-leaking diverter will typically make the shower more comfortable and because it takes more effort and plumbing knowledge to replace a diverter than to replace a showerhead.

Other Issues

Leaking diverters can cause auditors to miss low-flow opportunities because the leak reduces the flow from the showerhead. Showerhead flow should be re-measured after a leaking diverter is fixed, and a new showerhead should be installed if the existing one has a flow higher than 2.5 gpm.

Existing Leak (gpm)	Heated by Electricity		Heated by Gas	
	Annual Savings ($/yr)	Payback (yrs)	Annual Savings ($/yr)	Payback (yrs)
0.1	$4.60	21.7	$1.70	58.8
0.2	$9.20	10.9	$3.40	29.4
0.3	$13.80	7.2	$5.10	19.6
0.4	$18.40	5.4	$6.80	14.7
0.5	$23.00	4.3	$8.50	11.8
0.6	$27.60	3.6	$10.20	9.8
0.7	$32.20	3.1	$11.90	8.4
0.8	$36.80	2.7	$13.60	7.4
0.9	$41.30	2.4	$15.30	6.5
1	$45.90	2.2	$17.00	5.9

Note: The savings in this chart include a savings factor of 0.7 to account for the additional water that comes out of the showerhead when a leaking diverter is fixed. Electricity is assumed to be $0.12/kWh and gas is assumed to be $1.10/therm. We assume the shower is used for 10 minutes/day and that a gas water heater has an efficiency of 83% and an electric heater has an efficiency of 98%. Payback is calculated based on an installed cost of $100 per diverter. Savings do not include the cost of water.

Table 5: Annual savings and payback for various leak flows

Resources

Measuring Leaks

Measuring an existing diverter leak is straightforward. It requires a stopwatch, a bucket to collect the water, and a measuring device (for example, a measuring cup from your kitchen or a water bottle marked in milliliters and/or fluid ounces). Turn on the shower, then use the bucket to collect water leaking from the tub spout, using the stopwatch to time 60 seconds. Very carefully pour the water from the bucket into your measuring device and count how many cups, fluid ounces, or milliliters you collected. Then convert your measurement into gallons. Since you measured the flow for one minute, you now have gallons per minute. For example, if you measured 140 fluid ounces coming from your tub spout in 60 seconds, 1.09 gallons in total leaked. You therefore have a leak of 1.09 gpm.

Calculating Potential Energy Savings

To calculate potential savings, multiply your measured flow rate by a savings factor of 0.7, as discussed above, to account for the water that gets forced through the showerhead when you fix the leak. Then multiply by the number of minutes per year your shower is on to calculate potential savings in gallons of water per year. Finally, gallons per year of hot water should be converted into saved therms or kilowatt hours, depending on how you heat your hot water.

Using our sample measured flow rate of 1.09 gpm, here is how we calculate dollar savings per year:

1. Calculate the achievable savings by multiplying the measured flow rate by 0.7:

Measured flow rate	x	Savings Factor	=	Achievable savings flow rate
1.09 gpm	x	0.7	=	0.76 gal/min

2. Calculate the gallons saved per year by multiplying the achievable savings rate by the number of minutes per year the shower is in use. Assuming one person lives in the apartment and that he showers 10 minutes per day, that is 10 minutes/day times 365 days/yr, or 3,650 minutes/year:

Savings flow rate	x	Minutes/year the shower is used	=	Gallons/year saved
0.76 gpm	x	3,650 minutes/year	=	2,785 gallons/year

3. Calculate how much energy it takes to heat 2,785 gallons of water up to the showering temperature by multiplying the gallons saved/year by the specific heat of water and by the temperature rise in the water. Estimate that the cold water from the street enters the building at 50°F and that the person in the apartment showers at 110°F. This is a temperature rise of 60°F. It takes one Btu to raise one pound of water one degree Fahrenheit. Water weighs approximately 8.3 pounds/gallon.

Gallons saved/year	x	Specific Heat of Water	x	Weight of Water	x	Temperature Rise	=	Btu/year saved
2,785 gallons/year	x	1.0 Btu/lb-°F	x	8.3 lbs/gal	x	60°F	=	1,386,905 Btu/yr

4. Calculate therms/year or kWh/year saved by dividing by the appropriate conversion factor and then by the efficiency of the heater. There are 100,000 Btu/therm and 3,412 Btu/kWh. Assume a natural gas heater has an efficiency of 83% and an electric heater has an efficiency of 98%.

Natural Gas:

Btu/yr saved	÷	Btu/therm natural gas	÷	Efficiency	=	Therms/yr saved
1,386,905 Btu/yr	÷	100,000 Btu/therm	÷	0.83	=	16.7 therms/yr

OR Electricity:

Btu/yr saved	÷	Btu/kWh electricity	÷	Efficiency	=	kWh/yr saved
1,386,905 Btu/yr	÷	3,412 Btu/kWh	÷	0.98	=	415 kWh/yr

5. Calculate dollars saved per year by multiplying by the cost of energy. In this tech tip, we have assumed natural gas costs $1.10/therm and electricity costs $0.12/kWh.

Natural Gas:

Therms/yr saved	x	$/therm	=	$/yr saved
16.7 therms/yr	x	$1.10/therm	=	$18/yr saved

Electricity:

kWh/yr saved	x	$/kWh	=	$/yr saved
415 kWh/yr	x	$0.12/kWh	=	$50/yr saved

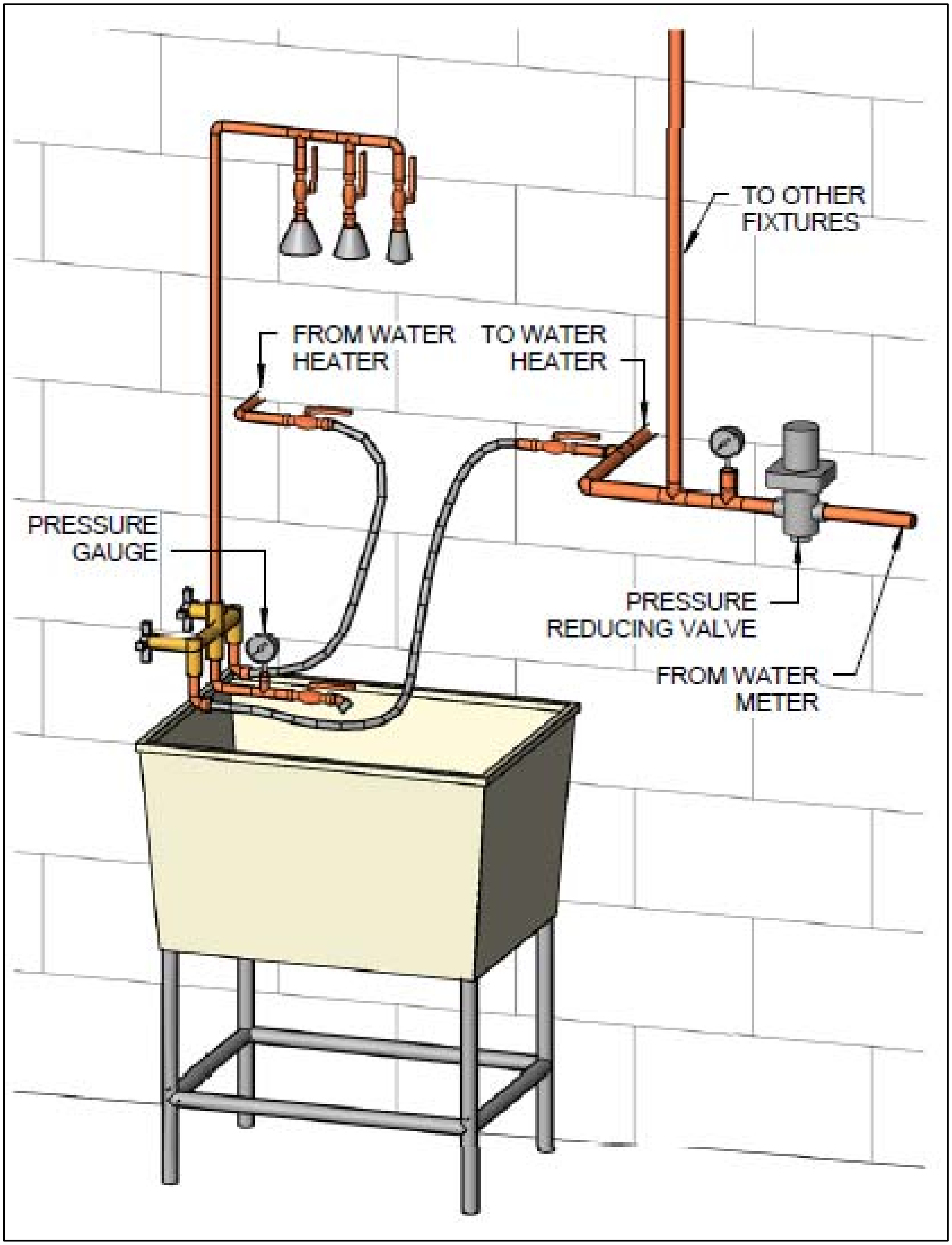
Please note that we have not included the cost savings due to reducing water consumption in the above calculation. Including those savings will reduce the payback time of replacing a leaking diverter.

Fixing Leaking Diverter Valves

It is relatively simple to replace a leaking tub spout diverter. However, especially in older showers, it is common for the tub spout to have become stuck to the water pipe. If the spout is stuck, be very careful to not break the pipe behind the wall of the shower. It may be impossible to replace the tub spout without opening up the shower wall and also replacing some of the piping. It may also be impossible to replace some kinds of diverters without opening the shower wall. A plumber or a building maintenance person with basic plumbing knowledge should be able to replace a tub spout diverter in less than an hour if the diverter is not stuck.

Be extremely careful not to damage the existing shower wall and piping. Removing the existing fixture can require significant force, especially if the fixture is old and may have rusted to the pipe. Protect the wall and pipe from damage. Also, if you can feel the piping flex as you attempt to loosen the tub spout, proceed only if you are willing to cut a hole in the shower wall to repair a broken pipe.

Appendix A: Diagram of the Test Rig



Appendix B: Tub Spouts Tested

Tag	Manufacturer	Model #	Price	Diverter Mechanism	Leak Rate (gpm) Low Pressure	Medium Pressure	High Pressure
TS-1	Danze	D606225	$24.00	Lift	0.02	0.01	0.00
TS-2	LDR	BT129/502 4250	$15.05	Lift	0.00	0.00	0.00
TS-4	American Standard	8888025.002	$19.25	Lift	0.02	0.03	0.03
TS-5	American Standard	8888055.002	$21.45	Lift	0.10	0.08	0.05
TS-6	Moen	391	$32.41	Lift	0.00	0.00	0.00
TS-7	Grohe	13 611 000	$30.00	Lift	0.00	0.00	0.00
TS-8	Moen	IPS 3830	$30.09	Lift	0.01	0.01	0.00
TS-9	Delta	RP 19820/ 33714	$21.63	Lift	0.01	0.16	0.06
TS-10	unknown		--	Lift	0.01	0.00	0.00
TS-11	Kohler	389-CP/ Devonshire	$25.50	Lift	0.26	0.02	0.00
TS-12	Danco	34224CCB	$12.58	Lift	0.03	0.03	0.00
TS-13	unknown	17463CV	--	Ring and Spring	0.01	0.00	0.00
TS-14	Delta/Brass Craft	SWD0205/ RP17453	$20.38	Ring and Spring	0.03	0.01	0.00
TS-15	Waxman/Spray Sensations	24501	$7.95	Lift	0.01	0.01	0.01
TS-17	Waxman/Spray Sensations	26629	$15.98	Lift	0.02	0.01	0.01
TS-18	Danco/Universal	88703	$16.97	Lift	0.12	0.03	0.03
TS-19	Kohler	Coralais/ 15136-S-CP	$19.22	Lift	0.09	0.09	0.08
TS-20	BrassCraft/OEM Mixet	SWD0411	$20	Positive Pressure	0.00	0.00	0.00

Please note: TS-3 and TS-16 were old tub spouts that were not specifically purchased for this project. We did not include the test results from either spout in our analysis.