An Improvement
to the Hartford Loop

Advantages of the Gifford Loop include the Hartford Loop's safety features, plus stabilization of the boiler water line, drier steam, and elimination of some condensate pumps

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The Hartford Loop has been around for eight decades and has prevented thousands of boiler explosions and failures. Still, it is time to consider an improvement. It has been discovered that a boiler's waterline can be stabilized greatly by installing a Gifford Loop—a Hartford Loop with the bottom of the close-nipple at least 1/2 in. *above* the water level where the automatic feeder starts to add water. It is named after one of the co-authors of this article, Henry Gifford, a boiler mechanic in New York City who recently invented it.

THE HARTFORD LOOP

A conventional Hartford Loop has a single purpose: to keep water in the boiler in the event that a wet return line breaks. Figure 1 shows what the Hartford Loop looks like in action.

If a wet return breaks, the water in the boiler will drop down to the height of the loop,but no farther. Without the loop, the water would all drain out of the boiler through the broken wet return.

The Hartford Loop comes into play only during an emergency. It has no effect on the boiler's waterline during normal operation (the equalizer does *not* keep water in the boiler while the loop is submerged). So, what *does* affect the boiler's waterline?

Consider a new boiler equipped with an automatic feeder. The feeder sets the boiler's minimum water level. As water steams out of the boiler, the feeder adds water as needed. Eventually, steam completely fills the system and the feeder stops adding water. Steam condenses in the radiators, drops by gravity into the drip legs, and then flows through the wet returns back into the boiler.

Once the system builds pressure, the waterline is actually lower in the boiler than in the drip legs. How can this occur? Friction in the pipes robs energy from the steam so that the steam's pressure has been reduced by the time it reaches the end of a main. With steam pressure higher at the boiler than at the ends of the mains, the water level in the drip legs climbs up.

To see why, imagine blowing down into a U-tube manometer. If you apply 1 psi of pressure to one of the legs, the waterline will drop in that leg and rise in the other, until one waterline is 28 in. higher than the other (Figure 2).

In the same way, greater steam pressure at the boiler causes water to rise in the drip legs. If the pressure drop from the boiler to the end of a steam main is 4 oz per sq in. (typical in these systems), water will be 7 in. higher in the drip leg than at the boiler (Figure 3).

This is the reason for measuring "dimension A," which is the difference in height between the boiler's waterline and the lowest steam main. Traditional practice is to ensure at least 28 in. of di-

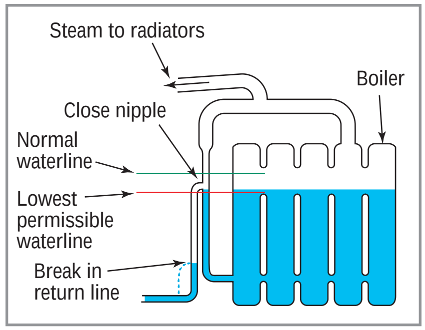

FIGURE 1. The Hartford Loop protecting a boiler from a broken return line.

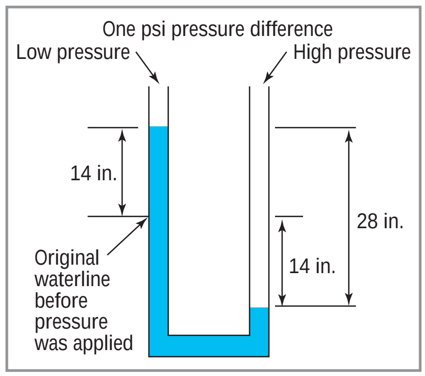

FIGURE 2. A U-tube manometer with pressure applied.

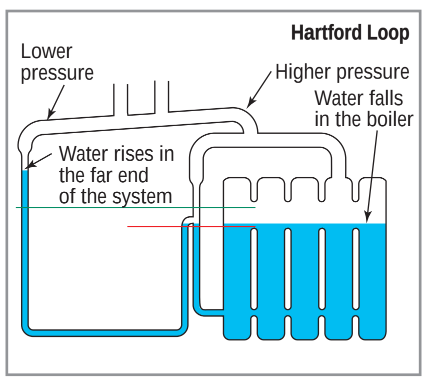

FIGURE 3. Water levels during system operation.

mension A, so that the water rising in the drip legs cannot reach up into the steam mains.

BOILER WATERLINES

Now let's get back to our boiler. The system is filled with steam, and water has climbed up in the drip legs. Water steaming out of the boiler is replaced by condensate returning through the wet returns, so that the returning condensate replenishes the boiler water continually. The feeder only replaces water lost to leaks or evaporation, and so it does not feed during a normal steaming cycle.

Or does it? Everything is fine as long as the boiler's water level does not vary, but what in life is that simple? In reality, the pressure in a steam system fluctuates. Even a system with bone dry steam experiences these fluctuations, which cause water to slosh back and forth continuously between the wet returns and the boiler.

When the pressure drops briefly in the boiler relative to the system, condensate will flow into the boiler from the returns. This slight but rapid raising of the waterline can reduce steam quality as water is splashed up towards the boiler's steam takeoffs.

What happens when the pressure in the system drops briefly? Water is pushed from the boiler into the returns. If enough water leaves the boiler, even if only for a second, *the automatic feeder will add more water!* When this happens, excessive water will be added and the boiler's waterline will rise. A boiler with the waterline too high has insufficient space for steam to separate out from the water. Instead, the steam will carry water up out of the boiler and into the system, causing hammer.

The more volatility in the system, the more the water level bounces. For example, hammer in the system causes rapid oscillations in pressure out in the steam piping, which is telegraphed eventually to the boiler waterline. The bouncing waterline sends more water up into the system, causing yet more hammer. Eventually, all this water returns to the boiler, flooding it. And, of course, a flooded boiler sends up the wettest steam of all. Bouncing waterlines and boiler flooding thus form a vicious circle.

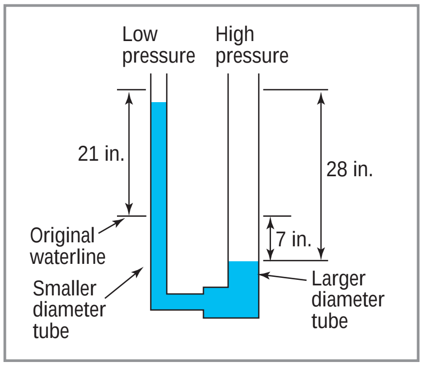

FIGURE 4. A U-tube manometer with unequal legs.

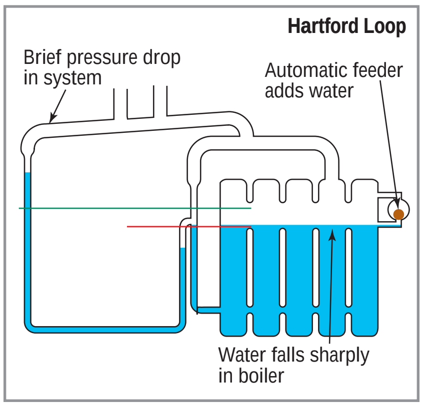

FIGURE 5. System pressure drop causing feeder to operate.

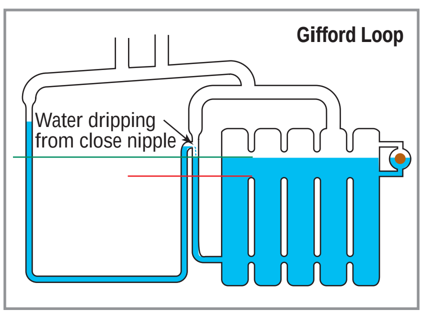

FIGURE 6. Condensate dripping through the close nipple back into the boiler.

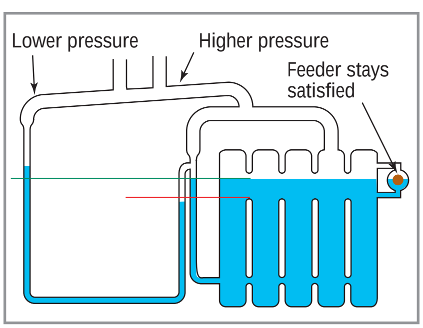

FIGURE 7. Gifford Loop prevents drop in system pressure from activating feeder.

New, low-water-content boilers are especially affected by pressure fluctuations. When the pressure rises briefly in a boiler, water flows from the boiler into the returns, stopping when the water rises high enough in the drip legs. In a high-water-content boiler this has little effect on the boiler's waterline. In a low- water-content boiler, however, this outflow of water can cause the boiler's waterline to drop precipitously, activating the feeder. To understand this, think about two different U-tube manometers, each measuring 1 psi of pressure. In the first U-tube, both legs are the same diameter (Figure 2). The water level drops by 14 in. in one leg and rises by 14 in. in the other to make up the total height difference of 28 in.

What happens if one of the manometer's legs is wider than the other? In Figure 4, one leg has three times the cross-sectional area of the other. The wide leg has three times the volume of the skinny leg, so that if the water in the wide leg drops 1 in., the water in the skinny leg has to rise up 3 in.: that is the only way the skinny leg can accommodate all that water flowing in from the wide leg. With a pressure difference of 1 psi, the water would drop just 7 in. in the wide leg, while rising 21 in. in the skinny leg. The same effect occurs in a boiler. Like the manometer's wide diameter leg, a high-water-content boiler has a water level that is not drastically affected by fluctuations in pressure. A low-water-content boiler, having a smaller "diameter," will be much more affected by pressure fluctuations. A brief drop in steam pressure out in the system will cause a significant drop in the boiler's water level, and the feeder will kick in (Figure 5).

THE GIFFORD LOOP

A Gifford Loop is like a Hartford Loop, except that the bottom of the inside of the close nipple is located above the boiler waterline rather than below it. (The waterline is defined by the level at which an automatic feeder would start feeding water.) What happens if we install a Gifford Loop? As we mentioned, in a Gifford Loop the bottom of the close nipple is at least ½ in. above the water level where the auto-

Installing a Gifford Loop

PHOTO A. *A mason's or line level can be used to check the relative heights of the water feeder's cutoff level and the inside of the bottom of the Gifford Loop's nipple. To avoid errors, slide the line level to the center of the string instead of reading near one end. Reverse the line level and see whether the two readings match to check that the level itself is correct.*

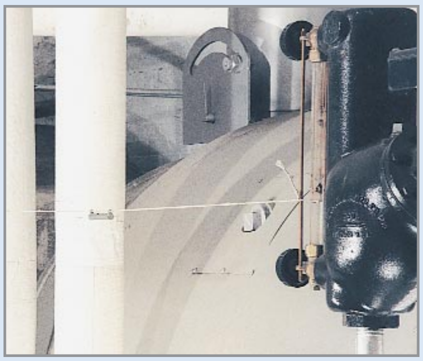

PHOTO B. *Closeup showing the water level control, the water in the gauge glass, the string with line level, and the silver-colored pipe that is part of the Gifford Loop.The water level in the gauge glass is higher than the reference mark on the water level control because the factory-set cutoff level is 15/16 in. above the reference mark. Therefore, the string is tied 15/16 in. above the reference mark to measure from the cutoff level to the Gifford Loop.*

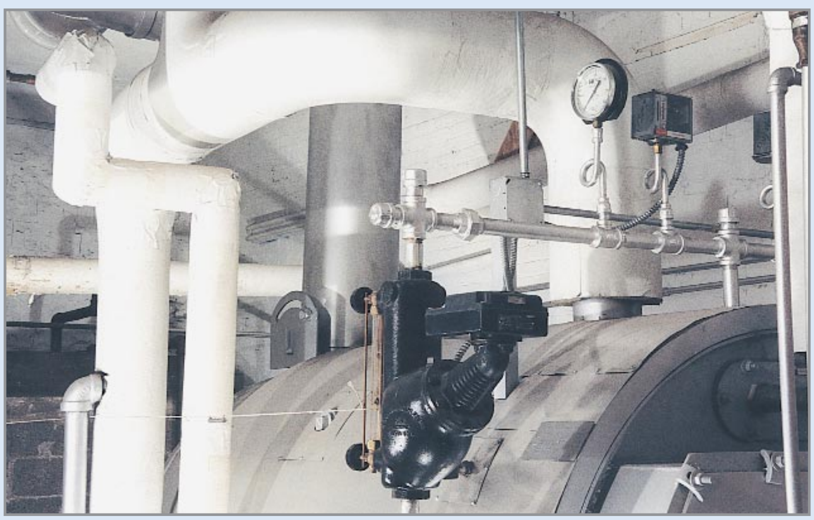

PHOTO C. *A properly piped steam header is shown from a distance.*

matic feeder starts feeding. Let's look at a system that has been firing long enough for condensate to stack up in the drip legs and start returning to the boiler. Figure 6 shows the water levels. What happens to the boiler's water line if pressure drops in the system? Absolutely nothing! Because of the increased height of the loop, water cannot flow out of the boiler. Instead, the waterline drops in the equalizer as shown in Figure 7.

At the same time, water doesn't rise as high as it used to in the drip legs. Again, what matters is the *total* difference in height between the two waterlines: in this case, the equalizer versus the drip legs. Because the equalizer has such a small diameter, the water level drops greatly there, while rising only slightly in the drip legs. The drip legs together act like the wide leg of our asymmetrical manometer, so their waterline is very stable. This is extremely helpful in cases where dimension A is tight.

What if the pressure drops in the boiler? In that case, the waterline in the drip legs drops slightly, and a gulp of water enters the equalizer, and spills over into the boiler, where it remains until it steams off into the system. Since increases in boiler pressure have no effect, and decreases have minimal effect, the boiler's waterline remains rock steady. We have lost 1/2 in. of dimension A, but this is offset by the reduced waterline fluctuations in the drip legs. What about hammer in the close nipple, since it is now above the waterline? All we can say is that it does not happen. This should not be surprising, since a Gifford Loop (like the Hartford Loop) is a false waterline. We have been putting in false waterlines for years, and they haven't hammered yet.

CONDENSATE PUMPS

Now, think about condensate pumps that get installed into one-pipe systems that have more than enough dimension A. These systems should work fine on gravity, so why does putting in a pump help?

What the pump really does is act like a Gifford Loop—it isolates the boiler from the return lines. As we observed, low-water-content boilers are especially subject to flooding caused by steam pressure fluctuations. When a condensate pump is installed, the check valve keeps the boiler water from flowing out into the returns. Like a Gifford Loop, a pump decouples the boiler from the wet returns.

CONCLUSIONS

The rock steady waterline achieved by a Gifford Loop thus has several benefits:

- drier steam
- elimination of boiler flooding
- elimination of pumps in many cases
- reduced risk of hammer when dimension A is tight.

Old habits die hard, and bad steam piping habits die hardest of all. Try a Gifford Loop on your next boiler installation, and you'll probably never put in a Hartford Loop again. **HPAC**