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The Locomotive

Low Water Cutoffs – What Can I Do To Prevent a Low Water Condition?

By Brian Moore, P.E., The Hartford Steam Boiler Inspection and Insurance Company

Introduction

According to Hartford Steam Boiler's claim loss history and data from the National Board of Boiler Inspectors, low water conditions are the leading cause of boiler incidents. How do low water cutoff devices, designed to prevent low water levels, contribute to the problem? What can you do to reduce losses due to these incidents? This article discusses the operation of low water cutoffs, the problems to watch out for, and steps you can take to help avoid boiler failures that result in property damage and possible serious injuries.

The Leading Cause of Boiler Breakdowns

About one-fifth of all the boiler incidents and failures reported to Hartford Steam Boiler are linked to low water conditions. Some years it has been as much as half. In fact, except for one or two years, low water conditions have been the leading cause of boiler incidents for more than two decades. Why should such a major causal factor be so difficult to control? The reasons are varied. But, at the risk of over simplification, they can be summarized as loss of water, failure to replace the water, and failure to detect the situation.

Defining Low Water Conditions

A low water condition in a steam boiler is any situation in which the water dips below the minimum safe operating level as intended by the manufacturer. During operation, sudden steam demand changes can result in temporary dips below that level with no adverse effects, if everything is working properly. However, if the situation continues without replacing the water, the metal, normally cooled by boiling water, must now be cooled by steam.

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Since heat transfer to steam is not as rapid as to boiling water, the metal gets hotter. When the metal gets too hot, it loses its mechanical strength and fails. Failures can range from short term overheating with little visible damage, to small bulges or warping of metal parts, to catastrophic failure. Life and property are at risk when a boiler fails catastrophically while under pressure.

Types of Low Water Cutoff Devices

To help prevent damage and possible injuries, boilers are fitted with low water cutoffs (LWCOs). These devices are intended to detect the low water condition and shut down the boiler. The burner remains off until the water returns, then the burner is allowed to fire normally.

Some LWCOs have a dual function of starting and stopping feed water flow as well as stopping the burner. This device is called the Primary LWCO. A Secondary LWCO provides another function: to initiate a safety shutdown and lockout. When this happens, the burner remains off until an operator corrects the situation manually and restarts the boiler.

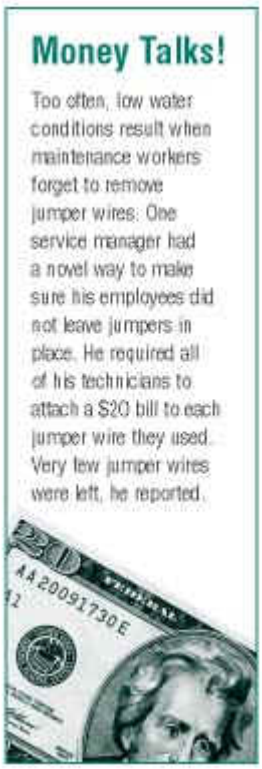
LWCO devices are normally very reliable and function well. After a failure that causes the water level to drop and not refill, the LWCO must also fail to cause the low water condition. But even though these devices are generally reliable, the following factors can lead to a breakdown.

What Makes LWCOs Fail

Deposits — Condensate water and new make-up water entering a boiler bring minerals and solids. As the water is converted to steam these minerals and solids stay behind in the boiler. These not only collect in the boiler itself, but also collect in the piping connecting the LWCO to the boiler. One common type of LWCO uses a float inside a chamber connected to the boiler. It functions much like the float in a toilet tank.

If deposits collect in sufficient quantities inside the LWCO or its connecting piping, two things can happen. Either the float cannot move downward properly to detect the decreasing water level. Or water gets trapped in the bowl, falsely indicating proper water level. The single most common factor causing failure in this situation is failure to maintain the LWCO properly. The float chamber and the connecting piping must be routinely purged according to manufacturer recommendations to keep them clean.

Jumpers — Sometimes jumper wires are used as a temporary means to diagnose a problem or to bypass a circuit for testing purposes. If they are inadvertently left in place, the LWCO cannot shut down the burner even if the float works properly. All operators and service technicians should be alert to jumpers. If not removed after the temporary situation, low water conditions are nearly certain.



Age — As does any piece of equipment, LWCOs age. Floats can become damaged and leak. Electrical contacts can become fused or pitted. Wiring and insulation become brittle from the heat of the boiler. Most manufacturers suggest replacement of the mechanical and electrical components periodically. If not replaced, brittle wiring or insulation can cause electrical shorts. Mechanical seals such as bellows can leak. Mechanical linkages such as the springs on the float linkage can fail.

Don't take your LWCO for granted. Although very reliable, the electrical and mechanical portions need to be replaced periodically. If your LWCO is more than 10 years old, you should ask you service technician to look carefully at the wiring and contacts during your next scheduled internal inspection.

Maintenance — Periodic replacement of the mechanical and electrical components is only part of the required maintenance to assure proper operation. Purging the float chamber and connecting lines is another. Inappropriate purging, however, can also cause damage, especially in high-pressure boilers. Purging is accomplished by slowly opening the valves in the LWCO drain line. The flow flushes out the float chamber and connecting piping. If the valves are opened too quickly, the resulting flow can cause the float to jerk downward in the float chamber. This can cause damage both to the float and the mechanical linkages. Your service technician or boiler operator should be careful to open the valve slowly on a high-pressure boiler.

Loss of Water — A low water condition cannot occur unless the water leaves the boiler and system and is not replaced. Steam leaks, faulty steam traps, and processes that require high percentage makeup water can all contribute causal factors that lead to boiler and LWCO problems. Your entire system needs proper maintenance to continue reliable operation.

Low Water, High Risk

What happens in a high-pressure steam boiler when the water level gets too low and the burner does not shut off? The answer, "It depends," may be surprising. Low water conditions can cause a range of damage.

On one end of the spectrum is a short-term condition that results in little or no visible damage. Telltale signs of metal discoloration may be all that is visible. Metallurgical hardness testing may reveal areas that have overheated. A moderate degree of damage may include the main furnace tube and firetubes in a firetube boiler. These may sag or bow slightly. In a watertube boiler, the furnace walls may bow.

At the other extreme is a catastrophic failure of a boiler under pressure. One such failure occurred several years ago in the eastern United States. A firetube scotch marine type boiler was providing steam to the process at about 125 psig. When it failed catastrophically, the laws of physics best describe how the boiler moved.

A Million Pounds of Pressure

Low water caused the furnace tube to overheat and weaken. As it sagged, or bagged as it is often called by boiler inspectors, the weld between the furnace tube and tube sheet failed. The full operating pressure of the boiler then slammed against the rear door which normally receives only the pressure of the combustion gases; a few inches of water. Based on the diameter of the door, the steam pressure (125 psig) caused a force of nearly 1 million pounds to be exerted against the door!

The door, weighing about 4,000 pounds, was torn off the boiler and hurled through an overhead door. It traveled over 300 feet in the air, reaching a height of more than 20 feet, before landing in the bed of a pickup truck, setting the truck and several nearby cars on fire because of hot refractory. The 40,000-pound boiler, as required by the laws of physics, was pushed in the opposite direction. It broke through a cement block wall, breaking the natural gas line connections as it moved.

Thankfully, there were no serious injuries in this incident. We calculated that the 4,000-pound door left the boiler at about 90 miles per hour to travel a distance of 300 feet in the air. The 40,000-pound boiler traveled initially at 30 miles per hour, although for only a short distance before it hit the wall.

What were the factors causing this dramatic incident? Nothing more than a jumper wire on the LWCO. We were not able to determine why or how the jumper wire was placed on the LWCO, but it prohibited the device from shutting off the burner when low water occurred. The results were sobering and should alert both owners and boiler operators that boilers and their safety devices, though very reliable when properly maintained and operated, should never be taken for granted.

Summary

What can be done to help prevent such incidents? Owners and operators need to understand that LWCO devices must be maintained and parts replaced according to manufacturer recommendations. These devices also need to be flushed out periodically to prevent deposits from accumulating within the LWCO. These are relatively low-cost actions that can greatly reduce and prevent property damage and personnel injuries.

About the Author

Brian W. Moore, P.E., is a Principal Engineer and boiler specialist for The Hartford Steam Boiler Inspection and Insurance Company. He earned B.S. and M.S. degrees in mechanical engineering from the Massachusetts Institute of Technology, and an M.B.A from the University of Connecticut. Moore has more than 20 years of experience in the boiler business.