

# Limit Controls for Steam and Hot Water Boilers

## *A Closer Look at Component-level Approvals that Help Ensure System Integrity*

The selection process for incorporating electronic controls into a boiler system can be daunting and can vary depending on the application. For the simplest of applications a basic safety relay may be all that is needed. For more complex applications, feature rich controllers that can assist the end user in troubleshooting the heating system are a necessity. No matter what your application, specifying and designing in a controller that meets local and federal regulations is a must. Gems Sensors & Controls, manufacturer of the industry respected Warrick Line of boiler controls, developed this article to help those within the boiler industry understand the codes that cover boiler safety controls.

The days of temperamental boiler systems have all but passed. Nation-wide adoption of safe installation practices, regular maintenance and technological advancements are edging boilers into the category of set it – forget it. This is not to say that accidents have been entirely eliminated. Accidents do still occur, but fortunately the introduction of critical operational and safety controls have significantly lowered the frequency.

According to the American Society of Mechanical Engineers (ASME), the recognized authoritative association dedicated to making a safe boiler industry safer, most problems with boilers result “from a loss of water (low water), pressure vessel explosion, over pressure and over temperature. [Among the list of] principal causes of accidents to automatically fired boilers are lack of proper controls and safety devices ... failure to test controls and safety devices.”<sup>1</sup>

Experts believe that “improved instrumentation, controls and safety devices, proper operating procedures, and a clearer understanding of

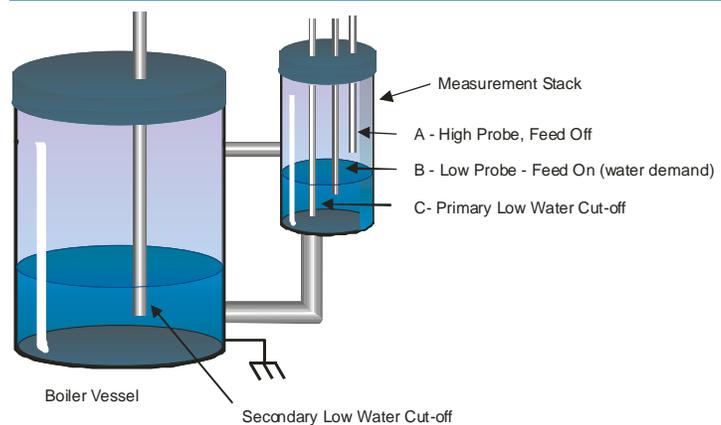
installation requirements by manufacturers, installers, and operators will greatly reduce the chances of personal injury, damage to property, and the loss of equipment from accidents.”<sup>2</sup>

Control products must be robust, have a long service life, and be reliable. With all the apparent options available how is an OEM assured that the products they specify will operate safely and reliably in their boiler applications?

## **National Recommendations – Local Regulations**

Although it is true that boiler codes vary somewhat between municipalities, as a general rule, the codes set forth by ASME are referenced or used as a basis for local regulations. Enforcement of the code occurs at the state and local levels through various administrations and/or agencies.

The typical steam boiler has at least two or more independent Low Water Fuel Cutoff circuits per CSD-1 code, and the system comprises a water feeder (water make-up) circuit responsible for replenishing water as it is converted to steam. There are both mechanical and electrical means supporting feeder circuits. Shown below is an electrical version using conductivity sensing probes.



<sup>1</sup> *Controls and Safety Devices for Automatically Fired Boilers*, The American Society of Mechanical Engineers, 29 December 2006, v.

<sup>2</sup> *Controls and Safety Devices for Automatically Fired Boilers*, The American Society of Mechanical Engineers, 29 December 2006, v.

This can be viewed a few different ways. ASME sets the rules and leaves the enforcement to the local authorities or local authorities seeking to ensure the public safety of their municipalities look to ASME for guidance.

### **The Claim: “CSD-1 Compliant”**

There are many aspects of a boiler system. The CSD-1 code was developed by ASME to specifically address controls and safety devices. More specifically controls and safety devices for automatically fired boilers using gas, oil, gas-oil, or electricity, with fuel input ratings of 12,500,000 BTU or less are subject to the code rules set forth by ASME’s standard CSD-1-2006<sup>3</sup>.

The requirement for most OEMs is to ensure that the control methodology used in their boiler applications adheres to CSD-1 guidelines. This is where an OEM needs to step carefully to avoid pitfalls.

### **CSD-1 and the link to UL 353**

ASME is a society of Mechanical Engineers. When developing test and certification criteria for electronic controllers ASME looks to an accredited nationally recognized test facility such as Underwriters Laboratories® (UL) for help. “UL is an independent product safety certification organization that has been testing products and writing standards for safety for more than a century. UL evaluates more than 19,000 types of products, components, materials and systems.”<sup>4</sup> If your company sells Wallbox dimmers, they are probably tested to UL 1472 Solid-State Dimming Controls, and carry a UL Recognized logo.

The ASME CSD-1 code states that “each low water fuel cut-off or combined feeder/cut-off device shall conform to UL 353, Standard for Limit Controls, and shall be accepted by a nationally recognized test agency.”<sup>5</sup>

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<sup>3</sup> Certain exclusions and acceptance to other listings apply; consult ASME CSD-1-2006 for details.

<sup>4</sup> “About UL”;

<http://www.ul.com/global/eng/pages/corporate/aboutul/> accessed 06/01/09

<sup>5</sup> *Controls and Safety Devices for Automatically Fired Boilers*, The American Society of Mechanical Engineers, 29 December 2006, 12.

### **Caution, UL 353 Covers more than Just Boilers!**

The controls covered by the UL 353 standard are intended to safeguard a wide variety of heating appliances, heating systems, processing systems and air conditioning and ventilation systems. UL Standard for Safety for Limit Controls, UL 353, is a publication by Underwriters Laboratories that sets forth “requirements covering limit controls, furnace fan controls, and other interlocks responding to changes in liquid level, pressure, or temperature.”<sup>6</sup> A high level explanation of the various devices covered within UL 353 can be found in the UL quick guide titled: MBPR.GuideInfo. Eight different product groups are defined (A-H) for UL Listed controls.

MBPR Guide Groups G and H address water level controls for use in boilers. Specifically, Group G covers “controls operated by a change in water level for boilers to prevent operation of the heating appliance in the event of a low water in the boiler.”<sup>7</sup> This is the low water fuel cut-off function. Group H addresses “controls operated by changes in liquid level to regulate the delivery of feed water to boilers.”<sup>8</sup>

Controllers designed to be integrated within a larger system requiring G or H listing, having passed UL 353 requirements, are filed under UL Guide MBPR2.

Limit controls designed as stand alone systems, having passed UL 353 requirements, are filed and listed under UL Guide MBPR with group classifications (A-H) clearly stating the intent and application of the device.

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<sup>6</sup> *Standard for Limit Control UL 353, Fifth Edition*, Underwriters Laboratories Inc., 23 September 1994, 5.

<sup>7</sup> “MBPR.GuideInfo Controls, Limit”;  
[http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=MBPR.GuideInfo&ccnshorttitle=Controls,+Limit&objid=1074236412&cfgid=1073741824&version=versionless&parent\\_id=1073989832&sequence=1](http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=MBPR.GuideInfo&ccnshorttitle=Controls,+Limit&objid=1074236412&cfgid=1073741824&version=versionless&parent_id=1073989832&sequence=1) accessed 06/01/09

<sup>8</sup> “MBPR.GuideInfo Controls, Limit”;  
[http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=MBPR.GuideInfo&ccnshorttitle=Controls,+Limit&objid=1074236412&cfgid=1073741824&version=versionless&parent\\_id=1073989832&sequence=1](http://database.ul.com/cgi-bin/XYV/template/LISEXT/1FRAME/showpage.html?name=MBPR.GuideInfo&ccnshorttitle=Controls,+Limit&objid=1074236412&cfgid=1073741824&version=versionless&parent_id=1073989832&sequence=1) accessed 06/01/09

Controls certified to the appropriate sections of the UL 353 standard ensure compliance to CSD-1 and ultimately safe operation of the boiler. Limit controls subject to CSD-1 must have UL 353 approval and bear the proper UL Listing or UL Recognized logo acknowledging such.

## **I Found a Device Listed in UL 353, but what's the M1 & M2 all about?**

Local building codes vary making multiple reset alternatives a necessity. Within UL 353 a suffix M1 or M2 is added to a group designation that defines the type of reset the Low Water Fuel Cut-off control comes with. If no suffix is added the controller is understood to come equipped with an automatic reset.

M1 refers to a Manual Reset control that automatically resets to the "closed" position after safe conditions have been restored and the reset means is held in the "reset" position. In this situation the maintenance professional can hold the reset means while the boiler is refilling. The boiler controls will allow the boiler to restart as soon as all the safe operating conditions were satisfied, at which point the reset can be released.

Conversely M2 refers to controls that do not automatically reset to the "closed" position if the reset means is held in the "reset" position. In this case the maintenance professional will have to establish all the safe operating conditions before they reset the device.

Automatic reset is exactly as it sounds. The controller will automatically reset itself once safe operating conditions are restored. Involvement by a professional is not necessary prior to the burner firing back up.

In all of these cases, "closed", refers to a set of closed contacts on the control that indicate the presence of liquid. The identification of the equipment and its primary function as indicated by the MBPR Groups serve as a guide for specifying or ordering devices. One can view listings on the UL site for such devices by doing a search for MBPR and viewing the resulting listings.

## **Keeping the Application in Mind**

Why all this emphasis on UL 353? Every UL standard is established with the final application in mind. Electronic controls that are

covered under UL 353 and relied upon to perform a safety function are subjected to a circuit analysis known as the Failure Mode and Effects Analysis (FMEA). The FMEA is used to link potential failure modes of individual components, circuits or assemblies to the effects on the application. A comparative example can highlight its importance.

UL1563 covers controls that are used in hot tubs, swimming pools and spas. These controls may be provided with a circulating pump option that is designed to circulate the water within a spa. A malfunction of a component within this control could result in the failure to circulate the water, ultimately leading to a dissatisfied customer. This same controller could be misapplied and used as a low water cut-off device, covered by UL 353. The ultimate effect of the same component failing may in fact be a boiler explosion. Differing potential effects warrant that differing degrees of safeguards be built in.

## **What it Takes to get a Controller to Meet the UL 353 Standard**

The UL 353 standard defines such critical elements such as operating voltage, current, materials, enclosure, Electromagnetic Compatibility (EMC) and testing to specific environmental conditions. In short, this requires an electronic assembly; particularly, the safety critical circuit to be evaluated for component faults (ie, opens, shorts, indeterminate states) A single point failure must not result in failure of the operation of the control in a low water condition. This requirement may necessitate redundancy; duplicate parts on the electronics board to ensure that a single component failure will not cause undo operation.

Further specified in UL 353 is the requirement to meet UL 1998, "Software in Programmable Components" should the device use firmware or embedded software. This process is particularly demanding as it requires that a formal development process and quality system be in place specifically to address faults in the software or in the process used to develop and maintain the software. UL 1998 defines specific hardware/firmware topologies and provides measures to address microelectronic hardware failure modes. Evidence must be presented that the firmware has been thoroughly tested and independently evaluated for proper coding.

The UL 353 for Limit Controls, and the UL 1998 specified within for microprocessor based controls, are comprehensive standards that ensure Limit Controls go through a full set of reviews and tests and are free from reasonably foreseeable risks of fire, electric shock and related hazards. Not only is it in the best interest of product safety and integrity to ensure compliance to UL 353; it is code by most state or local jurisdictions.

### What to Look for on the Box

When searching for an approved product for limit controls for boilers, it is important to ensure the control complies with the UL 353 standard as this specifically addresses limit controls for boilers.

The device should be either UL Listed or UL Recognized and carry the appropriate logo. The UL Listed logo is the UL letters contained within a circle outline. The UL Listing mark is normally composed of four elements: the "UL in a circle Mark, the word "LISTED in capital letters, an alpha-numeric control number, and the product name, (e.g., "toaster and "portable lamp). See figure 2 for examples of Listed and Recognized Marks.



Figure 2. Examples of some UL Listed Marks and UL Recognized Marks. Shown left to right: UL Listed (US), UL Listed (US and Canada), UL Recognized (US), UL Recognized (US and Canada). Absent for the Listing Marks are the alphanumeric control number, and the product name.

The difference between Listed and Recognized is relatively simple. A component that requires integration into a larger system, or requires the addition of other components to operate, or is incomplete in its construction gets a Recognized mark. A complete system that can be sold to an end-user gets a UL Listed Mark. For example, a Boiler would be UL Listed as it is a complete system used by the end-user. The control that monitors the water level in the boiler could be a UL Recognized component, that is, it is a component of a larger system. It should be prefaced that a system using entirely UL Recognized components does not mean the system is UL Listed. The entire system requires UL evaluation for a Listing Mark. In this example, boiler systems, equipment assemblies and associated equipment, would apply for the Listing.

- Phil Draper  
*Director of Engineering  
 Gems Sensors & Controls*

## Warrick Low Water Fuel Cut-off Solutions

Gems Sensors & Controls manufactures 2 controls that serve as Limit Control components in the typical boiler application. The Warrick Series 26 control is a single level conductivity sensor designed for Low Water Fuel Cutoff applications. The Warrick DF product combines a single level conductivity sensor with a differential-level sensor circuit. The Warrick DF product can serve both a Low Water Fuel Cutoff and a Feeder function all in one solution. Products are available in UL-353 listed and recognized versions.

