# Boiler and Turbine Protection (T.W.I.P.) Systems

## 1.1 Introduction

Boiler damage is very costly, both in money and time. Boiler protection systems are available to prevent unnecessary downtime and provide considerable cost savings. This technical note provides an overview of the **Delta Mobrey** steam/water gauging and boiler and turbine protection systems that are available.

### Contents

Overview . . . . . page 2
Electronic water detection systems protect boiler drums and turbines . . . . . page 3
An example of a protection application . . . . . page 5

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# 1.2 Overview

When the boiler on a power plant runs dry, or the turbine blades are damaged by water induction, the outcome is both dramatic and highly expensive. Repairing this damage to a power plant can take months, if not years, to complete. The plant downtime results in lost production and costs a huge amount of money. The following sections provide an insight into critical protection systems that monitor boiler levels and detect water in steam lines to prevent such eventualities.

## 1.2.1 Steam drum level

Modern boilers used in power generation are designed to provide clean dry steam. On top of the boiler, sits a vessel known as a steam drum ("drum"). It is here that the steam/water level is monitored. Wet steam is generated if the water level is too high, which may in turn lead to turbine blade erosion. Conversely, there is very real danger of a plant explosion if boiler tubes overheat when the water level is too low. This may sound very dramatic, but it highlights the real need for safety devices in this type of application.

National legislation specifies the mandatory need for monitoring and indication of feed water levels in steam generation plants. Drum level indication is typically indicated both locally, at the steam drum, and remotely in the control room. Very reliable monitoring of these points needs to take place to provide alarms and system shut down on dangerous water level conditions, and also to avoid false alarms and trips that could force a plant to shutdown, resulting in a potential significant loss of revenue.

## 1.2.2 Turbine damage

Water induction into steam turbines may have catastrophic consequences and it is essential that automatic protection devices are installed to prevent this occurring. Even a small amount of water can cause enormous damage to the turbine blades, the cylinders, and the housing.

There is very little chance of an operator assessing a deteriorating situation quickly enough to judge whether or not water, water droplets, or flash steam are present in steam lines. This is complicated by the fact that a manually initiated shutdown of the turbine may further aggravate the situation, as the decay of pressure in the turbine stages to vacuum can potentially cause reverse flow.

## 1.2.3 Causes of water induction

Water can also reach the turbine from various feedwater plant sources and under a number of operating conditions. For example, it can occur when the water level is too high in the high or low pressure feedheater, caused by tube leaks or the failure of the drainage system. A high water level in the de-aerator is another potential source. If there is a mismatch between the inflow and outflow the vessel can flood. In each of these cases, the water may flow via the bled steam lines and against the steam flow towards the turbine.

Un-drained bled steam lines are yet another source. Wet steam can deposit water on the pipework walls, and condensation can occur at bends in the pipework and at valves. Condensation is also a problem during start-up when the steam lines are being warmed.

If a unit trip occurs or there is a sudden load reduction, this can result in a pressure reversal. During a trip, the high pressure (HP) turbine pressure decays rapidly and the intermediate/low pressure (IP/LP) falls to condenser vacuum almost immediately. In contrast, the pressures in the

feed system change relatively slowly. Large pressure differentials are created, which will tend to stimulate flow towards the turbine from the feed system.

Reverse steam flow in the bled steam lines can potentially carry water from heaters or un-drained low points to the turbine with consequential damage. Water induction is not only a problem when the turbine is at operating speed; water flowing onto hot cylinders can cause severe chilling with distortion or cracking of the cylinders.

# 1.3 Electronic water detection systems protect boiler drums and turbines

## 1.3.1 Traditional approach to level gauging and protection

Traditionally, sight glasses (water gauges) were fitted to the boiler drum. However, these devices can suffer from reliability issues, requiring intensive maintenance programmes. The drum is normally well away from the control room, and this means a secondary form of surveillance equipment is needed to report the level back to the engineering team. For these devices to be used effectively, they must be monitored 24 hours a day, 7 days a week.

Mechanical/optical methods are regularly used for measuring levels within vessels, but the drawback with such devices is they are susceptible to wear and therefore also need regular checking and maintenance. This increases maintenance costs and, with a 24/7 operation, downtime for maintenance is not always possible, leading to insufficient checks and subsequent reliability issues. Sight glasses are still in use today, but this would only be as the final verification method of drum level if all other methods are unavailable.

## 1.3.2 Electronic gauging systems

The power industry demanded a reliable dual-redundant technology with remote transmission instead of the traditional sight glasses. A customer-led development saw the birth of electronic steam/water gauging systems. Delta Mobrey, at the forefront of this technology field, has the highly regarded Hydrastep 2468 and Hydratect 2462 systems, seen by many as the industry standard.

### Hydrastep 2468 Electronic Steam/Water Gauging System

The Hydrastep system is used worldwide to monitor water levels within boilers.

A Hydrastep system consists of a series of electrodes installed within a water column that is attached to the steam drum (Figure 1-1 on page 4). The electrodes act as the “seeing eye” above and below the normal water level. Electrodes are arranged on each side of the column and connected to an electronics unit by separate specialist cables. This arrangement provides redundancy against failure in any part of the system.

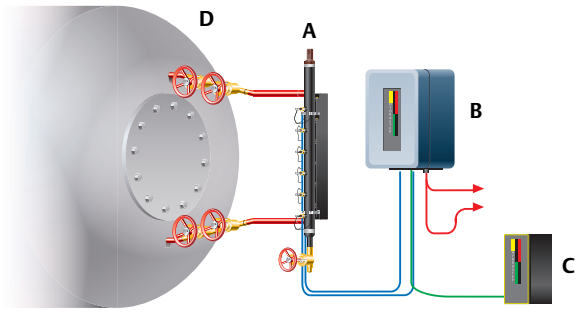
The principal of measurement is fairly simple. The electronics is constantly looking for a change in resistance with respect to ground. A step change in resistivity between two adjacent electrodes identifies the water level.

An important feature for the end user is to be able to set alarms and trips to aid their operations teams and trip the system on dangerous water levels. Alarm relay outputs deliver high and low level alarm indications or trips. Local and remote displays provide operators with high visibility of boiler levels. Should a fault occur within the system or its associated wiring or power supply, a fault is indicated but the system remains active. This fault-tolerant design allows continued

operation and reduces the need for routine testing. Fault conditions are also shown on the displays so that remedial action can be undertaken.

The reliability of these systems can be dependent upon the quality of the water in the system. Whilst this is usually clean the presence of dirty water can foul the electrodes. However, in more sophisticated systems this will not cause a fault or a trip.

**Figure 1-1. Hydrastep 2468 Electronic Gauging System Installation**




A. Hydrastep 2468 water column and electrodes
B. Local Hydrastep 2468 control unit
C. Remote Hydrastep 2468 control unit
D. Boiler drum in plant

## Hydratect 2462 Steam/Water Detection System

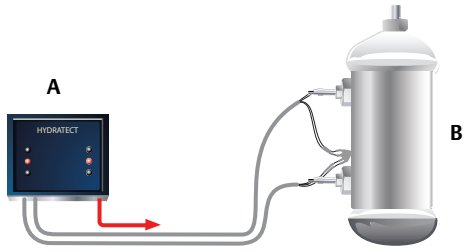
The different resistive properties of steam and water may also be exploited in turbine water induction prevention (T.W.I.P.) systems. By installing electrodes in steam lines and measuring the resistance, the unwanted presence of water can be detected allowing the appropriate safety measures to be taken.

An electronic steam/water detection system, such as Delta Mobrey's Hydratect, provides high levels of reliability for detection of water or steam in lines. Each electrode is specified as being either normally in steam or normally in water. An alarm/trip output is signalled whenever an electrode detects a 'not normal' condition. 'Steam normal' is used for high water level detection in steam drums, feedheaters and in turbine water induction prevention systems on steam lines.
'Water normal' is used for low water level detection.

Hydratect has two independent channels which may be used separately, or for validation. Reliability is designed in with critical components being triplicated for redundancy.

Electrodes, installed on the drain pot in the super-heated steam line, detect the level of condensed water and operate a drain valve, protecting the turbine.

**Figure 1-2. Hydratect 2462 Steam/Water Detection System Installation**




A. Hydratect 2462 control unit
B. Drain pot in plant with Hydratect electrodes

### Reliability of electronic gauging systems

For applications requiring the detection of either steam or water, resistivity measurement is a proven technique. Using an electronic method to indicate water level, or differentiate between the presence of steam or water, offers a very high level of system self-checking and integrity compared to mechanical methods. There are no moving parts, and this greatly reduces the requirement for routine maintenance.

Protection is critical to plant safety, but false trips are also a major issue. The electronic system must not just be completely reliable when it comes to detection and prevention of water in turbines, they must also prevent nuisance trips that reduce plant efficiency and throughput. An independent report by Factory Mutual Research concluded that the probability of Emerson's Hydrastep system missing a trip condition is less than 1 in 300 million, and that nuisance trips will be less than 1 in 10 million.

## 1.4 An example of a protection application

Delta Mobrey's Hydrastep continues to be installed around the world. The Matla power station in the province of Mpumalanga, South Africa wanted to replace its existing boiler monitoring systems, which had become unreliable and obsolescence had made it difficult to source spare parts and technical support. Previous deployment of Hydrastep at other facilities meant that plant operator was familiar with the Delta Mobrey system and aware that it was the ideal solution for steam drum level measurement.

The 3600 MW coal-fired power plant, consisting of six 600 MW units, is currently undergoing refurbishment and upgrade of its control systems and instrumentation. The aim is to improve reliability and efficiency of the plant as part of a capacity expansion programme.

Replacing the aging existing systems, Hydrastep will monitor and report on water levels within boilers providing the required continuous protection of the boilers. The new system will increase reliability and reduce the required levels of maintenance. An additional benefit is that the upgraded products will provide space savings within the control room. Systems have been installed on two units to date, with work on a third now in progress.

Delta Mobrey's Hydrastep systems were selected because they provide an ideal fit and forget solution, combining optimum safety indication with virtually no risk of false alarms that reduce plant availability.

Delta MobreyHydratect water/steam detection systems are also being deployed to monitor steam and water within steam lines at the power plant. These will replace the existing systems, which again had become unreliable and obsolete. The detection systems will work with the water gauging system to provide a complete water induction protection system.

**Delta Mobrey Limited**
Riverside Business Park, Dogflud Way
Farnham, Surrey, GU9 7SS, UK

+44(0)1252 729 140
+44(0)1252 729 168
sales@delta-mobrey.com

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