Surefire

Boiler Manager Technical Report

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Process Description

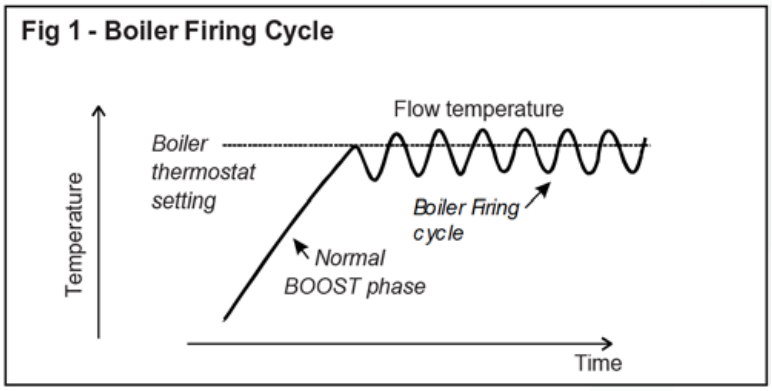
The Boiler Manager works by controlling the boiler firing cycle.

What is the Boiler Firing cycle?

When the central heating system is started from cold then whilst the system is warming up the boiler is firing continuously. During this period the full heating capacity of the system is required. This is the “Boost Phase”.

Figure 1 shows the Boiler Firing Cycle for a normal system without the Boiler Manager in control. Once the system has reached the boiler thermostat setting then it begins to cycle.

Fig 1 - Boiler Firing Cycle



What does the Boiler thermostat do?

The boiler thermostat determines the temperature of water flowing from the boiler. Once the setting is achieved the boiler enters the firing cycle. This cycle is of short duration typically less than 5 minutes. Most boiler thermostats are mechanical devices closing the gas valve when vapour in a bulb expands pushing a piston in cylinder against a spring. Different settings are achieved by adjusting the spring pressure. Their most important purpose in as a safety feature. That is to say the maximum setting of about 85ºC prevents overheating. The control at the lower end of the adjustment is not precisely calibrated.

Why do we measure the return temperature?

The temperature of the water returning to the boiler indicates the heating demand of the system. Typically a central heating system is designed to cater for the coldest of days. Water is heated by the boiler to the flow temperature and returns at a lower temperature after transferring heat via the room heaters or radiators.

In a typical system, the boiler is designed to operate efficiently at a difference of 11ºC between flow and return temperatures.

Figure 2 shows data recorded on an actual installation. On this particular day there was not much heating demand. After just 5 minutes of operation the water was returning at 10.5ºC

What is Cycle Saving?

It is not efficient to cycle the boiler quickly. Larger boilers are fitted with Cycle Saving controllers. This is a method of extending the boiler duty cycle over a longer time period. Because this results in better boiler efficiency the proportion of ON time to OFF time is less.

Introducing the Boiler Manager

The Boiler Manager extends all the benefit of Cycle Saving to domestic systems in a low cost instrument.

The Boiler Manager is powered via the boiler timer (if fitted).

The software in the microprocessor adapts to the actual operating cycle of the boiler and modifies the firing cycle to optimise the energy efficiency of the system.

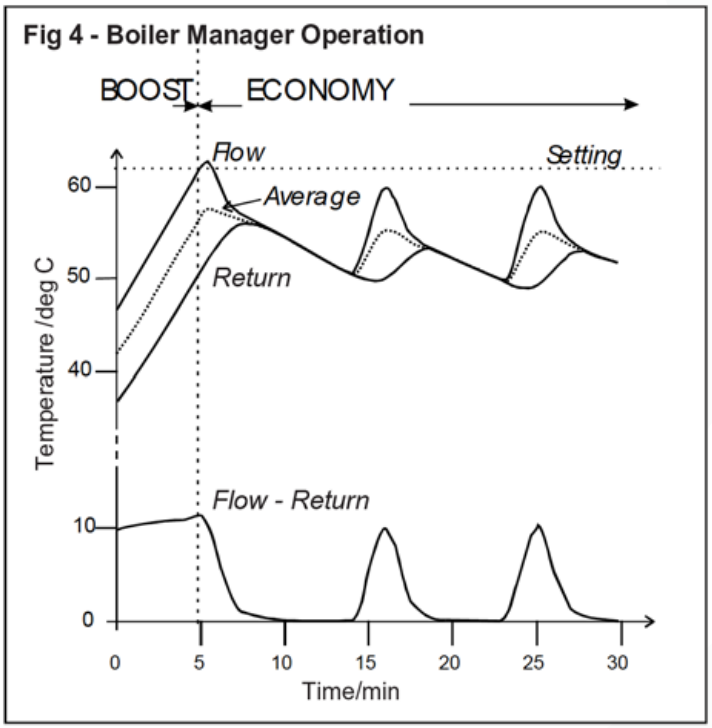


Figure 4 illustrates how the Boiler Manager changes the boiler firing cycle. Notice how each time the boiler fires the Flow-Return temperature difference rises to 10ºC not far short of the initial value on cold-start.

The central heating system continues to warm the house whilst the radiators are slowly cooling down. After a delay the boiler fires again warming circulating flow water . In Economy mode the Boiler Manager achieves an energy saving by reducing the Flow temperature setting. A further energy saving is achieved by delaying the firing cycle. Once the Economy/Firing cycle is established it delays the firing sequence by a variable amount.

Boost Mode

From cold the Boiler Manager starts in BOOST mode. In this mode the Setting is used to operate a simple threshold on the Flow temperature with a 3ºC hysteresis but no additional delays.

When the Flow temperature reaches the Boiler Manager setting the unit starts to measure the firing ratio (duty cycle). On cold-start the unit stays in the BOOST cycle for up to 15 minutes or until the Return temperature is within 8ºC of the Flow temperature when the upper threshold is reached.

How does the Boiler Manager avoid loss of comfort?

On cold start or whenever it senses a peak demand such as after running a bath, then the Boiler Manager will sense that the temperature of the water returning to the boiler is too cold and it reverts to Boost mode.

At any time during the Economy/Firing cycle, if the RETURN temperature falls to more than 12ºC below the Flow temperature, then the unit will return to BOOST mode for a further 5 minutes. This is a very important feature which prevents a loss of performance at the expense of economy.

Boiler Manager - Economy Cycle

Figure 5 illustrates in detail the 2 ways that the Boiler Manager achieves an energy saving.

- It reduces the Flow temperature setting
- It extends the boiler cycle

If we compare the firing cycle with and without the Boiler Manager *(see Figure 6)* then the cost savings are obvious. Not only is the boiler firing less frequently but the proportion of the time that the boiler is firing in each cycle (Duty Cycle) is much less. If you burn less gas then you save money.

Fig 5 - Boiler Manager Economy Cycle

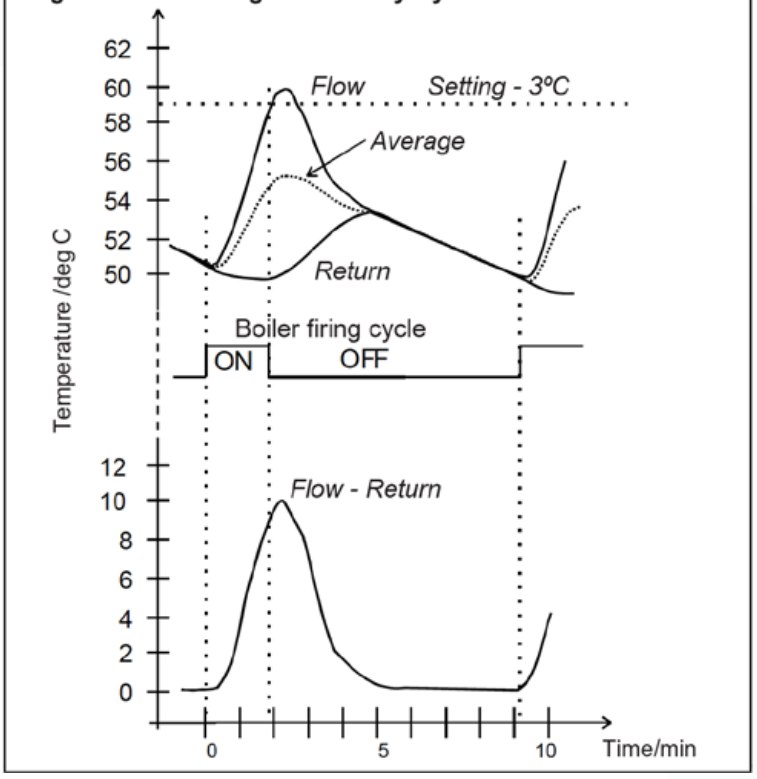
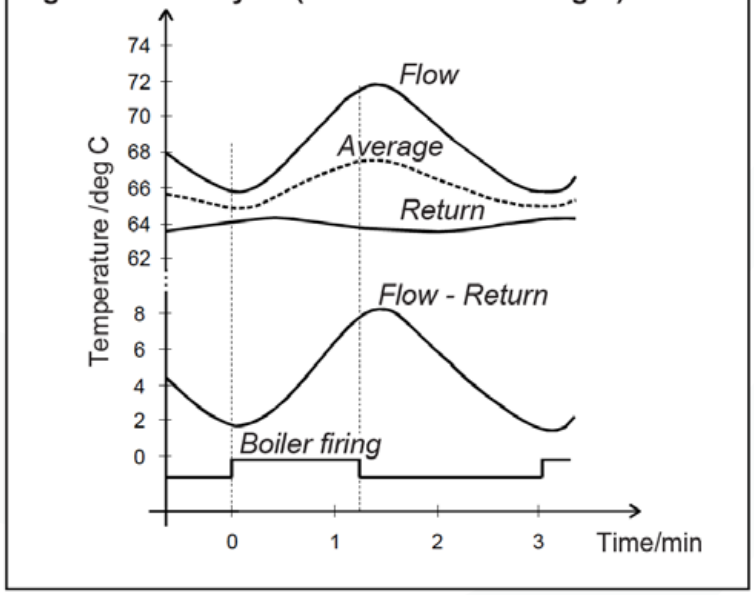
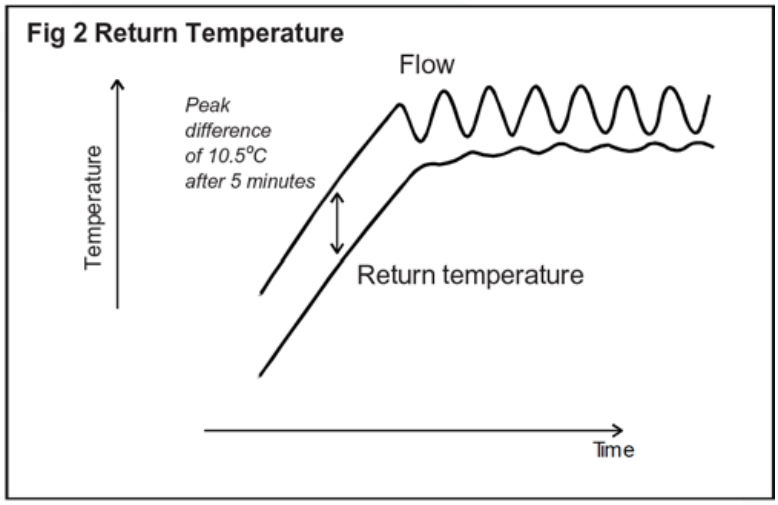


Fig 6 - Normal Cycle (without Boiler Manager)



In the normal cycle the mean water temperature is about 66ºC. The boiler is dry cycling. The radiators feel very hot all the time but a lot of that heat is returned to the boiler and vanishes up the flue. *This is comfort at a cost*.

lower than the flow temperature. Then after the initial heating or "Boost" phase the return temperature is almost steady.



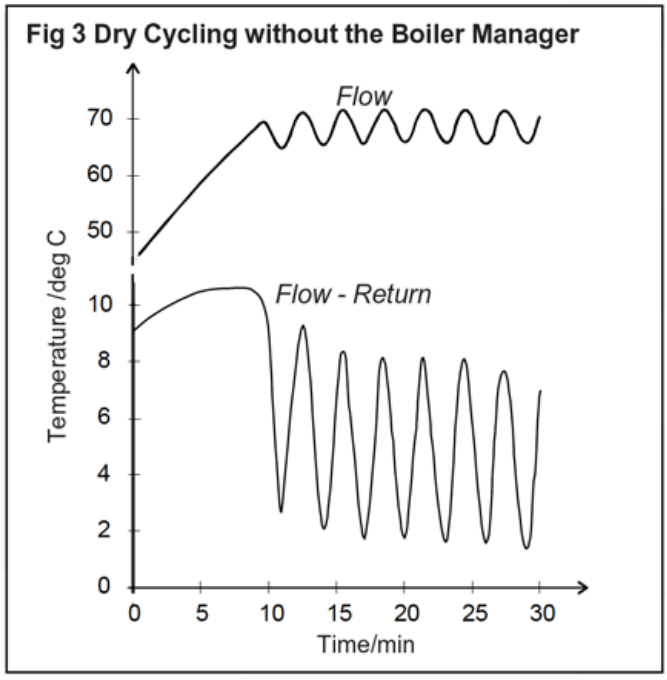
What happens is that the thermal capacity of the room heaters or radiators, the circulating water and the pipes all tend to store heat and even out the fluctuation in flow temperature caused by the boiler cycling.

Nevertheless there is still a heating requirement and the room heaters continue to pump out heat. The problem is that the boiler has a fixed heat output. It is either firing or not firing. Not all of this heat output can be usefully recovered. The heat exchanger in the boiler will only work efficiently if water is returning appreciably cooler than the flow temperature.

Without the boiler manager the boiler regulates its heat output by cycling. Because the heat exchanger is operating inefficiently waste heat is lost up the boiler flue.

Dry Cycling

The inefficiency of a typical central heating system is illustrated in *Figure 3*. Now we plot the difference between flow and return temperatures.



The following chart has been plotted from actual Flow and Return temperatures. After a warming period which on this day lasted about 10 minutes. The boiler began cycling with a period of about 3 minutes.

On this particular day the difference was about 8ºC on the first cycle and steadily declines on each successive cycle. This is a measure of the useful heat recovered via the boiler heat exchanger. This inefficient rapid cycling of the boiler is termed Dry Cycling.

These temperature readings were recorded by a Boiler Manager running data-logging software. *(See Data Logging for a description of this special add-on feature used during development.)*

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With the Boiler Manager economy cycle the mean water temperature is cooler at about 53º C, varying between a maximum of 55º C and a minimum of 50º C. So the radiators are still hot. This may actually be more comfortable than 66º C once a steady room temperature is reached. It depends how cold you feel. Which is very subjective.

The economy cycle falls into 5 distinct phases as follows.

1. Boiler ON. Flow temperature rises to Boiler Manager *Setting* - 3ºC. The unit displays the message “FIRING”.

2. Boiler OFF. The Boiler Manager relay opens and the boiler stops firing. The unit displays the message “ECONOMY”. The boiler heat exchanger is still hot and water continues to heat beyond the set-point.

3. In the first part of the cooling curve the flow temperature falls rapidly as the heat exchanger is cooled.

4. The flow temperature falls past *Setting - 6ºC*. The Boiler Manager starts its cycle delay timer. In the first full Economy/Firing cycle this is a 5 minute delay. Thereafter the delay period adapts trying to optimise efficiency.

5. The Boiler fires again. The heat exchanger may take several seconds to begin heating the flow water. The Economy/firing cycle continues.

The Firing Delay is adjusted to optimise the firing ratio. If this delay causes the firing time ratios to increase above those experienced without a delay, then the 5 minutes will be reduced on the next cycle by a factor determined by the increase. If the 5 minute delay causes a decrease in firing time ratios then it will indicate a reduction in the demand on the boiler. Therefore the delay will be increased on the next and subsequent cycles in order to balance the firing time accurately to the system demand.

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