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# SUMMARY REPORT ON THE HYDROPATH WATER CONDITIONING DEVICE

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**EXTRACTS FROM** SUMMARY REPORT ON THE HYDROPATH WATER CONDITIONER DEVICE

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## SUMMARY

There has been an increase in the distinct problem related to scale blockage of heat exchangers on some gas fired instantaneous water heaters and combination boilers. This is primarily due to more combination boilers being installed.

Customer Services Division (HQ) therefore requested WHRS to evaluate a selection of water conditioning and automatic chemical dosing devices, in order to establish their effectiveness in protecting appliances from scaling and identify the potential benefits to British Gas resulting from reduced service and maintenance.

This report is a summary of the evaluation and performance of the Hydropath HP 18 water conditioning device.

If adopted in only the most severe cases of scaling problems ie (normally 1%) of boilers, the potential **savings in servicing to BG should be not less than £72.5m in the first 5 years.**

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# SUMMARY REPORT ON THE HYDROPATH

# WATER CONDITIONING DEVICE

## INTRODUCTION

Hard water scaling progressively reduces the efficiency of water heating appliances and ultimately results in over heating and corrosion failure of heat exchangers.

At the request of Customer Services (HQ, Holborn), WHRS has evaluated a selection of water conditioning and automatic chemical dosing devices, in order to establish how effectively they protect appliances from scaling. An evaluation of economic benefits resulting from reduced service and maintenance was also requested. Water conditioning devices do not change the composition or quality of water. It is claimed that they interfere with the nucleation and morphology of calcium carbonate scale, which in turn prevents hard water scaling of heat exchangers.

This report summarizes the evaluation and performance of one of the devices, the Hydropath HP18. This electromagnetic device, has some unique operating features which involves continuous operation at high temperature and unlike all other devices tested to date, works at all flow rates of water. Other devices are subject to flow rate and variation in magnetic gap. The HP18 showed significantly superior performance to the other devices tested.

**BACKGROUND TO HARD WATER SCALING OF EXCHANGERS**

It is estimated that scaling of heat exchangers costs industry in the UK over £2 billion a year. Water hardness is derived from calcium carbonate, calcium Sulphate, calcium Phosphate, magnesium hydroxide and silicates dissolved in the water as hardness salts. Calcite, the commonest form of calcium carbonate in hard water scale, deposits out of solution, when water is heated, to form a hard scale on pipes and heat exchanger surfaces. This deposit Progressively reduces the efficiency of water heating appliances and ultimately results in overheating and possibly corrosion failure of heat exchanger tubes. Depending upon the amount of calcium carbonate present in water, the problem of scale formation can be exacerbated. Hardness salts have an inverse solubility in water, ie, as the water temperatures increases, these salts becoming insoluble and precipitate out of solution. The amount deposited out, increases with the rise in temperature of the water. For example, a water with a 145ppm of Calcite flowing at 5000 litres per day can produce 4.8 Kg of scale each year at a water temperature of $60^0$C, but at $80^0$c it produces 29.9 Kg. This has implications for service and maintenance of water heating appliances, ie, instantaneous water heaters. These can be subject to rapid scale formation, particularly in high water hardness areas in the UK (> 300ppm hardness).

There are several methods used to help the prevention of scaling in heat exchangers. Water softening and chemical treatment are both expensive and labour intensive. Water conditioning using magnetic and electronic devices has been around for some 50 - 60 years without success, because of the dearth of scientific evidence to establish their effectiveness to prevent scale. Within the last five years, there has been a resurgence in the claims for new designs. Such claims include better performance than their predecessors; their numbers and variety have proliferated in the domestic scene. As part of a general environmental drive, research in many countries has increased in recent years and there have been well-designed experiments, which have provided positive results, with basic benefits and explanations of mechanisms for preventing scale.

More recently there has been an increase in district problems experienced on some gas fired instantaneous water heaters and combination boilers.
Customer Services Division (HQ) therefore requested WHRS to evaluate a selection of water conditioning and automatic chemical dosing devices in order to establish their effectiveness in protecting appliances from scaling and identify the potential benefits to British Gas from reduced service and maintenance.

METHOD OF EVALUATION OF WATER CONDITIONING DEVICES

A number of magnetic and electromagnetic water conditioning devices have been tested on the WHRS test rig in a hard water area (>300ppm hardness). A series of identical instantaneous water heaters were operated in parallel circuits.

The test regime was designed to be representative of real but severe domestic use of water heaters and the appliance was chosen to provide controlled water flow rates, heat flux and heat exchanger geometry, to test the Propensity for this new generation of improved (design and field strength) water conditioning devices, small diameter finned tube heat exchangers with high heat flux provided a stringent test for these devices.

Although all the devices had some Physiochemical effect on calcium carbonate in the water, none of the physical permanent magnetic devices were significantly effective in Preventing the water from scaling. Most devices appeared to Partially restrict the formation of hard calcite at the expense of aragonite, which is a less dense form of scaling but which still adheres to tube walls at temperatures in excess of $55^{0}$C.
The electrolytic, electromagnetic and electrosonic devices were only able to increase the time to failure by approximately 50%.
The chemical automatic dosing devices (Fernox Limited "Quantomat" and the Cistermiser Limited "Combimate") prevented blockage throughout the duration of the test. These are polyphosphate dosing devices which have proved themselves on district.

It is considered that the ideal device for reducing or eliminating hard water scaling problems should be continuously effective, cheap and simple in operation, need no constant

attention from the user and have long periods of operation without the necessity for servicing.
The Hydropath electromagnetic water-conditioning device came close to this ideal on our test rig and it surpasses the Performance of all the other non-dosing devices by a large margin and would warrant full scale field testing on district, which has now been initiated by Customer Services, HQ, Holborn. To date, no failures on district have been reported and the units are working satisfactorily on new and Previously scaled gas fired appliances.

Performance

It is clear that the Hydropath has provided a level of performance under the severe test regime, almost three times better than the best of the other water conditioning devices. This is the first non-chemical water conditioning device, of the type required by British Gas, to show potential for reducing the scale formation, and to offer economic benefits from reduced service and maintenance on gas fired water heaters and boilers.

Technology

The Hydropath unit is unique in the way in which the electromagnetic field is applied to the water and the way the device varies the strength of the field according to flow rate, monitored by the sensor in the transducer unit. These two factors are critical to the propensity for this device to work efficiently to prevent scale deposition at low and high temperature under varied heat flux conditions. These factors set it apart from other electromagnetic devices.

A skin effect is generated in any AC coaxial high frequency conductor, ie, current flow is more intense at the center than at the surface of the conductor. The loss at high frequencies in coaxial conductors is due to the skin effect, which forces current in the central core to flow near to its surface which increases the resistance of the conductor. In the case of the copper pipe with water as the coaxial system, all the electrons (current) travel at the pipe/water interface. Therefore, there will be current carried by the pipe and

current in the water. All the electrons (current) in the water would be flowing at the skin interface while electrons (current) on the pipe will flow in the copper pipe. A protective shield is established to force nucleation of calcium carbonate both in the centre and at the interface.

In the electromagnetic field the lines of force are most intense in the centre of the conductor. In any system there is a growth and decay of the field and the velocity of this process is increased as the frequency goes up. A back emf is set up, which increase the resistance of the centre conductor (water) which pushes the current to the surface of the conductor (the pipe/water interface). The power supplied for the process of interaction with charged species in the water is controlled via the flow sensor in the transducer unit.

Crystal growth is preceded by nucleation, although the actual mechanism is still uncertain. Any species of material (salts, etc) in the water will tend to concentrate close to the pipe water interface, particularly charged species and these interact with and will be influenced by the magnetic field. They will be held and repelled by the field at the interface and away from the pipe wall. Free electrons generated at the interface will interact to assist in nucleation of charged species, while hetero—nuclei (organic matter, rust particles, corrosion products) will also play a part in seeding embryonic nuclei.

## Morphology and Crystals

Clusters of charged species of these nuclei are repelled from the interface force field to form crystals (microns in size) and move downstream.

Because there is an AC field these charged species are held and released alternatively, in an intense field from the centre to the interface. The co-operation of hetero-nuclei and thermal vibration from heating the water may also dictate the final embryonic nuclei and morphology of the crystals, which form a fine suspension and finally coagulate to form larger crystals in a turbulent environment of flow of water and convection from heating the water.

The Hydropath operates continuously and is not dependent upon flow although it does sense it, and by its AC pulsed field it holds and releases nuclei continuously throughout the system. Because it is a coaxial system the current flow is along the entire length of the pipework system, but diminishing somewhat down stream, at bends particularly. It therefore covers the whole circuit. Current flow, on the copper pipe in the low power, AC, high frequency device is unlikely to cause corrosion.

Effect of Temperature

The Hydropath HP18 can operate at high temperature (95 100°C). This is because of the continued conductivity at the pipe water interface in a coaxial circuit. Both copper pipe and water have a positive coefficient of resistance and there is no diminution in the activity of the device on scale reduction at higher temperatures.

Comparison with other Water Conditioning Devices

None of the other electromagnetic devices on the market have the unique facilities of the Hydropath, since the other units only effect the water hardness salts in the vicinity of the device within the force field delivered. Similarly other permanent magnet devices influence scale reduction in the vicinity of the force field and only under set flow conditions and annular gap restrictions according to design. The Hydropath HP18 works continuously throughout the system and is flow independent, while the other devices are flow dependent.

It is important to note the mode of operation of ordinary magnetic devices and that hardness salts have an inverse solubility in water, ie, as temperature is increased calcite and aragonite (crystalline forms of calcium carbonate) are deposited out as hard scale on heat exchanger surfaces. At lower temperatures <55°C some of the magnetic devices appear to show that something is happening to influence nucleation of calcium carbonate in either crystal form, to prevent the rapid rate of scaling. At temperatures of 70, 80 and 90°C there is a decrease in the ability for these devices to cope. The Hydropath by

design would appear to cater for this critical temperature range for gas fired instantaneous water heaters, where small diameter tube and high heat flux are important to the design of these appliances and future designs of heat exchangers for combination boilers and high efficiency condensing boilers appliances.

BENEFITS TO BRITISH GAS

There are approximately 12.5 million water heating appliances in British Gas installations throughout the UK. This is made up of 9 million boilers, 1 million combination boilers and 2.6 million instantaneous water heaters. In certain hard water areas problems often arise from premature blockage by scale within 6 months of installation, particularly with instantaneous water heaters, cast iron boilers and combination boilers.

For contractors to descale boilers, the cost would be approximately £300/boiler, depending upon severity of scaling. This involves isolation of the boiler on site, descaling (24 —— 48 hours pumping), and neutralising and finally flushing, prior to the reinstallation. It is a 24-72 hour job and is labour intensive.

The going rate for instantaneous water heaters is a call—out charge plus cost of heat exchanger which is on average £40 per appliance. This is simple and easier than for boilers.

On average the call-out and descaling charge for both boilers and instantaneous water heaters would be approximately £170 per appliance. If only 1% of the total population of appliancas were at risk from scaling and assuming 3 star customers, ie, 125,000 appliances, the cost to our industry would be £21.25 million per annum. Therefore, for a modest investment in the purchase of a Hydropath device to be installed in high and medium risk areas the benefits and savings to British Gas would be, over 5 years, £85 million, minus the investment in Hydropath units on district of £12.5 million, which gives a total saving of £72.5 million.

## CONCLUSIONS

Under the severe test regime of small bore pipe and high heat flux it has been shown that Hydropath HP18 performs significantly better than the other non-chemical devices tested with substantial benefits to service and maintenance of water heating appliances.

The technology is in large measure substantiated according to the claims of the manufacturers and it is the only device to approach an ideal device for reducing/preventing scale formation on a continuous operational basis at high temperature. This is an essential and unique feature required by gas fired water heating appliances.

Installation is simple involving only mounting the transducer unit on the rising main and plugging the power unit source into a 13 amp socket. There are no moving parts, the unit is external.

The adoption of the device, with full regional trials, should provide data on the wider economic benefits to service and maintenance of a large population of existing and future appliances.

## RECOMMENDATIONS

Due consideration should be given to the wide use of the Hydropath device in the Regions, to reduce service and maintenance costs resulting from hard water scaling problems.