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Pulse Eco Shower
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FAO: James Clarke/ Christie Allen
Date: 17th January 2012

QUESTOR Quote Number: 11Q072

Dear James/Christie,

Please find attached a copy of the report to compare the Pulse Eco Shower against its main competitors shower heads.

Best regards

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Introduction to Case Study

The QUESTOR Centre carried out a case study on behalf of Pulse Eco Shower comparing their new product, the Pulse Eco Shower, to standard shower heads that deliver the water jet through multiple small holes, commonly known as a spray plate. These shower heads are referred to in this summary as ‘Shower Head B’. Pulse Eco shower is referred to as Pulse.

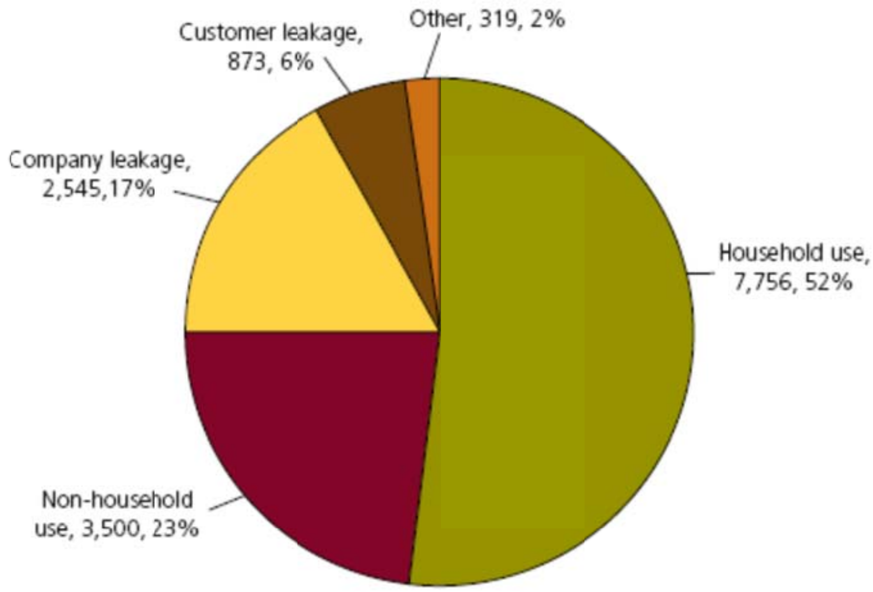
Prior to delivery at the QUESTOR Centre, two of each of the shower heads had been trialled over an eight week period in a hard water in County Laois in which at least two adults reside. Following the trial, one of each of the shower heads was analysed for build-up of limescale, whilst samples of the others were obtained and examined using a Scanning Electron Microscope (SEM). These samples were compared the clean and unused shower heads samples.

Water demand today

Access to a safe water supply is a fundamental requirement. We do not want restrictions, least of all on essential uses, but in many areas there are excess claims on available water, and in nearly all areas there are environmental costs associated with abstraction and treatment. We must practice water efficiently and try to minimise waste. Reducing the inadvertent wastage of water, particularly hot water, also reduces our greenhouse gas emissions. This is why hot water efficiency is part of the governments climate change campaign, Act on CO2.

Household water demand has been increasing since the 1950s, due to population growth and changes in the way we use water in the home, and is now more than half of all public water supply use (Figure 1). In contrast, public water supply usage by industrial and commercial sectors has been declining, reflecting, in part, the changing nature of UK industry.

Figure 1: Public water supply, England and Wales (megalitres (Ml) per day, and %)



Source: based on Ofwat 2007 data

More pressure will be put on our water resources from changes in population, household formation and development, and lifestyles. The UK Government has an ambitious new housing agenda, to meet the demand for housing in the places where people want to live. However, in most cases, these places coincide with areas where there is already a lot of pressure on our water resources. Climate change is already a major pressure. With predictions for the UK of rising temperatures, wetter winters, drier summers, more intense rainfall events and greater climate variability, we can expect to experience higher water demand and more widespread water stress, with increased risk of drought and more water quality problems, as well as more extreme downpours with a higher risk of flooding. If we are to maintain our quality of life while protecting the environment, we must take action now. Water use also produces greenhouse gas emissions that contribute to climate change. These come from the water industry, primarily from treating and supplying water and disposing of wastewater, and from water use more widely. We must mitigate climate change by taking action to reduce these emissions wherever possible.

Defra's action plan to meet the water efficiency targets included a number of actions, one of which was directed at the household water user. It stated a need to:

Pursue options for introducing a product labelling scheme.
Promote water efficiency in new buildings and developments and examine options for improving water efficiency in existing buildings.

1. Develop standards for rainwater harvesting, grey water and raw water reuse.
2. Develop proposals for setting standards for key fittings.
3. Encourage the take up of the Code for Sustainable Homes.
4. Consult on making rating against the Code mandatory for all new homes.
5. Develop and implement an amendment to the Building Regulations to set minimum performance standard for new dwellings.
6. Lead a review of options for improving water efficiency in existing homes and buildings.

It is clear that the Government alone cannot deliver the changes needed to adapt our water management to the changing climatic conditions. Everyone must play their part and work together. By doing so we can help drive innovation and share best practice to ensure that we are prepared for the future. Pulse Eco Shower head will help to address the issue of water efficiency in new and existing homes. This will help the government meet its target of reducing per capita consumption to 130 litres per person per day by 2030. The aim of this investigation was to determine any other advantages of the shower head e.g. reduction in lime scale or reduced opportunities for bacteria to develop and colonise the shower head.

Initial results

Water samples

The results of the 2 water samples delivered for the test areas as shown below in Table 1.

Table 1: Water sample results

SAMPLE ID	11-Oct-32	11-Oct-33
QUESTOR ID	Large bottle	Small bottle
Alkalinity (mg/l as $CaCO_3$)	356	248
Total Hardness (mg/l as $CaCO_3$)	0.19	2662
Non-Carbonate Hardness (mg/l as $CaCO_3$)	0	2414

METALS (Full scan) ppm		
Al	<0.004	<0.004
As	<0.016	<0.016
B	0.034	<0.016
Ba	<0.001	0.030
Ca	0.074	1038
Cd	<0.006	<0.006
Co	<0.001	<0.001
Cr	<0.004	<0.004
Cu	<0.006	<0.006
Fe	<0.010	<0.010
Hg	<0.008	<0.008
K	1.31	1.16
Mg	<0.002	16.97
Mn	<0.008	<0.008
Na	2397	7.13
Ni	<0.001	<0.001
Pb	<0.012	<0.012
Sb	<0.010	<0.010
Se	<0.020	<0.020
Si	4.03	3.70
Sn	<0.012	<0.012
Sr	<0.003	0.16
Ti	<0.001	0.006
V	<0.003	<0.003
Zn	<0.001	0.012

Definitions of the analysis terms:

- Alkalinity (mg/l as $CaCO_3$)
- Total Hardness (mg/l as $CaCO_3$)
- Non-Carbonate Hardness (mg/l as $CaCO_3$) Alkalinity

Total alkalinity is the measure of the amount of alkaline buffers (primarily carbonates and bicarbonates) in water. These alkaline substances buffer the water against sudden changes in pH. Total alkalinity is considered the key to water balance. If the alkalinity is too low, anything introduced to the water will have an immediate impact on pH. Abrupt shifts in pH can cause scaling or corrosion of metal equipment and fixtures as well as other problems. When the total alkalinity is high, the pH has a tendency to drift upward, causing scale to form.

Maintaining an ideal level of alkalinity will protect equipment from the harmful effects of sudden pH fluctuations. Think of the alkalinity as training wheels: it keeps the pH in balance without allowing it to tip too far to either side. Of course the pH can still drift upward or downward, but that change will happen gradually as long as the alkalinity falls within the ideal range.

The total water hardness, including both $Ca2^+$ and Mg^{2+} ions, is reported in parts per million (ppm) or mass/volume (mg/L) of calcium carbonate ($CaCO_3$) in the water. Although water hardness usually measures only the total concentrations of calcium and magnesium (the two most prevalent divalent metal ions), iron, aluminium, and manganese can also be present at elevated levels in some locations. Because it is the precise mixture of minerals dissolved in the water, together with the water's pH and temperature, that determines the behaviour of the hardness, a single-number scale does not adequately describe hardness. Descriptions of hardness correspond roughly with ranges of mineral concentrations.

Soft: 0–60 mg/L
Moderately hard: 61–120 mg/L
Hard: 121–180 mg/L
Very hard: ≥181 mg/L

Non-carbonate hardness is the portion of total hardness that is not produced by carbonates, but primarily by sulphates. Non-carbonate hardness does not disappear during boiling, consequently it is also known as "permanent hardness."

From the results above it can be concluded that sample 11-Oct-32 is soft water which contains no non-carbonate hardness, in comparison samples 11-Oct-32 is very hard water which is predominantly made up of non-carbonate hardness.

Wetted surface area

To allow us to evaluate the potential advantages of the Pulse Eco Shower heads we compared the internal wetted surface areas of a competitor's products and the original and updated Pulse Eco shower heads.

The wetted surfaces areas were estimated by breaking each shower head into sections through which water flows from entering from the hose to leaving through the nozzle. Sections were chosen which resembled regular shapes, for example, the Chrome Pulse Eco Shower was made up of nine shapes: 3 tapered cylinders, 3 regular cylinders and 3 circles.

The surface area of this regular shape was calculated and a factor applied to the surface area based on how well the section fitted the regular shape (e.g. a section with extra surface area due to supports may have a factor of 1.1, whilst one with surface area missing a factor of 0.8).

The areas of each of the shapes was then added to give the estimates of the wetted surface area of each shower head, as shown in Table 2:

Table 2: Estimated wetted surface areas

Shower Head	Estimated wetted surface area
Chrome Pulse Eco Shower	131 cm^2
New Pulse Eco Shower	117 cm^2
Shower Head B	304 cm^2

Examination of the data in Table 2 shows that the wetted surface areas of the Pulse Eco Shower products are much less than those of the competitor products. Compared to the New Pulse Eco Shower, Shower head B has 160% more wetted surface area.

The nature of estimation means that there are margins of errors in these figures. However, these margins will be much less than 160%, meaning that the Pulse Eco Shower product has significantly less wetted surface area than its competitor's, Shower Head B

The surface area that is wet during operation of the shower has significance on the amount of bacteria that can build up within it. Bacteria can either exist in a planktonic (free swimming) or as a biofilm. A biofilm is a colony of microorganisms which adhere to a surface. ***In simple terms, a reduction in the area available for colonisation will lead to a reduction of the amount of bacteria a shower head can support.***

Water retention trials

The amount of water retained within the shower head when not in use is another factor which is important in the build-up of scale and biofilm. To quantify the amount of water retained, the following procedure was used:

1. The shower heads were weighed dry and their dry masses recorded
2. Water was passed through the shower heads and excess water allowed to drain.
3. The shower heads were re-weighed and their wet masses recorded.

The procedure was repeated three times for each shower head. The average mass of water retained by each shower head is shown in Table 3.

Table 3: Average water retention of clean shower heads (standard errors shown)

Shower Head	Average mass of water retained
Pulse Eco Shower	21.4±0.5 g
Shower Head B	70.5±0.5 g

This procedure was repeated for 2 of the 4 returned shower heads (2 of each shower head Pulse Eco & B) which had been in use for 8 weeks in an area known to have an issue with hard water. Each of the shower heads was used in a domestic home with no more than 2 adults residing. The water retention values are shown in table 4.

Table 4: Average water retention of used shower heads (standard errors shown)

Shower Head	Average mass of water retained
Pulse Eco Shower	33.1±4.2 g
Shower Head B	55.4±1.0 g

Scale determination

The water passed through the shower heads to determine the water retention was collected and analysed for its metal content, the results are shown in Table 5.The metals which we are most interested in are calcium (Ca) and Magnesium (Mg) as they indicate possible scale deposits.

To begin with we will discuss the Ca results. There was a slight increase in the Ca content between the Pulse new and used shower head, (approximately 10%). This would suggest a small scale deposit.

Shower Head B had a dramatic increase in the content of Ca which would suggest that there was a substantial deposit of scale in the shower head. This would be possible as this shower head has more spray nozzles than the other showers tested. These are ideal points of scale build up as the moisture dries and salt crystals are formed between uses.

Shower Head B had a decrease in the Mg content of the wash water as with the Ca content which could be due to polymer fillers.

Shower Head B also has an increase in the Mg content which would support the idea that it would contain a deposit of scale.

Table 5: Metal content of both new and used show heads

Metal	Pulse Eco Shower		Shower head B	
	New (control)	Used	New (control)	Used
Al	0.0202	0.0274	0.1438	0.1335
As	<0.016	<0.016	<0.016	<0.016
B	<0.016	<0.016	<0.016	<0.016
Ba	<0.001	<0.001	<0.001	<0.001
Ca	6.091	6.694	3.235	146.6
Cd	<0.006	<0.006	<0.006	<0.006
Co	<0.001	<0.001	<0.001	<0.001
Cr	0.0334	0.0317	0.0052	0.1174
Cu	3.615	22.91	0.6642	3.283
Fe	0.2309	0.2113	0.0108	0.0595
Hg	<0.008	<0.008	<0.008	<0.008
K	0.2047	0.1431	0.1549	0.3778
Mg	0.5727	0.1905	0.9362	1.767
Mn	<0.008	<0.008	<0.008	<0.008
Na	1.076	0.2989	1.922	0.7681
Ni	0.1784	1.899	0.8477	0.8409
Pb	2.324	2.972	<0.012	0.0852
Sb	<0.010	<0.010	<0.010	<0.010
Se	<0.020	<0.020	<0.020	<0.020
Si	0.3329	0.3791	0.7327	0.2469
Sn	<0.012	0.0787	<0.012	<0.012
Sr	<0.003	<0.003	<0.003	0.0982
Ti	<0.001	<0.001	<0.001	0.0153
V	<0.003	<0.003	<0.003	<0.003
Zn	1.113	4.331	0.0998	1.146

All results are recorded as ppm

Scanning Electron Microscope

The scanning electron microscope (SEM) uses a focused beam of high-energy electrons to generate a variety of signals at the surface of solid specimens. The signals that derive from electron-sample interactions reveals information about the sample including external morphology (texture), chemical composition, and crystalline structure and orientation of materials making up the sample. In this application, data was collected over a selected area of the surface of the sample, and 2-dimensional images were generated.

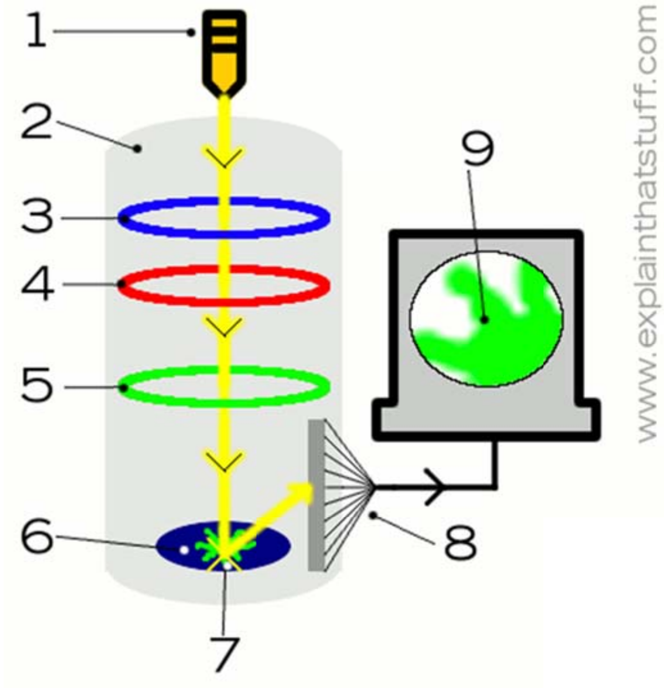
How a scanning electron microscope (SEM) works

A scanning electron microscope uses a beam of electrons to produce a magnified image of an object instead of a beam of light.

1. Electrons are fired into the machine.

2. The main part of the machine (where the object is scanned) is contained within a sealed vacuum chamber because precise electron beams can't travel effectively through air.
3. A positively charged electrode (anode) attracts the electrons and accelerates them into an energetic beam.
4. An electromagnetic coil brings the electron beam to a very precise focus, much like a lens.
5. Another coil, lower down, steers the electron beam from side to side.
6. The beam systematically scans across the object being viewed.
7. Electrons from the beam hit the surface of the object and bounce off it.
8. A detector registers these scattered electrons and turns them into a picture.
9. A hugely magnified image of the object is displayed on a TV screen.

Figure 2: stages in Scanning electron Microscope



Sample preparation

Samples were obtained from each of both the new and used showers heads from each of the models. Samples were taken from the widest point in the flow path through the shower where the slowest flow velocity would be observed. This location was chosen as it was felt that this would be the most likely location for fouling to occur.

To prevent the samples being contaminated by dust or other small fragments, the samples were cut using a heated metal tube rather than a saw or a knife.

The collected samples were fixed to a 25mm (1inch) diameter disc and then coated in a thin layer of gold and then rendered conductive by evaporation of an Au/Pb alloy, the vapour of which condensed onto its surface. The sample was then placed into the microscope chamber and photographed at magnifications of between x200 to x10000.

What we saw

Figure 2-7 illustrates what was seen using the microscope, included in the report is a CD of the original scans. It was noted that Pulse Eco shower heads had rougher surfaces than

Shower head B. There were limited differences in the new showerheads except that some salt crystals were identified on the surface of the Pulse Eco shower head.

Both of the used showerheads had bacteria present. The Pulse Eco shower head had only rod shaped bacteria and in the higher resolution scans only a small number were identified. Bacteria are living things made of only one cell. Bacteria come in three basic shapes: cocci, shaped like small balls or spheres; bacilli, shaped like rods or sticks of chewing gum; and small spirals called spirillum.

Shower head B scans indicated a large deposit of bacteria which were visible at lower magnitudes than that of the Pulse Eco shower head. It also contained 2 types of bacteria rods and cocci (circular). It should be noted that as Shower head B had a smoother surface the bacteria is easier to identify.

Figure 3: Pulse Eco Shower clean (left) and used (right) magnification x200 – x1000

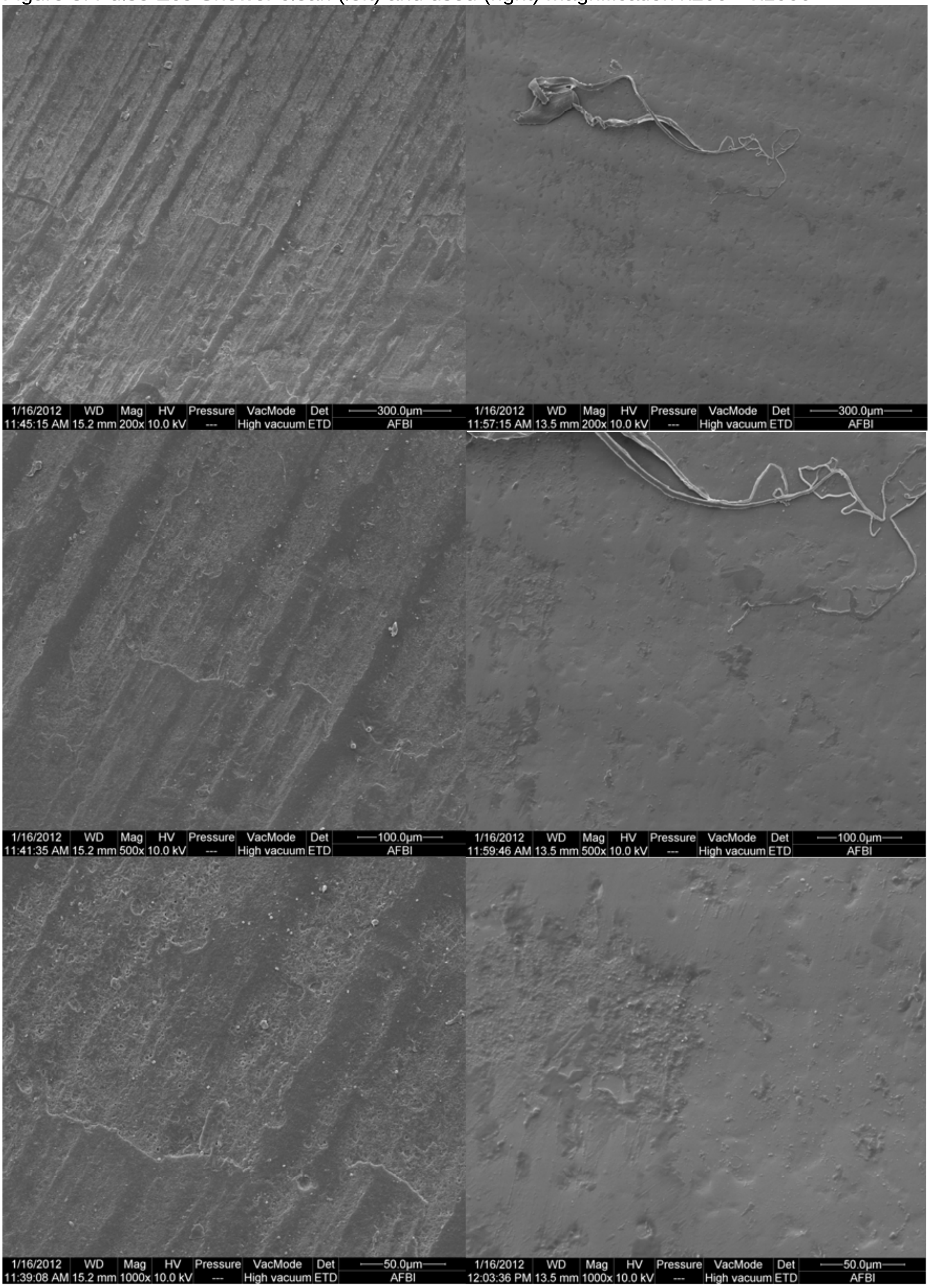


Figure 4: Pulse Eco Shower clean (left) and used (right) magnification x2000 – x10000

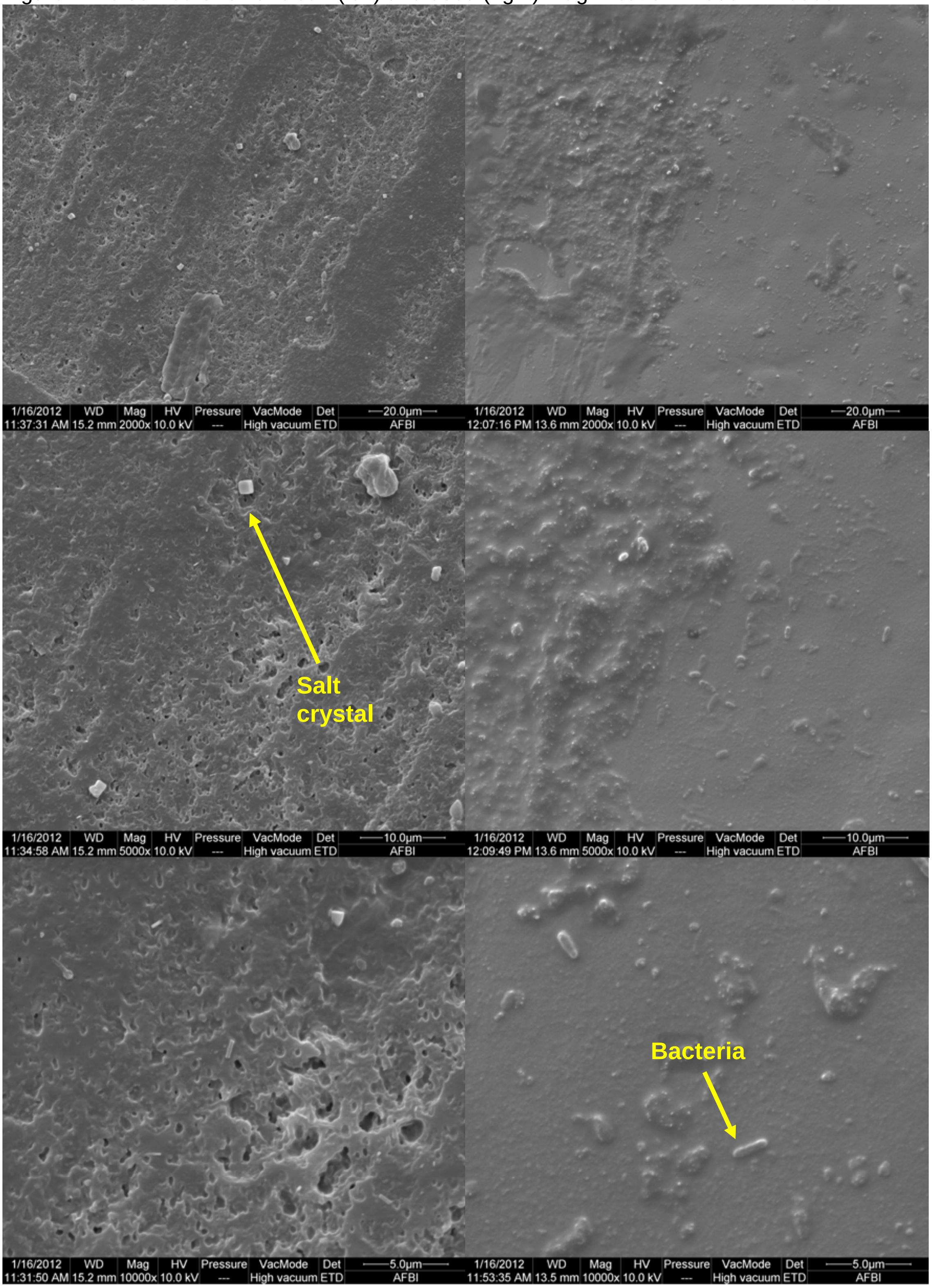


Figure 5: Shower head B clean (left) and used (right) magnification x200 – x1000

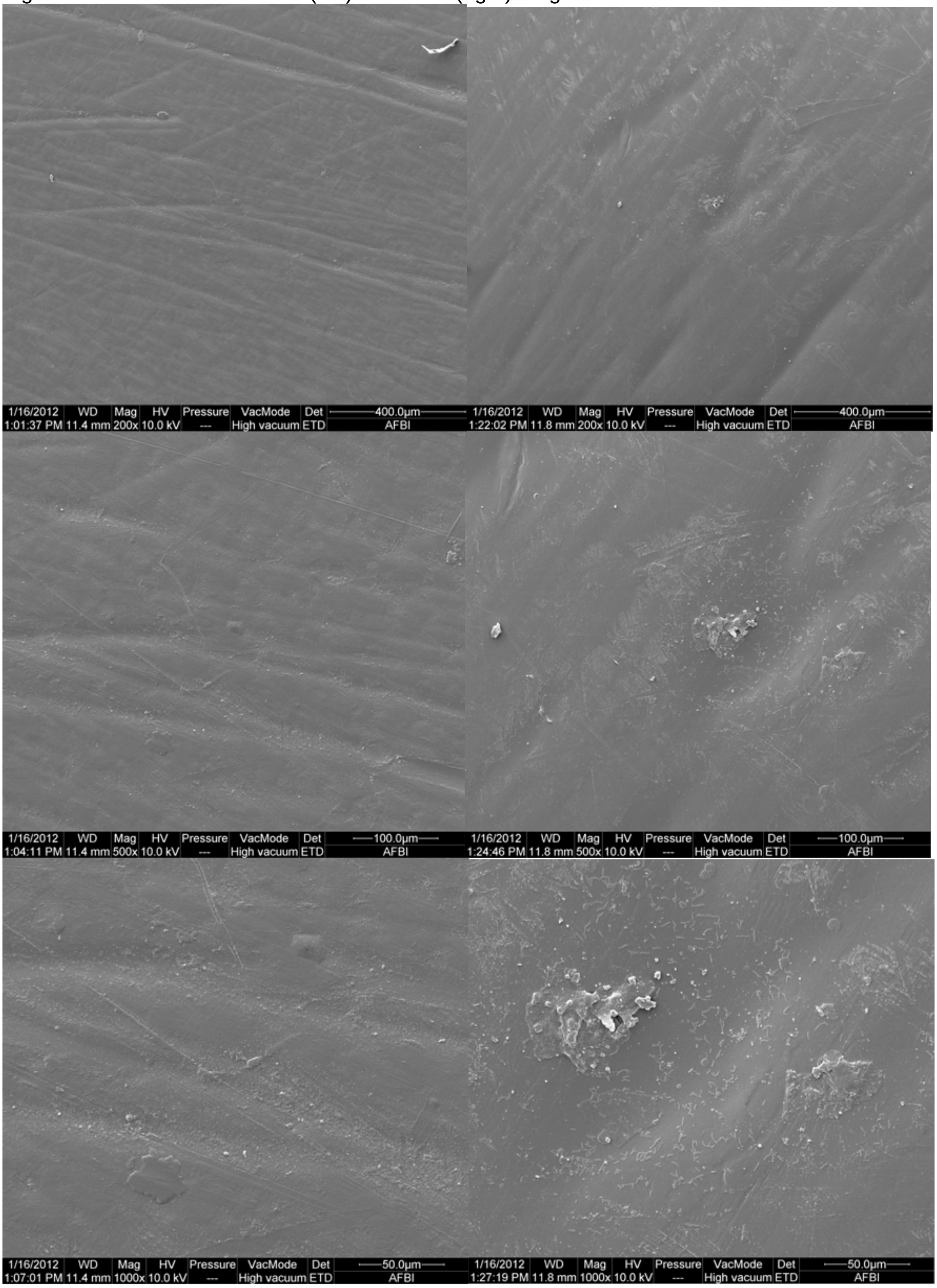


Figure 6: Shower head B (left) and used (right) magnification x2000 – x10000