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Technical Report

***Subject*:** Comparative Capacity Tests of Jug Water Filter Cartridges *Claroswiss*® and *Brita Maxtra*®

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1) Introduction

This technical report describes the test of *Aquis* jug water filter cartridges as well as of a cartridge manufactured by a competitor.

To improve and balance the mineral level of tap water filtered by jug water filter systems, Aquis GmbH developed the *Claroswiss*® jug filter cartridge with a mineral preservation technology. *Claroswiss*® cartridges contain a bypass and therefore maintain a balanced concentration of minerals but secure an efficient hardness reduction to prevent lime scaling by the water. In previous studies carried out by Aquis GmbH it could be proven that the fluctuation of the total mineral content in the filtrate of a *Claroswiss*® cartridge is considerably smaller than in the filtrate of the *Maxtra*® cartridge, a trademark of *Brita* GmbH, Germany. To verify their results, *Aquis* ordered test series by *Zurich University of Applied Sciences*.

2) Chemical analysis

Claroswiss® and *Brita Maxtra*® filter cartridges – each installed in their original jugs – were compared in a one week life cycle testing. The initial two litres of filtered tap water were discarded. At intervals of 15 minutes, each jug was filled with 1 litre of tap water. The cartridges were loaded during 9 hours every day. Appropriate samples were collected every 3 hours to measure the pH-value, carbonate hardness and total hardness of the filtered water as well as the tap water. In addition the content of calcium and magnesium was established. The measuring methods applied were potentiometric and complexometric titrations.

2.1 Measurement of the total hardness

The sum of the temporary and the permanent hardness and hence the total amount of Ca^{2+} and Mg^{2+} bonded in the water on carbonate and sulphate is defined the total hardness.

Earth alkali ions were titrimetrically determined in alkaline medium. Eriochrome Black T was used as complexometric indicator. This indicator is blue in alkaline medium. Primary it turns red when it forms a complex with calcium, magnesium or other metal ions. In the EDTA titration the characteristic blue endpoint is reached when sufficient EDTA is added and metal ions form complexes with the EDTA instead of the Eriochrome.

The following procedure was applied: To decompose carbonic acid and to subsequently remove carbon dioxide, each sample was heated until boiling after the titration of the carbonate hardness. Then 5 ml ammonium hydroxide buffer of pH 10 and a small amount (tip of a spatula) Eriochrome Black T were added after cooling

the sample to around 50 °C. The titration with 0.02 M Komplexon-III (EDTA-Na_2) until the characteristic blue endpoint was reached, had to be carried out immediately after. The total hardness of the water samples was calculated based on the consumption of Komplexon-III. As each molecule of the chelating agent reacts with one metal ion (independent of the respective metal) the following equation can be applied:

$$c(Ca^{2+} / Mg^{2+}) = \frac{c(KomplexonIII) \cdot V(KomplexonIII) \cdot 1000}{V(sample)} = c(KomplexonIII) \cdot V(KomplexonIII) \cdot 10$$

c(Ca^{2+}/Mg^{2+}):	concentration of calcium and magnesium ions in mmol/l
c(Komplexon III):	concentration of ethylenediaminetetraacetic acid (dipotassium salt) = 0.02 mol/l
V(Komplexon III):	consumption of Komplexon III solution (ml)
V(sample):	volume of sample = 100 ml

Multiplying the above result by 5.6, yields the total hardness in °dH (German hardness).

2.2 Measurement of the content of calcium ions

Ca^{2+} was determined by Komplexon-III solution titration in the presence of Kali alkaline and calconcarbon acid. To precipitate Mg^{2+}, 100 ml of the water sample were adjusted with potassium hydroxide to pH 12. After addition of a small amount (tip of a spatula) calconcarbon acid (trituration with sodium sulphate) the titration was started with 0.02 M Komplexon-III (EDTA-Na_2) from ruby colour to blue colour. The content of Ca^{2+} of the water samples was calculated as stated under 3.2 based on consumption of Komplexon-III:

$$c(Ca^{2+}) = \frac{c(KomplexonIII) \cdot V(KomplexonIII) \cdot 1000}{V(sample)} = c(KomplexonIII) \cdot V(KomplexonIII) \cdot 10$$

c(Ca^{2+}):	concentration of calcium ions in mmol/l
c(Komplexon III):	concentration of ethylenediaminetetraacetic acid (dipotassium salt) = 0.02 mol/l
V(Komplexon III):	consumption of Komplexon III solution (ml)
V(sample):	volume of sample = 100 ml

2.3 Calculation of the content of magnesium ions

The difference between the total hardness and the concentration of calcium ions provides a good approximation of the of the Mg^{2+} ions concentration.

3) Results

3.1 Measurements of raw water

Our measurements of the total hardness revealed 15.4 – 16.4 °dH which corresponds to an average of 15.8 °dH and lies in the range of the Winterthur Water Works' data (average 15.7 °dH). Whereas an average tap water pH value of 7.4 is declared, our measurements yielded pH 7.23 – 7.63 which results in an average of pH 7.42.

3.2 Measurements of the filtered water

One criterion to show the difference between *Claroswiss*® and the competing product was the capacity in relation to the removed total hardness and in thus the capacity of the filtered water volume.

A minimal reduction of 30% of the total hardness should normally be enough to insure a sufficient protection from limestone, when using heated water. The stop criterion for the capacity was therefore fixed at a 30% reduction of the total hardness or 70% slip of the tap water.

Thus the data obtained was plotted as a function of the total hardness versus the accumulated volume of filtered water. The vertical line at the intersection of the graph and the 30% capacity stop criterion (11.16 °dH) shows the capacity of the particular cartridge in litres. Both cartridges achieved this fixed stop criterion at the same point, i.e. **at 90 litres** of filtered water.

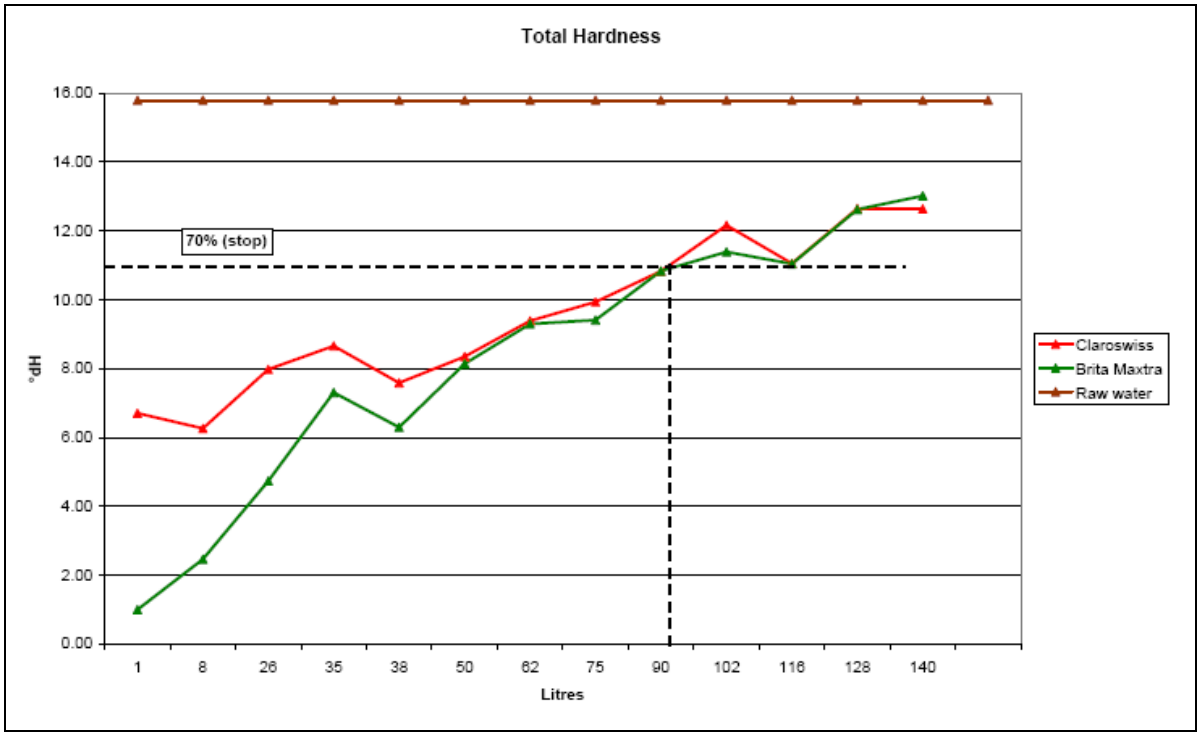

Fig. 1: Comparison of the capacity of jug water filter cartridges measuring the total hardness of the filtered tap water. The stop criterion for the capacity is given as 30% reduction of the total hardness compared to the tap water or 70% slip.

Concerning the 90 litres of filtered water used – which correspond to a usual application period for this water hardness – the content of minerals is as follows:

Mineral content	*Claroswiss*®	*Brita Maxtra*®
Minimum	39.14 mg/l	6.72 mg/l
Maximum	64.74 mg/l	67.10 mg/l
Average	50.43 mg/l	39.63 mg/l

The following results show in the range of 90 litres a maximum fluctuation more than twice as high for *Brita Maxtra*® than for *Claroswiss*®.

	Claroswiss®	*Brita Maxtra*®
Maximum fluctuation	39.55%	89.98%
Ratio	2.3	

Concerning the first 30 litres of filtered water the content of minerals is as follows:

Mineral content	*Claroswiss*®	*Brita Maxtra*®
Minimum	39.14 mg/l	6.72 mg/l
Maximum[1]	52.0 mg/l	35.0 mg/l
Average	44.89 mg/l	21.47 mg/l

The following results show that the fluctuations of the mineral content of water, filtered with the *Brita Maxtra*® cartridge are 4.6 times as high as the fluctuations of the mineral content of water, filtered with the *Claroswiss*® cartridge.

Average fluctuation	*Claroswiss*®	*Brita Maxtra*®
related to the minimum	12.82%	68.68%
related to the maximum	15.84%	63.01%
Average of both fluctuations	14.33%	65.85%
Ratio *Brita Maxtra*®/ *Claroswiss*®	4.6	

[1] Values were read at 30 l from the diagram.

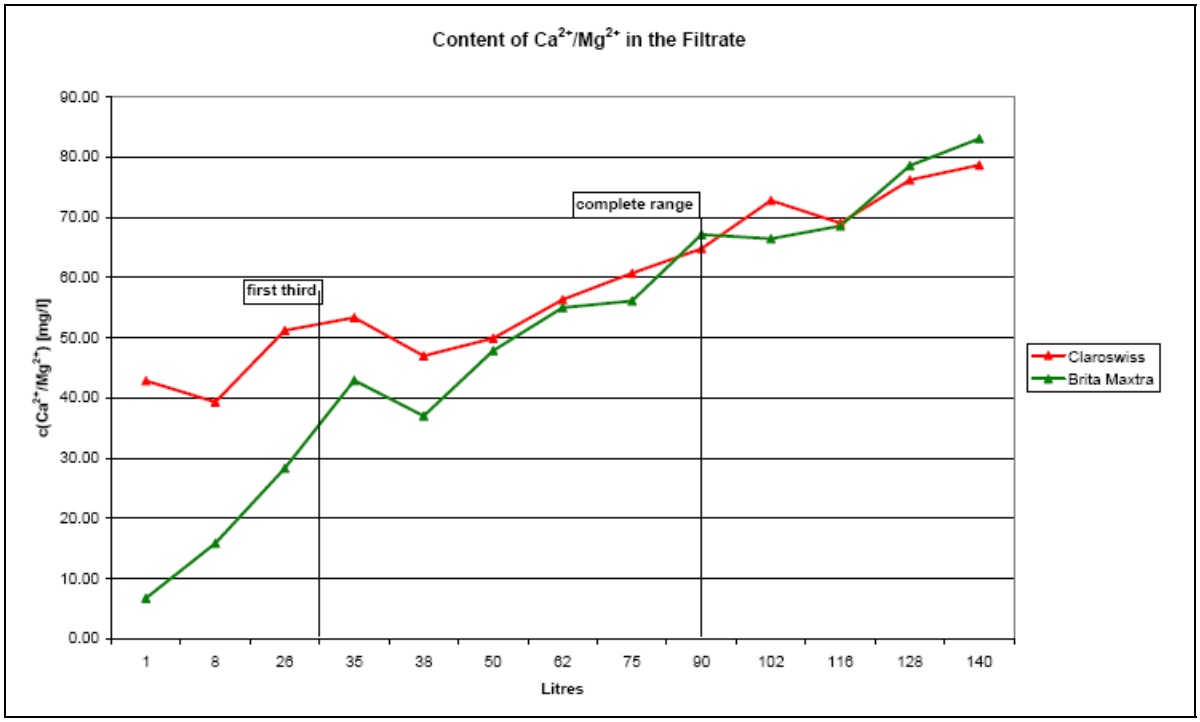

Fig. 2: This diagram illustrates the total mineral content in the filtrate of the particular jug water filter system. These values concern the range of 90 litres of filtered tap water corresponding to the stop criterion of 70% slip as well as the first 30 litres. As can be seen, the content of minerals in the water, filtered by the competing product, in the first 30 litres lies appreciably under the values generated by the *Claroswiss*® cartridge.

To interpret the data of Cartridge no 3 (*Claroswiss*®, utilised with a *Brita*® jug) was not possible due to a manufacturing fault. It turned out that the bypass of the cartridge was insufficiently injected. Furthermore was the bypass itself blocked by an active carbon particle and hence without the requested effect on the filtration. Nevertheless it can be said that the defective *Claroswiss*® cartridge bears a certain resemblance to the competing product (see figure below).

On the one hand it shows the function of the bypass, because in this case the fluctuation of the *Claroswiss*® cartridge is nearly the same as the one of the *Brita Maxtra*®. On the other hand it reveals that the blends of both cartridges have nearly the same exchange capacity.

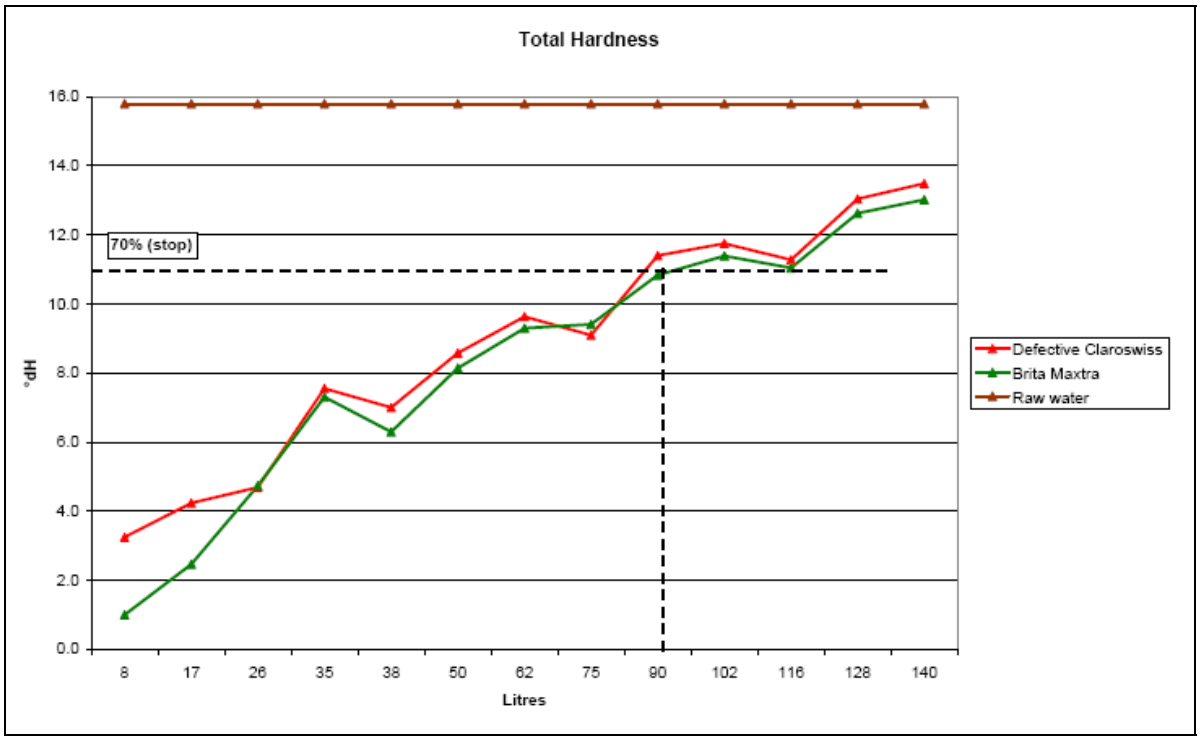

Fig. 3: Comparison of a defective *Claroswiss*® cartridge with the regular *Brita Maxtra*®. The values of the total hardness follow approximately equally.

4) Summary

The data was plotted as a function of the total hardness versus the accumulated volume of filtered water. Both cartridges achieved the stop criterion - fixed at 30% reduction of the total hardness (11.16 °dH) - at the same point, i.e. **at 90 litres** of filtered water. Thus, both cartridges have the same capacity.

The mineral content of *Claroswiss*® during the filtration of 90 litres rises from 39.1 mg/l to 64.7 mg/l. The values of the competing product lie between 6.7 mg/l and 67.1 mg/l. The first 30 litres of water filtrated with *Claroswiss*® contain 39.1 mg/l to 52.0 mg/l. In the same section *Brita Maxtra*® filtrate contains 6.7 mg to 35.0 mg minerals per litre. The average content of minerals for the entire 90 litres is 50.4 mg/l (*Claroswiss*®*)* and 39.6 mg/l (*Brita Maxtra*®), respectively. The average content of minerals in the first 30 litres of the filtration lies for *Claroswiss*® at 44.9 mg/l and for the competing product at 21.5 mg/l.

Thus the competing product shows – when relating the minimum to the maximum – fluctuations twice as high as the *Claroswiss*® cartridge during the usual use of a cartridge. During the first third of the usual use of a cartridge the fluctuations of the

mineral content of water filtered with *Brita Maxtra*® cartridges are four times higher (comparing the average to the minimum and maximum values).

5) Annex

Raw Data