Scale Prevention Systems

The problem

Calcium creates scale in pipes, on appliances and other plumbing surfaces. This leads to higher heating and energy costs and expensive repairs to appliances, such as ice machines, coffee makers, dishwashers and cooling towers in commercial buildings.

Scale can also be a source for bacteria to grow, which can be a health concern in drinking water applications. Calcium, on the other hand, is important to human health, and supplements are recommended if Calcium is reduced or totally void in one's diet.

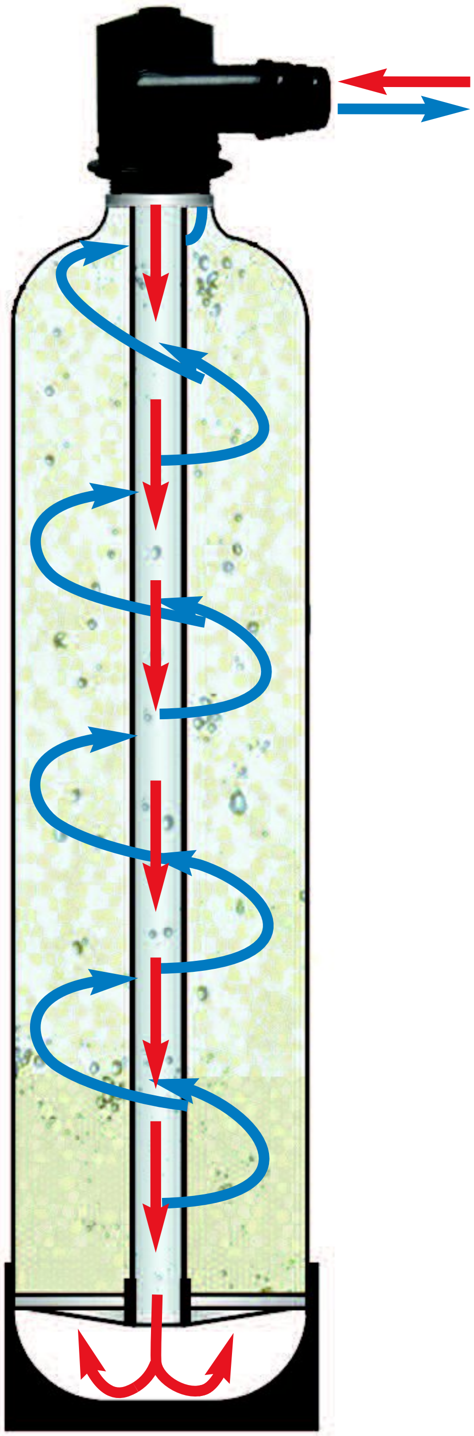
The solution

Scale Out scale prevention systems transform Calcium *ions* into Calcium *crystals*, which are stable and cannot attach to pipes, surfaces, hardware or heat exchanger components. The crystals are so small they are easily rinsed away by the water flow.

Benefits

- No scale!
- No costly repairs.
- Saves water!
- No salt!
- No brine tank!
- No control valve!
- Easy installation!

Note: For satisfactory results recommended flow rates and model sizing must be followed.



Scale

Anti-Scale Systems

The problem

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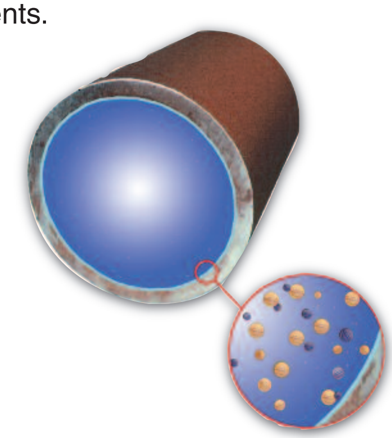

A controlled laboratory evaluation of the scale prevention properties of

Scale Out Media

Testing performed by the German Technical and Scientific Association for Gas and Water (DVGW) according to the DVGW Standard W 512.

This is a translation of the original test results.

A description of the test procedure follows the test results.

Test Report

Equipment Tested: Scale Out Media

Tested in accordance with DVGW Article W512 “Verification of a water treatment device for the reduction of scale formation”

The test report covers four parrallel test rigs. Two of the test rigs are untreated or “Blind” and two of the test rigs are treated or “test”. Please see the accompanying test procedures document for a complete description of the test.

Test Conditions and Results

1. Water Chemistry of test water. See Appendix 1.
2. Test Paramaters See Tables 1.1 and 1.2

Table 1.1 First Test Series (Test Rigs 1 and 3 are “blind” or untreated)

	Test Rig 1	Test Rig 2	Test Rig 3	Test Rig 4
Temperature	80 +/- 3 K	80 +/- 3 K	80 +/- 3 K	80 +/- 3 K
Duration (days)	21	21	21	21
Water volume (l)	3080	3105	3051	3057
Electrical work (kWh)	272.4	287.4	258.6	278.4

Table 1.2 Second Test Series (Test Rigs 2 and 4 are “blind” or untreated)

	Track 1	Track 2	Track 3	Track 4
Temperature	80 +/- 3 K	80 +/- 3 K	80 +/- 3 K	80 +/- 3 K
Duration (days)	21	21	21	21
Water volume (l)	3034	3028	2900	2995
Electrical work (kWh))	284.6	266.8	267.8	256.5

Analytic Results

Table 2.1 First Test Series (Test Rigs 1 and 3 are “blind” or untreated)

$Ca^{2+} + Mg^{2+}$ (mol)	**Test Rig 1** (untreated)	**Test Rig 2** (OneFlow)	**Test Rig 3** (untreated)	**Test Rig 4** (OneFlow)
Heating coil	0.414	0.001	0.455	0.001
Container Walls	0.622	0.000	0.691	0.000
Residual >500 µm	0.180	0.011	0.121	0.000
Total	**1216**	**0.012**	**1267**	**0.001**

Table 2.2 Second Test Series (Test Rigs 2 and 4 are “blind” or untreated)

$Ca^{2+} + Mg^{2+}$ (mol)	**Test Rig 1** (OneFlow)	**Test Rig 2** (untreated)	**Test Rig 3** (OneFlow)	**Test Rig 4** (untreated)
Heating coil	0.001	0.448	0.001	0.470
Container Walls	0.001	0.513	0.001	0.579
Residual >500 µm	0.002	0.189	0.000	0.172
Total	**0.004**	**1.150**	**0.002**	**1.221**

$$\textbf{Effectiveness Factor} = \frac{{}^{2+} + Mg^{2+}]\text{ untreated} - M\,[Ca^{2+} + Mg^{2+}]\text{ treated}}{M\,[Ca^{2+} + Mg^{2+}]\text{ untreated}}$$

Remarks: Scale Out Media operated in recirculation. The blind streams were also recirculated.

Examined by Mr. Schmidt/Schiemann

Appendix 1. Water Analysis

Parameter		
pH		7.79
Temperature	(°C)	12.3
Conductivity	(mS/m)	72.3
Acid capacity KS bis pH 4.3	mol-m^3	6,44
Base capacity KS bis pH 8.2	mol-m^3	0.22 (15.0 °C)
Calcium	Ca^{2+} (mg/l)	124
Magnesium	Mg^{2+} (mg/l)	12
Sodium	Na^{+} (mg/l)	23.4
Potassium	K^{+} (mg/l)	3.2
Chloride	Cl^{-}	41.1
Nitrate	NO^{-3}	23
Sulphate	SO^{2-}_{4}	60.5
Calcite precipitation capacity after DIN 38-404-10	$CaCO^3$ (mg-l)	44.5

DVGW Regelwerk

Technical Direction Worksheet

W 512

September 1996

Testing procedure for the evaluation of the effectiveness of water conditioning devices for the prevention of scaling.

Forward

This worksheet describes a testing process for determining the effectiveness of water conditioning devices which are installed to prevent or to bring about a long-term reduction in scaling in drinking water heating systems and the secondary installations. It is not the object of this worksheet to describe the particular water conditioning devices which meet these demands. In addition, definitions are made concerning the assessment of the test results.

The worksheet specifies the general implementations of the VDI (Association of German Engineers) guidelines 2035 Sheet 1, section 7, “Examination of the Effectiveness of Safety Measures”.

The proof that the standards of this worksheet have been adhered to is an essential but not sufficient condition for the granting of the DVGW certificate. The additional standards concerning the safety, hygiene, and the performance capability arise from the relevant technical regulations, especially from DIN 1988 “Technical directions for drinking water installations (TRWI)”, as well current legal regulations such as the food and consumer goods law (LMBG).

Bonn, September 1996
DVGW Deutscher Verein des Gas- und Wasserfaches e.V. (German Association of Gas and Water Boards, registered)

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Table of Contents

1 Scope

This worksheet applies to the heating of drinking water as well as to its storage and transporting. Furthermore, it applies only to the assessment of systems which should be installed with the object of the prevention or long-term reduction of scaling in installations within the sphere of DIN 1988 (TRWI).

2 Concepts

2.1 Heating of drinking water

For the purposes of this worksheet, the heating of drinking water is defined as the preparation of warmed water which is of drinking quality in the appropriate drinking water heating systems. The heating of technical water does not fall under this concept.

2.2 Water conditioning devices

For the purposes of this worksheet, water conditioning devices are defined to be devices and all technical equipment belonging to the system, as well as all agents, which have as their goal the prevention or long-term reduction of scaling.

2.3 Scaling

For the purposes of this worksheet, scaling is defined as the formation of sediments from hard water build-up, which are created in the form of solid deposits on heat-conducting surfaces and in the containers and which remain there as such.

2.4 Calcite depositing capacity

The calcite depositing capacity gives the amount of calcium carbonate which is available in the water at a given temperature to be thrown down as insoluble matter. The calcite depositing capacity is calculable according to DIN 38 404-10. It doesn't describe the amount of low-solubility compounds of hard water build-up material which actually is deposited.

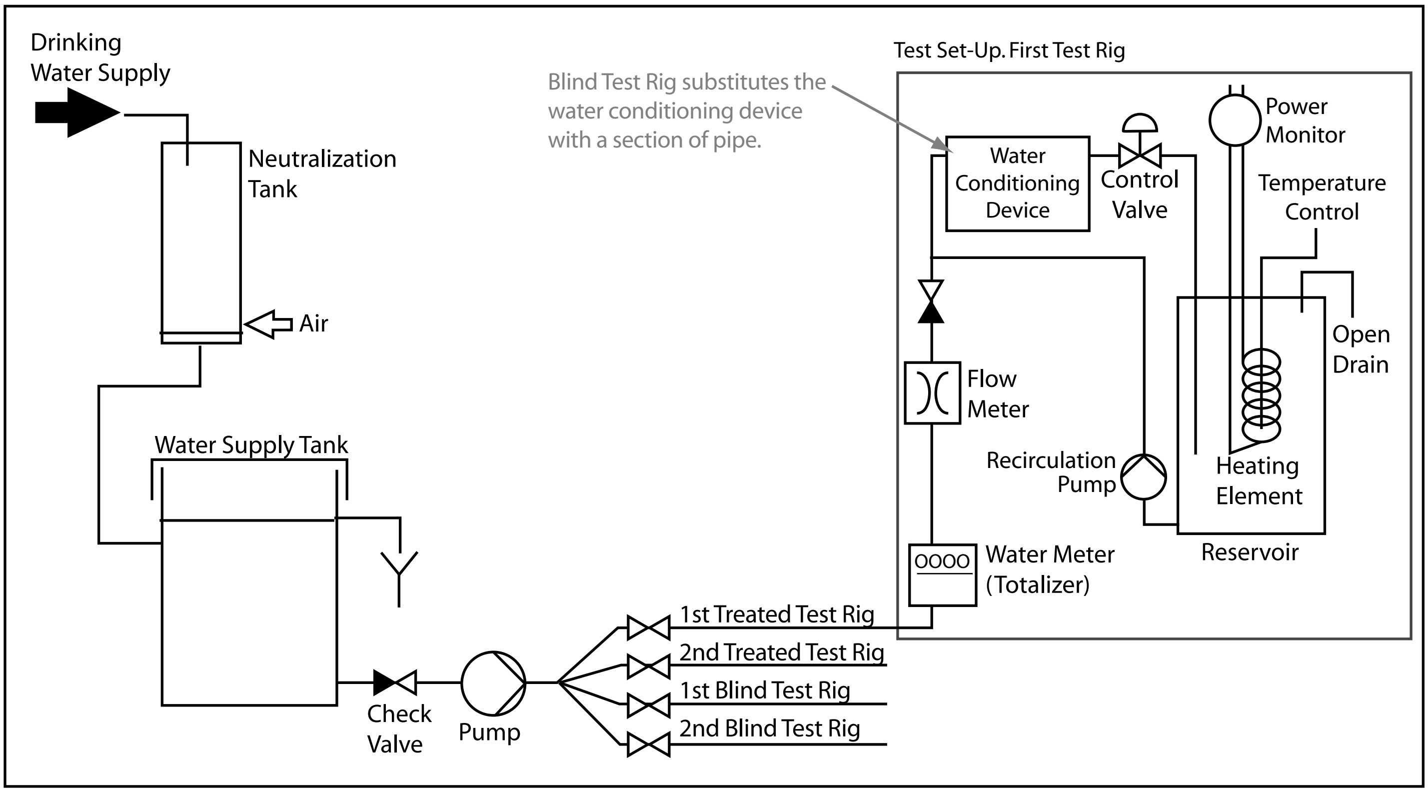
3 Standards

3.1 Test water

The tests are carried out with drinking water which, when unheated, already has a calcite depositing capacity (calculated at 15*C) of at least 30mg/l in the form of $CaCO_3$. The total hardness of the test water must be at least 3.5 mol/m^3, as the sum of alkaline earths. The percentage of magnesium in the water may be a maximum of 25% of the calcium content in mol (20% of the entire mass). If the original water used doesn't have the required calcite depositing capacity, it can be adjusted by taking the appropriate neutralising measures (such as shown in the picture on page 8, for example). It should be determined in a pre-trial (blind test – see section 3.5) if an amount of scaling sufficient for making the assessment will build up during a test period of 21 days. This can be taken as a given if, using the testing method according to section 3.4, a minimum of 0.1 mol alkaline earths (10g), calculated as calcium carbonate, results for each test rig during the analytical determination.

3.2 Test set-up

The schematic test set-up is illustrated below.



The test set-up consists of four identical sets of equipment (Two "treated" test rigs and two "untreated or "Blind" test rigs) for the examination of one type of water conditioning device. The four sets of equipment for testing are to be operated simultaneously, where two test devices are run as treated test rigs and two are run as untreated or blind test rigs.

The supplying of the test water to the drinking water heating system is to be implemented entirely in austenite, chrome-nickel-steel pipes containing molybdenum. The supplying is to take place using a feeding pump with an operating pressure of from 2.5 +/-0.3 bar (pressure reducing valve). The pump should draw the test water, described in 3.1, from an unpressurized water storage container during the water tapping only.

In each supply line of the four testing facilities, the requested amount of water will be measured by a water meter (Qn 1.5) and a flowmeter and regulated with a control valve. The shut-off valve (preferably controlled with compressed air) is to be arranged in the supply to the drinking water heating system.

Standard factory manufacture, unpressurized and electrically-heated 10-Liter reservoirs made of rustproof steel, whose heating elements have a maximum surface power density of 6.5 W/cm2 and which can be operated to a maximum water temperature of 80*C, are to be used as the drinking water heating system.

In addition, to determine the temperature of the stored water, temperature probes with a precision of * 2K are to be installed near the heating spirals in each drinking water heating system. The installation should be done in the same way for each system. The course of the temperature during the test operation is continually to be measured and registered. Voltage and current or voltage and power should be recorded simultaneously.

The warm water drain is open. The control of the amount of water to be drawn is done by opening or closing the shut-off valve in the test water supply.

3.3 Test procedure

A total of 130 l of water must pass through each testing facility each day. This amount is to be taken in intervals within a time period of 16 hours. In addition, the flow rate amounts to at least 5l/min. Furthermore, the entire supply of water in the drinking water heating system is to be exchanged during two daily samplings.

The samplings are to be carried out within the 16 hours as follows: At 0h; 2h; 2.5h; 3.5h; 4h; 4.5h; 5h; 6h; 6.5h; 7h; 7.5h; 8h; 9h;9.5h;10h; 11h; 11.5h; 12.5h; 13h; 13.5h; 14h and 16h - 5l each time, at 3h and 12h 10l each time.

After the 16 hour operating phase, an 8 hour standstill time (without sampling) is to be adhered to.

The water temperature in the drinking water heating systems is 80*C +/-3C. If a water conditioning device which, according to the manufacturer's specifications, has a lower temperature (tolerance +/- 3C), is tested, then this information is to be taken from the product documents and the installation and operating directions.

3.4 Test implementation

For all tests, the treated test rigs and untreated or blind test rigs are to be operated simultaneously using the same test water. The length of the test is always 21 days.

After ending each test, the drinking water heating systems are to be opened and the heating spirals are to be removed. The deposits remaining in the container are to be passed through a sieve with a mesh size of 0.5mm. The residue in the sieve is to be dissolved in dilute nitric acid. The sediments on the heating spirals and on the insides of the containers are to be removed with dilute nitric acid. The combined solution of the sieve residue and the deposits taken from the heating spirals and the insides of the containers is to be checked for calcium and magnesium according to DIN 38406-3. Then the drinking water heating systems and the heating spirals are to be cleaned again with dilute nitric acid and rinsed with demineralized water, before the drinking water heating systems are reassembled (the components must not be switched among the systems) and installed for the next series of tests. The cleaning procedure is to be carried out in the same way for all drinking water heating systems.

3.5 Blind tests

The test set-up is to be tested using blind tests where intermediary pieces are installed in place of the drinking water conditioning devices which are to be built in later.

The blind tests are to be carried out under the conditions described in 3.1 to 3.4. Every test series is to be carried out at least three times.

Every test series gives four separate results. The arithmetic mean for the test series is calculated from these established separate results. In addition, the separate results from within a test series may not deviate more than 20% from the arithmetic mean.

Within the three consecutive test series, the separate results may not deviate more than 30% from the arithmetic mean of all the separate results.

If the two above-mentioned criteria are not met, the testing facility must be readjusted.

3.6 Tests with water conditioning devices

For these trials, the water conditioning devices are installed in the lines of two of the four test rigs (see the picture on page 7) according to the written installation and operating instructions of the manufacturer. The two remaining test rigs are operated as blind test rigs.

The test implementation takes place under the conditions described in 3.1 to 3.4.

The tests are to be carried out at least twice. The water conditioning devices and the corresponding blind test rigs are to be swapped with one another.

The results of the analytical evaluation of the separate test series are to be compared with those from the blind trials which have already been carried out (section 3.5). For the tests, the measuring results of the blind test rigs with the intermediary piece must always lie in the range of the blind trial series which have already been determined(section 3.5).

This means that, again, the separate results from the blind test rigs of this trial may not deviate more than 20% from the arithmetic mean and not more than 30% from the arithmetic mean of all the accumulated separate results of the blind test rigs.

4 Assessment of the results

As defined by this worksheet, a sufficient effectiveness of the water conditioning device is given when the effectiveness factor fE * 0.8. This value is to be met with a confidence level of 95%. Therefore, using the number of the tests trials as given, a single measuring value with a minimum effectiveness factor of 0.66 will be accepted. The effectiveness factor fE is defined as follows:

$$fE = M[Ca2+ +Mg2+]untreated – M[Ca2+ +Mg2+]treated / M[Ca2+ + Mg2+]untreated$$

Where M[ ] are the respective amounts of the substance in Mol.
M[ ]untreated are the arithmetic means obtained in the blind test rigs and
M[ ]treated are the means of the “active” test rigs

5 Test report

After carrying out a test series, a test report, which must contain the following information, is to be drawn up :

a) description of the composition of the test water
b) temperature of the test water in the drinking water heating systems
c) test length, in days, for each test series
d) water flow rate for each test rig
e) electrical work in kWh for each test rig
f) results of the analytical evaluation for the separate test series
g) results of the analytical evaluation for the corresponding blind tests
h) evaluation and statement of the determined effectiveness factor
i) remarks (e.g., peculiarities during the course of the trials)

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Cited norms and other documents

DIN 1988-1	Technical directions for drinking water installations (TRWI); General; DVGW Technical Directions
DIN 1988-8	Technical directions fordrinking water installations (TRWI);System operation; DVGW Technical Directions
DIN 1988-2	Technical directions for drinking water installations(TRWI); Planning and implementation; Components, apparatus, materials; DVGW Technical Directions
DIN 38 404-10	German unit process for water, sewage and sludge inspection; physical and physico-chemical substance characteristic quantities (Group C); Calcite saturation of water (C 10)
DIN 1988-3	Technical directions for drinking water installations (TRWI); Determination of the pipe diameter; DVGW Technical Directions
DIN 38 406-3	German unit process for water, sewage and sludge inspection; Cations (Group E); Determination of calcium and magnesium (E 3)
DIN 1988-4	Technical directions for drinking water installations (TRWI); Protection of drinking water, preservation of drinking water quality; DVGW Technical directions
VDI 2035 Sheet 1	Avoidance of damages in warm water heating systems; Scaling in water heating and warm water heating systems
DIN 1988-5	Technical directions for drinking water installations (TRWI); Increase and decrease of pressure; DVGW Technical Directions *Decree concerning drinking water and water for foodstuffs firms (Drinking water decree – TrinkwV) in the form of an announcement from December 5, 1990, German Civil Code*Page 2612, 1991*Page 227*
DIN 1988-6	Technical directions for drinking water installations (TRWI); Fire extinguishing and fire protection plants; DVGW Technical Directions
DIN 1988-7	Technical directions for drinking water installations (TRWI); Avoidance of corrosion damage and scaling; DVGW Technical Directions