Non-Softening Scale Control Devices
Standards and Lack Thereof

By Rick Andrew

NSF/ANSI 44 includes requirements for assessing the material safety, structural integrity, pressure drop, softening performance and softening capacity of residential point of entry (POE), regenerable cation exchange water softeners. Assessment of softening performance and softening capacity is very straightforward—the hardness of the water entering the system (influent) and the water leaving the system (effluent) is chemically analyzed and quantified, thereby providing a measure of performance.

The standard requires that influent water containing 20 grains per gallon (342 mg/L as $CaCO_3$) of hardness must be softened to contain less than or equal to one grain per gallon (17.1 mg/L as $CaCO_3$) of hardness.

Non-softening scale control devices

There are a variety of devices that purport to eliminate or limit scale without softening. They use a variety of technologies in a variety of configurations, including magnetic, electrical and others. In each case, these products are not softening the water, but rather claim to alter the physical properties of the water so that scale will not form.

There are advantages to these approaches, assuming that they work. Chemical regeneration is not required, so there are no issues related to discharge of regenerant brine solutions. There are no regenerant chemicals to purchase or stock and no interruptions in service.

Do they work?

Assessing the performance of these devices is not straightforward, as they do not chemically alter the water. The hardness of the influent and effluent water is identical. So using hardness measurements as a mark of performance is not possible and alternate methods must be sought. This issue has been brought before NSF and WQA in the past without successful resolution.

In the 1980s and early 1990s, WQA questioned the effectiveness of magnetic scale control technology. WQA actually financed two studies during that time to attempt to assess the effectiveness of these devices. Neither demonstrated device effectiveness in reducing scale formation, although the designs of these studies have been criticized. This demonstrates just how difficult a task it is to determine whether a device that does not chemically alter the water can control or reduce scale formation.

In the late 1990s, NSF began an effort with manufacturers of magnetic water treatment devices to develop standards for testing their products to prove their effectiveness in scale control and reduction. This stemmed from controversy and questions that had been raised by the WQA studies and many others as a potential solution.

In some states, law enforcement and/or consumer protection agencies have periodically issued consumer alerts about buying magnetic water treatment devices or issued injunctions against specific companies and their agents for making claims of product performance that were not based on scientific testing. Ultimately, due to various issues of participation and technical complications related to the difficulties in protocol design, this effort never got off the ground.

Some manufacturers claim their devices are affected by a number of variables, including temperature, flow rate, electrical conductivity, strength of magnetic field and high concentrations of iron or silica. These variables make it difficult to administer empirical device-testing standards that will have repeatable results.

Unresolved issues

To this day, issues related to the performance of magnetic or other types of physical water conditioners remain open questions. In the US, there are no accepted standards for conducting laboratory tests on these devices to determine their effectiveness in scale control or reduction.

There have been some standards for these devices developed; however, they either do not address actual scale control or reduction performance or there are some technical issues with the approach that leave many experts questioning the methodology used.

Figure 1 summarizes two standards developed for these devices. The first is an interesting International Association of Plumbing and Mechanical Officials (IAPMO) standard developed recently

Figure 1. Standards for non-softening scale control devices

Standard	Description
IAPMO AB1953	Applies to electrical or magnetic anti-scale or water conditioning devices. Addresses materials of construction and marking. Does not address verification of effectiveness of scale control.
German Standard DVGW W512	Applies to magnetic anti-scale devices. Addresses verification of effectiveness of scale control. Test protocol involves side-by-side comparison with and without device and measuring scale deposited in small water heaters.

that addresses definitions, general requirements, materials of construction, marking and performance claims. The performance claims are, however, described in the realm of the device inducing a certain magnetic field as claimed by the manufacturer or the device creating specific electrical characteristics per the manufacturer's claims.

The standard does not address claims of scale control or scale reduction by the devices. This standard begs the question: "Why do we care about induced magnetic or electric fields unless those induced fields result in scale control or scale reduction?"

DVGW W 512, the second standard described in Figure 1, is a German protocol that addresses scale control by a device when the water is not chemically altered. Testing is conducted using hard water and side-by-side tests of four plumbing systems that include small water heaters. The four plumbing systems are identical except that two include the test device and the other two do not.

The systems are operated 16 hours per day, with 130 liters (34.34 gal.) of water processed through each hot water heater, set at 80°C (176°F) each day during this period. The heaters are refilled at a flow rate of five liters (1.32 gal.) per minute when they are drawn down by five or ten liters (1.32 or 2.64 gal.) at specific points in the 16-hour day.

At the end of the 21-day testing period, the amount of scale in the four water heaters is compared. Theoretically, the systems without the devices should have more scale in them than the system with the device. The test is run at least twice, with the devices being moved to the two systems that were initially run without devices for the second run.

On the surface, this seems like a reasonable approach. Multiple plumbing systems are used and tested with and without the device to help eliminate variability. Additionally, the standard uses statistical controls to determine if results are meaningful. There are limits on the amount of variability in individual results for each of the plumbing systems that are allowed, as well as statistical requirements to determine whether the devices are controlling scale formation or not.

However, there are questions that can be raised. Are four plumbing systems ever truly identical? They may have differences in surface scratches or welds that have slightly different characteristics or different electrical conductivity, such that some are more or less amenable to formation of scale.

When the plumbing systems are cleaned of scale to measure the amount of scale formed and the test repeated, does this eliminate the variable of differences in the plumbing systems? Maybe and maybe not, because now the systems have been cleaned and descaled, which could result in surface differences such as scratches. Also, the test devices are installed on the other plumbing systems, which can alter flow paths, etc. So, all four of them have been altered when the test is repeated.

Predictive difficulties

The biggest issue with *DVGW W 512*, though, is that there are a significant number of variables that affect scaling characteristics. As mentioned above, temperature, flow rate, electrical conductivity and high concentrations of iron or silica can all affect the tendency of a system to form scale. This test involves testing under exactly one condition of each: hardness, other water characteristics, flow rates, usage patterns, temperatures, materials used in the plumbing system, etc.

What would happen if any of these characteristics were altered and the test repeated? Would the results be the same? It is difficult to know because the mechanisms for how these systems may help control scale formation are not well understood. There are many different theories of how magnetic fields, electrical fields or other physical conditioning of water actually cause the effects on scale formation that are claimed. There is essentially no consensus on which of these theories is correct.

With traditional water softeners, testing under standardized conditions works because the mechanisms for how water softeners prevent scale formation are very well understood. This allows interpretation of the results in terms of how softeners will function under other conditions.

For example, if water is twice as hard, softeners will require regeneration twice as often to be effective or possibly conducted at the same frequency with more salt. The exact parameters can be accurately calculated. Limits on iron fouling are well understood, as well as other limitations in operation.

But this is not the case with physical water conditioners. Showing performance under one set of conditions does not allow interpretation of performance under different conditions.

Future direction?

I do not mean to imply that physical water conditioners do not work. There is strong anecdotal evidence of effective performance in many cases, as well as some fairly convincing studies in industrial situations such as cooling towers. It is not well understood, however, under which conditions these devices will work and when they will not. Residential applications are often the toughest of conditions because they involve intermittent flow, variable flow rates and single-pass operation.

More understanding about the mechanisms of how physical water conditioners may prevent or reduce scale formation is required before truly meaningful product performance tests can be empirically validated and standards developed. If one does not understand the mechanisms of action, it is impossible to develop those standards with results that can be applied to a variety of conditions.

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