

Industrial Fouling

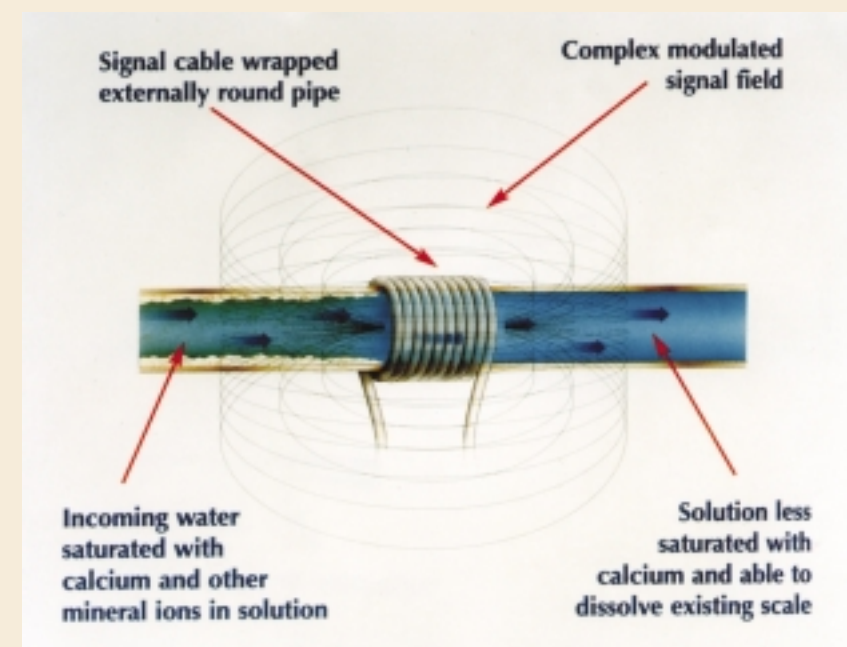
Controlling Scale Deposition

Look at the heating element of a washing machine or dishwasher in a hard water area and you will see a white encrustation containing hardness salts. This commonly is referred to as limescale and is an example of domestic fouling. The limescale (calcium carbonate) that deposits on the heating element will, if untreated, reduce the efficiency of the machine, induce corrosion of the element and ultimately lead to appliance failure.

Industrial fouling poses a far greater problem than anything in the domestic sector. Huge volumes of fouled fluids are handled, and the systems that contain the fluids can become fouled as well. The quality of water streams used by industry varies widely and gives rise to numerous fouling problems.

Type of Fouling

Mineral scale deposition occurs as a result of heat transfer or pressure changes. Calcium carbonate scaling from hard water, and calcium phosphate and oxalate formation in sugar refineries are examples. Other types of fouling include the growth of



algae and bacteria (biofouling) and the consolidation of loose particles (e.g., particulate fouling—corrosion byproducts and the accumulation of “coke-like” deposits).

What Can Go Wrong?

Process managers should be concerned about fouling. Deposits are an insulating

layer on heat transfer surfaces. This leads to more power being consumed or to the installation of heavier duty, more expensive heat exchangers to compensate. It is estimated that 40 percent more energy is needed to heat water in a system fouled with 1/4 inch of calcium carbonate scale. Scaled boiler tubes mechanically fail as a result of

overheating and cooling tower plates can collapse due to the weight of scale deposits. Erosion damage can occur as a result of scale particles breaking loose and then subsequently impinging upon other surfaces.

Pipework scale reduces the available cross-section area, and fluids are affected by increased pipewall friction. A larger, more power-consuming pump will be required to maintain throughput volumes but this may allow only a temporary solution to the problem. Plants that need to be shut down for cleaning cost money.

The formation of a thin uniform layer of scale or wax temporarily can reduce steel corrosivity, but eventually stagnant conditions develop under the deposit and electrochemical reactions will corrode the steel surfaces. The result can be fluid leaks and equipment failure, which is potentially very dangerous. In the food industry, the incorporation of even undesirable trace particulates can lead to off-flavors or off-colors, reduced shelf-life or even making the product not fit for selling.

Not only is plant and product integrity at risk but personnel health and safety may be compromised. Safety valves or emergency process sensors that are fouled may not operate in an emergency. Overheated boilers have been known to explode. Failure to control bacterial growth in cooling water can create conditions hazardous to health (e.g., production of *Legionella pneumophila*) or, in anaerobic conditions, may allow the production of toxic hydrogen sulphide from sulphate-reducing bacteria.

Recognizing Fouling

As scales and other deposits generally form inside closed systems, it is not always evident that deposition is occurring. There are some clues that can provide the evidence that is necessary. It is useful to try to answer the following questions.

- Do energy/heating bills reduce immediately after cleaning the plant?
- Is it necessary to arrange significant planned and/or unplanned downtime?
- Are heat exchangers performing below design?

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- Is corrosion a problem in the plant?
- Are there signs of unexpected deposit formation within the system?

The more times that the answer is "yes," the more likely it is that there is fouling. If fouling can be controlled, there is a potential to save energy, prevent equipment failure and reduce maintenance time and costs. Furthermore, a successful

treatment strategy will maintain fluid flow, reduce corrosion effects and provide a safer environment. In addition, it will save money.

Solving the Problem

A process audit would identify the extent of the current problem, the point in the system corresponding to initial fouling and, of most use, why there is a problem. From the evidence, it may be possible to suggest a solution without the

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need for expensive external control measures. Minor changes in the process temperature, pressure, pH or fluids composition significantly could reduce the fouling potential for little to no cost.

Treatment options include inhibitor chemicals, descalers, ion exchange and physical cleaning such as pipeline pigging or the installation of permanent magnets or electronic devices.

Although it usually is possible to find a chemical solution to a fouling problem, environmental and safety pressures demand that chemical consumption is reduced wherever possible.

Increasingly, restrictions are being applied regarding the use of chemicals due to their environmental impact.

Physical Methods

A range of physical methods can be used to remove fouling deposits. Water jetting, sand or plastic-bead blasting can be used in accessible locations. For other applications, such methods may be expensive and possibly can cause the abrasion of surfaces.

Magnetic, Electronic Descaling

Unlike other preventative techniques, these devices do not stop precipitation but rather alter the shape of the crystals to reduce the adherence and build-up of deposits on the pipewall. Perhaps the most remarkable observation is that devices

can affect descaling downstream of the point of installation. A softening and loosening of existing scale several weeks after installation commonly is reported.

To understand the mechanism, some knowledge of mineral scale precipitation is necessary. We know that in order to form a scale deposit three conditions must be met.

- The solution must be supersaturated.
- Nucleation sites must be available at the pipe surface.
- Contact/residence time must be adequate.

To prevent scale it is necessary to remove at least one of these preconditions. Clearly contact time is not an alterable factor. To be effective, any device must affect either the supersaturation value or the nucleation process.

The direct effect on electronic devices is on the nucleation process and, in particular, to enhance initial nucleation through the creation of new nucleation sites within the bulk fluid flow. Crystal growth then occurs at these points of nucleation and not at the pipewall. Suspended solids increase with a corresponding drop in the level of supersaturation, and these effects have been observed in the field. The localized pH increase near the pipewall caused by hydroxyl radicals formed by electromechanical interactions is one mechanism that drives the changed nucleation characteristics.

Electronic devices are not flow-rate dependent and can be built to fit pipe diameter up to 60 inches. The units are lightweight, easy to install, can be retrofitted and produce no significant magnetic field. They usually are effective on calcium carbonate claimed to reduce iron fouling and appear to prevent fouling by various other substances. **WQP**

About the Author

Jan de Baat Doelman is president of Scalewatcher North America, Inc. Scalewatcher North America, Inc.'s research of electronic systems in the United States, Europe and Asia has led to the implementation of an effective scale deposit-control strategy. The patented Scalewatcher Electronic Scale Control System, originally launched in 1989, provides a nonintrusive, chemical maintenance-free method of removing limescale from pipes and equipment.

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