# SCIENCE AND TECHNOLOGY OF CHEMICAL DOSING FOR DESALINATION: HISTORY, DEVELOPMENTS AND FUTURE TRENDS

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**Summary**

Correct chemical dosing is vital if the desalination plant is to function efficiently and uninterrupted. Descaling operations, and the repair of corrosion damage, are very costly both in terms of money and lost water production and so the effort required to ensure correct chemical dosing should be viewed as an investment.

In this article we have summarized the common problems encountered with chemical dosing systems. Many of these problems are due either to design faults or operator error.

Plant designers should take care to eliminate design shortcomings and operators should set up procedures which avoid operational problems. In this way, the efficiency, cost effectiveness and reliability of desalination plant, in general, will be markedly improved.

## 1. Scope

A variety of chemicals are dosed to modern desalination plants to achieve specific functions which are described elsewhere in this Encyclopaedia. The specific functions required are essential for efficient plant operation and so the subject of dosing systems is critically important.

The chemical dosing facility on the average desalination plant often tends to be overlooked, until plant problems caused by its malfunction become apparent. It should be remembered that, for all chemicals, dosing level is of prime importance. Each chemical has an optimum dose level at which the required performance is obtained without causing plant damage and without causing excessive cost. Table 1 shows some of the penalties incurred by poor chemical dosing.

Most of the chemicals must be dosed continuously and reliably. Shot dosing is not satisfactory in most instances and unreliable dosing may be worse than not dosing at all. In some ways, there is a similarity between dosing chemicals to a desalination plant and controlling the petrol metering (carburation) in a motor car. No-one expects their motor car to run efficiently if it is out of tune. Great efforts are made to set the mixture control so that the correct amount of petrol is dosed to the engine over a wide range of operating conditions. In this way, cost effectiveness is optimized and potentially harmful side effects (e.g. non-compliance with emission standards or engine damage) are avoided. Likewise, a little extra attention paid to the correct dosing of desalination chemicals will quickly pay for itself in optimizing chemical usage and achieving efficient and trouble free plant operation.

This chapter reviews the history of dosing systems including the need for chemical dosing and the design of the systems. It then seeks to identify the key factors for each chemical influencing the design of modern systems to ensure the best possible performance for each chemical dosed.

## 2. History

Chemicals are dosed to desalination plants to solve a variety of problems such as scale formation, corrosion, foaming and biofouling.

In the early days of desalination, plants were often not treated at all or were treated for scale control with such strange substances as potato peelings. Usually, these units were constructed in pairs so that each unit could operate whilst the other was descaled offline.

As the design of distillers improved, the need for more effective means of scale control became apparent since scale became the limiting factor in water production. Acid injection was first tried in an attempt to control scale and proved very effective in preventing the deposition of calcium carbonate within the distillers. However, severe plant corrosion often occurred due to poor control of acid injection and the deposition of calcium sulphate scale occurred due to inadequate control of concentration ratio.

The next attempt at controlling scale was by using powdered blends based on sodium polyphosphate, which had been identified as a "threshold" scale inhibitor. This type of product was first used at Shuwaikh, in Kuwait, supplied as a proprietary product (PD8) which was dissolved in distillate to make a dosing solution and dosed by a vacuum drag technique.

| Chemical | Deviation | Penalty |
|---|---|---|
| Acid | Too low | Scale formation |
| | Too high | Corrosion (may be severe) |
| Sulphite | Too low | Corrosion |
| | Too high | Excessive cost. May also be a risk of calcium sulphite scale |
| Chlorine | Too low | Biological fouling (e.g. shellfish) |
| | Too high | Corrosion (may be severe). Will destroy sulphite residual. |
| Ferrous sulphate | Too low | Corrosion of aluminium brass components |
| | Too high | Excessive cost. May also cause the deposition of iron containing scales |
| Scale inhibitor | Too low | Scale |
| | Too high | Excessive cost |
| Antifoam | Too low | Foaming and carryover |
| | Too high | Excessive cost. May promote foaming at very high levels |

Table 1. The effects of poor dosing control.

However, it was soon found that PD8 was only effective up to a top brine temperature of 90°C due to the hydrolytic instability of the polyphosphate component. Also, the control of scale, due to inadequate design and control, was poor by modern-day standards. Often, only 30 days running time was achieved before the design fouling resistance was reached and an acid descale was required.

In the 1970s, the quest for increased distiller efficiency provided a driving force for increasing the top brine temperature and this again raised the question of scale control. As PD8 would not provide the necessary degree of control, even when sponge ball cleaning was fitted, acid treatment was again used. However, the same old problems with increased corrosion rates and calcium sulphate scale persisted. Acid treatment is inherently more corrosive than additive treatment but the poor control of acid dosing systems made this even worse.

The advent of modern liquid additives, based on organic phosphonates or polymers, provided the key to good scale control coupled with acceptable corrosion rates. These products were hydrolytically stable, permitting operation at high temperatures and the fact that they were supplied in liquid form also meant they were easier to handle, making dosing control more effective. One important advance was that these products were liquid and could be dosed neat, eliminating errors due to inaccuracy with making up dilute dosing solutions. Antifoams were either dosed separately or, if compatible with the dilute scale inhibitor, were added to the same dosing tank as the scale inhibitor.

In addition to the above, other chemicals are conventionally dosed to distillers for specific reasons. Chlorine is often dosed to seawater intakes for the control of shellfish and seaweed. Sodium sulphite is sometimes dosed to further reduce corrosion rates and iron salts are sometimes dosed to reduce the corrosion of aluminium brass components.

## 3. Overview of Dosing Systems

Dosing of liquid chemicals is almost always best achieved using positive displacement pumps, properly sized for the job. However, some designs of evaporative plant have parts of the process which are under vacuum and, in this case, it may be possible to introduce the chemical using vacuum drag.

Vacuum drag may be used where the plant is of the evaporative, recirculating type and parts of it operate below atmospheric pressure. The vacuum provides the motive force for the dosing solution to be drawn from the dosing tank into the plant and the flow of the chemical is regulated by a manually adjusted valve. Monitoring of the flow is accomplished using a visual flowmeter, such as a rotameter, or by measuring the fall in chemical level within the dosing tank. This method was often used in early plant designs because it has the advantage of simplicity. It does not require expensive dosing pumps to be installed, no electricity supply is needed and there is little to go wrong. However, it does have the major disadvantage that it lacks accuracy. This was acceptable in the early days when relatively high additive dose rates were the norm but is not acceptable today when the drive to cut costs means that minimum dose rates are often used, giving very slim margins of safety.

Positive displacement dosing pumps require an electricity supply and routine maintenance is essential to ensure reliability. However, when operated correctly, they provide much more controllable and reliable dosing as required by modern highly efficient MSF units. To avoid loss of pump prime, dosing stations using positive displacement pumps should always be designed to provide flooded suction to the pumps.

Construction materials used for dosing systems need to be compatible with the chemical being dosed and advice should always be obtained from the chemical supplier. A corrosion resistant material, such as grade 316 L stainless steel, should be used for pumps and dosing lines but plastics may be used where applicable. Carbon steel should be avoided since corrosion will cause leaks and the resulting debris will cause blockages, resulting in unreliable dosing. Tanks should be constructed of stainless steel, plastics or rubber-lined carbon steel and, particularly if used for acid, should be fitted with a bund which will contain at least 110 per cent of the full tank volume.

Tanks should also be fitted with a cover to prevent ingress of extraneous matter which would otherwise block pipework and pumps. Due consideration should also be given to the task of filling the tanks with the chemical; access should be good and suitable lifting gear or transfer pumps should be available where the chemical is supplied in drums. In general it is preferable, where the throughput of chemical warrants it, to invest in bulk handling facilities so that the chemical can be pumped directly from an intermediate bulk container (IBC) or bulk tanker into the dosing tank. This minimizes manual handling resulting in a useful improvement in safety.

Adequate filters should be fitted to dosing offtakes to protect dosing pumps from blockage or damage. These should be regularly cleaned as part of the routine maintenance schedule. Tanks should be fitted with a sight glass to enable dosing rates to be verified by dead reckoning and to facilitate the calibration of dosing pumps.

For convenience, and to handle the large volumes of dilute dosing solution used on some sites, ring mains are installed so that large central tanks can be used for making up the dosing solution for distribution to individual plants. Where this type of system is in use, it is advisable to have a day tank for each individual desalination plant. This ensures that if a blockage should occur, starving an individual unit of dosing solution, it is more easily noticed and corrected. In this context, it should be noted that orifice plate meters, sometimes used for measuring the flow of dosing solution from a ring main directly into individual plants, require a high degree of maintenance if they are to be reliable.

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**Bibliography and Suggestions for further study**

The subject of chemical dosing systems for desalination applications is rather specialized and it is difficult to find any directly relevant papers. The following references are therefore presented as useful, general further reading and to provide reference data which may be of practical value to designers and operators.

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