THE PROBLEM OF NON-CONDENSABLE GAS RELEASE IN EVAPORATORS

Heike Glade and Klaus Genthner
University of Bremen, Germany

Keywords : Evaporators, Consideration, Gas Release, decarbonation, Deaerators, Non-condensable

Contents

Summary

The presence of non-condensable gases in desalination distillers, particularly carbon dioxide, nitrogen, oxygen, and argon, is caused by air leakages and the release of dissolved gases from the evaporating brine. The gases which are molecularly dissolved in seawater, namely nitrogen, oxygen, and argon, can be removed almost completely in a deaerator. When no deaerator is provided, they will be released from the evaporating brine and must be extracted by adequate venting. Carbon dioxide, which reacts chemically in seawater, cannot be removed by simple deaeration. For the removal of carbon dioxide, the addition of a strong acid to the feedwater and a decarbonator are required. Without decarbonation, carbon dioxide is released from the brine during evaporation and has to be extracted by adequate venting. The presence of non-condensable gases affects the heat transfer for condensation, energy consumption, operation, and material lifetime of desalination distillers.

1. Introduction

As in many other industrial distillation processes, the presence of gases which do not condense at the operating conditions of the process, in the following designated as "non-condensable gases", is a serious problem in seawater distillation. Since removal of non-condensable gases is vital to the efficient operation of all desalination distillers, each plant is equipped with a venting system. Deaerators and decarbonators are used in certain cases to remove the gases from the feedwater before they enter the evaporator.

The knowledge of which gases are present and in what quantities, how the quantities are distributed between the individual distiller stages, and how the gases affect the performance, energy consumption, and material lifetime of the distiller is of great importance in the design, operation, and costs of a desalination plant.

In the following, the sources of non-condensable gases, the effects of the gases in

desalination distillers, and the cases that require consideration of the gas release are summarized.

2. The Sources of Non-condensable Gases in Evaporators

The presence of non-condensable (NC) gases in seawater evaporators is caused by the leakage of ambient air through flanges, man-holes, instrumentation nozzles, etc., into the parts of the evaporator operating under vacuum (Gregorzewski et al. 1993) and the release of dissolved gases from the evaporating brine.

All the gases present in the atmosphere dissolve in seawater to a greater or lesser extent. As far as quantity is concerned, only four gases are of interest for engineering applications, namely nitrogen (N_2), oxygen (O_2), argon (Ar), and carbon dioxide (CO_2). Notwithstanding its low concentration in the air, it is mainly CO_2 which determines the nature of seawater to an outstanding degree. This arises from the fact that CO_2 is involved in the carbonate system of seawater which regulates the pH of the seawater.

The released NC gases can be classified into the following.

(a) Those which are molecularly dissolved in seawater and do not react chemically such as N_2, O_2, and Ar.
(b) Those which react chemically in seawater and are produced during the desalination process itself such as CO_2. Under the alkaline conditions prevailing in seawater, only a small proportion of the total inorganic carbon content in seawater is present as molecular CO_2 gas and the major proportion is chemically combined in bicarbonate HCO_3^- and carbonate CO_3^{2-} ions. During the desalination process CO_2 is released from the evaporating brine. Thus, the equilibria between HCO_3^-, CO_3^{2-}, and CO_2 in the brine are disturbed and new molecular CO_2 is produced by chemical reactions.

-
-
-

Bibliography and Suggestions for further study

Al Sum E A, Aziz S, Said M S and Heikal O (1993) Vapour-side corrosion of copper base condenser tubes of the MSF desalination plants in Abu Dhabi. *IDA and WRPC World Congress on Desalination and Water Treatment* (Proceedings of the World Congress, Yokohama, 1993), Vol. 1, pp. 501-511, Vol. 97 (1994) pp. 109-119. Elsevier Science B.V. Amsterdam, the Netherlands.

Bharadwaj J and Raghavan V R (1984) Influence of noncondensables on modern thermal desalination. *Desalination* 49, 357-365.

Chisholm D (1981) Modern developments in marine condensers: non-condensable gases: an overview. *Power Condenser Heat Transfer Technology* (ed. P J Marto and R H Nunn), pp. 95-142. New York: Hemisphere.

Genthner K, Khalaf S, Ruehle W and Seifert A (1987) The effect of preheater design on corrosion, heat transfer and operation of MSF-distillers. *Desalination* 65, 171-186.

Genthner K and Seifert A (1991) A calculation method for condensers in multi-stage evaporators with non-condensable gases. *Desalination* 81, 349-366.

Genthner K, Wangnick K, Bodendieck F and Al-Gobaisi D M K (1997) The next size generation of MSF evaporators: 100 000 m^3/d. Part I. *IDA World Congress on Desalination and Water Reuse* (Proceedings of the IDA World Congress, Madrid, 1997), Vol. 1 (ed. Centro de Estudios y Experimentacion de Obras Publicas), pp. 271-293. Madrid: Ministerio de Fomento Centro de Publicaciones.

Gregorzewski A, Genthner K and Seifert A (1993) The effects and limitations issued by non-condensible gases in sea water distillers. *Desalination* 93, 207-234.

Jensen M K (1988) Condensation with noncondensables and in multicomponent mixtures. *Two-phase Flow Heat Exchangers, NATO ASI Series E*, Vol. 143 (ed. S Kakac, A E Bergles and E O Fernandes) pp. 293-324. Dordrecht, Boston, London: Kluwer Academic Publishers.

Khan R A (1972) Effect of noncondensables in sea water evaporators. *Chemical Engineering Progress* 68(7), 79-80.

McGregor I D and Karim S (1995) Tube corrosion in high temperature stages of MSF distillers. *IDA World Congress on Desalination and Water Sciences* (Proceedings of the IDA World Congress, Abu Dhabi, 1995), Vol. 5, pp. 301-307. Abu Dhabi: Abu Dhabi Printing and Publishing Co.

Mc Gregor I D and Moore H (1992) Improvements in venting of some MSF distillers. *DESAL '92. Arabian Gulf Regional Water Desalination Symposium* (Proceedings of the Symposium, Al Ain, United Arab Emirates, 1992),Vol. 1, pp. 11-22. Abu Dhabi: Abu Dhabi Printing and Publishing Co.

Oldfield J W and Todd B (1987) Vapour side corrosion in MSF plants. *Desalination* 66, 171-184.

Rabas T J (1985) An improved MSF condenser design. *Desalination* 55, 169-184.

Rabas T J and Mueller A C (1986) Effect of noncondensable gases and vent flow rate on the thermal performance of single-pass X-shell condensers. *Heat Transfer Engineering* 7(3-4), 35-42.

Wangnick K, Genthner K and Al-Gobaisi D M K (1997) The next size generation of MSF evaporators: 100 000 m^3/d. Part II. *IDA World Congress on Desalination and Water Reuse* (Proceedings of the IDA World Congress, Madrid, 1997), Vol. 1 (ed. Centro de Estudios y Experimentacion de Obras Publicas), pp. 295-324. Madrid: Ministerio de Fomento Centro de Publicaciones.