MSF Plant Key to Libyan Chemical Complex

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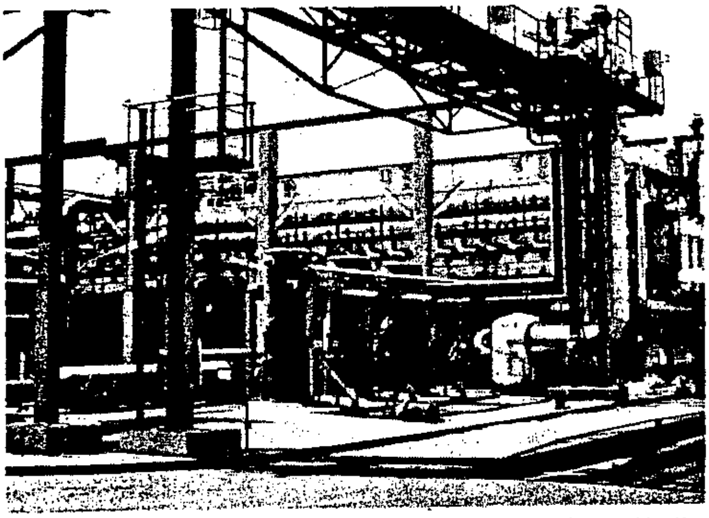
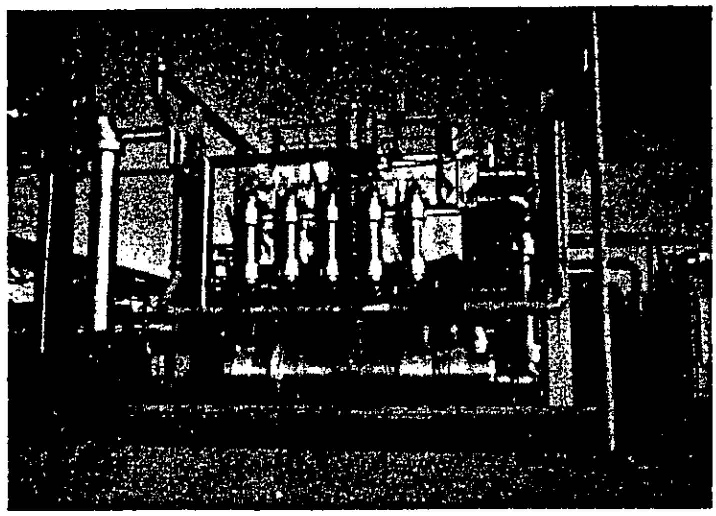




Side view (above) and brine end heaters (right) of the MSF plant at Abu Kammash which produces water at 170m³/h.

MSF plant key to Libyan chemical complex

A multi-stage-flash (MSF) desalination plant and a three-stage evaporation crystallisation plant have been successfully installed in Libya as the lynch-pins of a large chemical complex for the manufacture of vinyl and polyvinyl chlorides.

The plants also have been designed to produce salt for refining as table salt and also for use in electrolysis. Built at Abu Kammash on the Mediterranean coast west of Tripoli, the $29M salt-removal complex was designed by West German firm Standard-Messo Duisburg, better known as vacuum engineers in the steel industry.

Lack of available local fresh water sources meant that all requirements for potable and process water had to be met by seawater desalination. Thus the plant had to be designed for the utmost reliability, and all processes, control systems and components were selected with this in mind.

The salt-removal complex produces water at $170m^3/h$, of which $120m^3/h$ comes from the MSF plant and the remainder from the evaporation crystallisation plant. Of this $170m^3/h$, $30m^3/h$ is for potable purposes with a maximum of 500mg/l total dissolved solids. The remainder is process water with a maximum of only 100mg/l tds.

Scaling and corrosion having been recognised as two principal causes of failure in MSF plants, optimum material selection and plant layout were considered of vital importance by the designers.

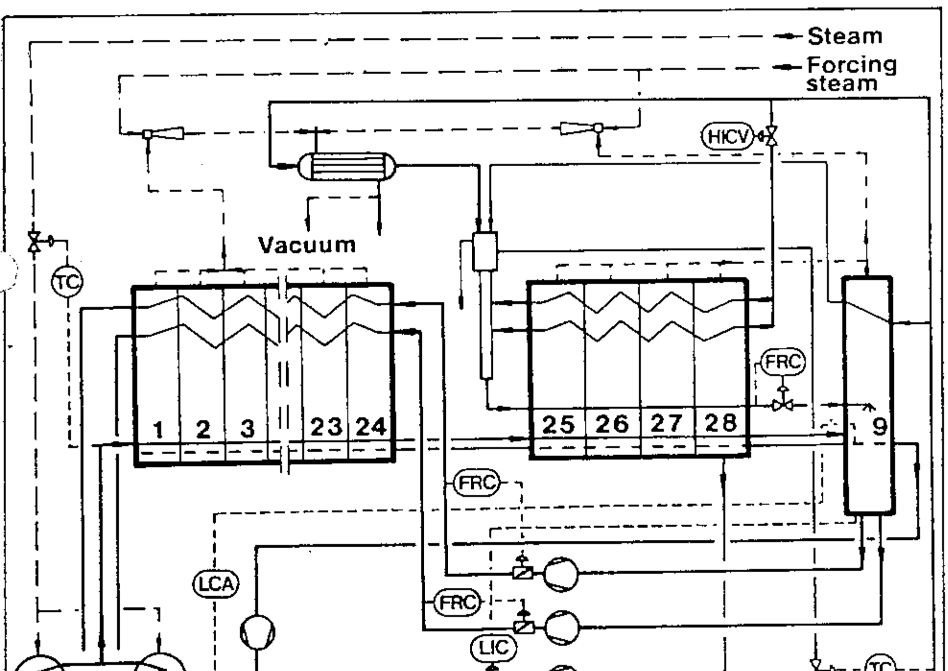
To minimise corrosion, the heat exchangers in the refrigeration and heat-recovery sections were constructed using a cupronickel/iron alloy (CuNi:10Fe) for the tubes, and a harder alloy (CuNi:30Fe) was used for the tube bottoms. The entire evaporation tank was also made of CuNi:10Fe, while Monel was selected for the demisters.

A rubber-lined steel structure was used for the turn-round caps and water chambers in the seawater section and for the brine circulation system. So far operation has been corrosion-free.

It was decided to split the heat-exchanger surface for the plant into two units which could be operated independently. Each half has its own cooling water inlet, circulation pump and end heater which enables the heat exchanger tubes to be cleaned without interruption of operation.

When operating normally, the plant has a maximum brine temperature of 90°C. However, if this is raised to 98°C, the plant can still be operated to 85% capacity even with one heat exchanger disconnected and thus only half the normal condensation surface. Thus cleaning and maintenance work on the condensate section can be carried out without a significant effect on distillate production.

If heat exchanger surfaces do become encrusted with carbonates or hydroxides, they can be cleaned independently using



Flow diagram of the MSF desalter.

diluted hydrochloric acid, allowing one line to be on full production while the other is cleaned.

The solution sides of the heat exchangers are set in a two-way arrangement to provide a flow velocity of 1.8m/s and this results in a horizontal arrangement of the brine overflow lines from stage to stage. To equalise flow and evaporation rates in the first stage, the heated brine is fed in parallel via five feeding tanks.

During acceptance tests in 1980, the MSF plant showed a remarkable improvement in performance ratio from 8 to 9.4 because the fouling factor for scaling included in the calculations proved unnecessary. The heat exchanger surfaces have experienced no scale during their two years of operation.

Scaling was also visualised as a problem for the three-stage evaporation crystallisation plant used for salt recovery.

Feed for the plant comes from a natural *sabkah* or salt lake and the evaporation output of $50m^3/h$ is reached by applying [illegible]m^3/h of live steam. Salt output is 15t/h of which 5t is table salt and 10t salt of electrolysis quality. The brine used as a feed contains 224g/l of NaCl and almost 120g/l of other salts. The brine reproduces continuously through diffusion of seawater through the lower salt layers.

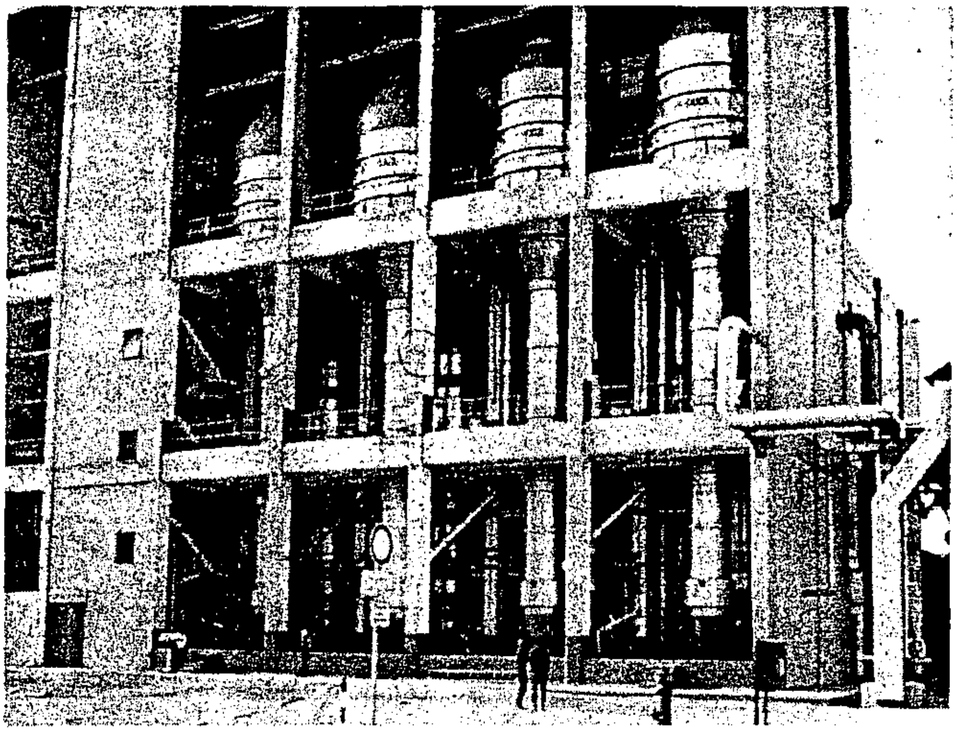
Scale is caused mainly by precipitation of calcium sulphate (gypsum) during crystallisation of the NaCl. To avoid this, a circulation was set up in the plant to keep the gypsum at a suspension density of several percent. Thus $CaSO_4$ crystallisation was controlled and scaling of the heat exchanger surfaces has not occurred.

To recover a pure vapour condensate, demisters were included in all evaporation stages ensuring impurities lower than 10mg/l dissolved solids. The distillate produced is conveyed to the desalting plant, while the salt is cleaned to the required quality. NaCl and $CaSO_4$ are removed from each other in hydroclones and solid impurities are removed by multistage counterflow washing using seawater.

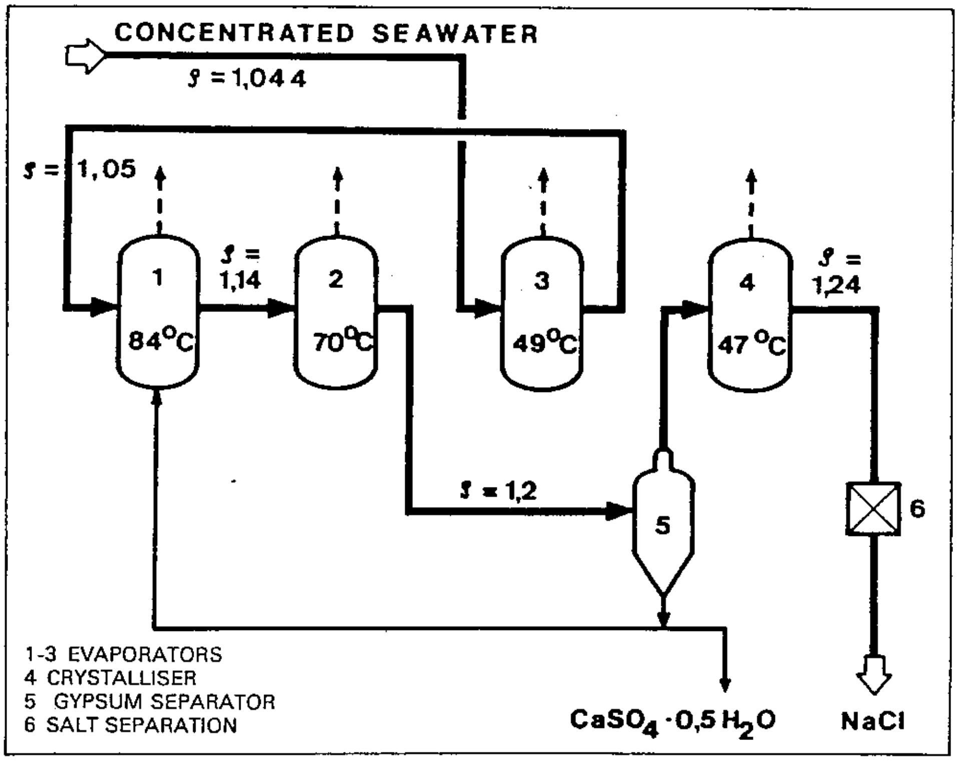
The salt destined for electrolysis is taken to the saturators while still wet; the table salt is dried and sprayed with anti-caking additives before packing.

If no brine is available for any reason, the discharge from the MSF plant can be used for salt recovery, with a respectively higher evaporation capacity and increased danger of $CaSO_4$ scaling.

Supersaturation-produced scaling in the evaporators can be avoided if, on one hand, the suspension density is maintained at around 10% mass, and, on the other, the especially suitable hemihydrate crystal $CaSO_4 \cdot \frac{1}{2}H_2O$ is being crystallised. Precipitation of this crystal is adjustable in salt solutions by choosing appropriate concentration/temperature fields.



View of salt evaporator plant and (below) flow diagram.



According to the plant's operation scheme, the hemihydrate is in the precipitating and constant solid phase due to the solution flow in the first two stages. In the third evaporation stage, however, preconcentration takes place, but not crystallisation. After separation and partial return of the $CaSO_4 \cdot \frac{1}{2}H_2O$ crystals into the pre-evaporators, the desired sodium chloride quality for electrolysis is produced in the last stage. Scaling with the hemihydrate crystal has not yet occurred in plant arranged this way.

Standard-Messo Duisburg has three plants of this type now operating, two in Kuwait and one in Abu Dhabi. The largest produces $100m^3/h$ of distillate and 4.5t/h of electrolysis salt from the discharge brine of an MSF plant. Its three-stage design consists of three fixed-circulation evaporators — two concentration stages and one crystalliser with diameters of 4.8m, 6.5m and 6.5m respectively. The heat exchangers have an exchange surface of $900m^2$ each while the last stage has an end condenser with a surface area of $1,200m^2$.