MARBELLA SEAWATER DESALINATION PLANT: CONSTRUCTION AND START - UP EXPERIENCE

AUTHORS: **Juan María Sánchez, Juan Velasco, Jose M. Kindelan and Jaime Andreu**

ABSTRACT:

Marbella seawater desalination Plant produces 8 x 6,875 m^3 / day of potable water for the area of the Costa del Sol that is a tourist destination. The most important cities in Spain for tourism lie within this area, including luxury resorts and beaches.

This paper includes a description of the various special characteristics of this Plant. Firstly, total production of potable water is 55,000 m^3 / day, making this the biggest Plant of its kind in Europe, and it is amongst the largest in the world to make use of the reverse osmosis process. The Plant was built in a very short period, with only 8 months separating the signing of the contract and start - up of the first line. The contract is for construction and financing, and operation and maintenance type.

The main source of water for the area of the Costa del Sol is Conception reservoir. However, the previous five years had been the driest of the century, and the water level in this reservoir was very low. The Regional Authority of the Costa del Sol therefore decided to install a desalination Plant to ensure supplies of water in the future, whatever climatological conditions prevail. The sea water desalination Plant will be able to supply the current and future development of the local tourism industry.

This paper describes the most important features of the Plant and seawater intake. It also gives basic design and performance data, while underlining the fact that specific energy consumption is the lowest of which we are currently aware.

1.- INTRODUCTION

The Regional Authority of the Western Costa del Sol groups the municipalities of Benahavis, Benalmadena, Casares, Estepona, Fuengirola, Istan, Manilva, Marbella, Mijas, Ojen and Torremolinos. All of these are located in one of the most important areas for tourism in Spain, in terms of the number of visitors as well as the level and quality of the tourism involved. The region also contains several international standard golf courses. The demand for water is therefore very high and increasing. The necessary rates of flow are 120,000 m^3 / day during the low season and 210,000 m^3 / day during the high season.

The recent cycle of drought showed that the tourism industry, which is highly sensitive to lack of water, could be seriously affected. The regional authorities therefore decided to install a seawater desalination Plant that would in all cases be able to supply 30% of the water needed for consumption during the high season. This ensures that all needs for water are met even in the least favorable circumstances.

To prevent the water supplied in the region from becoming too expensive, several alternative means were studied. These included Multiple Effect Evaporation and Multiple Stage Evaporation (both using cogeneration), Reverse Osmosis producing its own electricity and Reverse Osmosis using an external source of electricity. The last of these options was found to be the most economical from the investment cost point of view, and also has the lowest environmental impact. The latter consideration was highly important, as this is an area for tourism rather than industry.

The contract entered into by the Regional Authority of the Costa del Sol and the company which built the Plant is of the "Grant" type, i.e., construction was financed by the builder, who also took charge of running the Plant, charging the Regional Authority for the cost of each cubic meter produced. Given these aspects of the contract, the design was created with the aim of optimizing the costs of water production, using equipment which gives rise to savings (in labour costs, energy consumption, etc.), as well as in maintenance (the types of material used in pipes, valves, tanks, pumps, etc.).

2.- THE LOCATION OF THE PLANT

The Plant is located at a height of + 24 m above sea level, approximately two kilometers from the coast and close to the Potable Water Treatment Plant (ETAP) where the water supplied to Municipalities belonging to the Authority is treated. As the El Tejar stream crosses the land here, this had to be channeled under the process building. The seawater inlet is located at the mouth of the river Verde, and water is pumped to the plant through a pipe running along the right hand bank of this river.

The water produced is pumped to the storage tank of the Potable Water Treatment Plant, from which and mixed with water from other sources it is distributed to the whole region. This tank is at + 80 m above sea level.

Waste brine is gravity fed back into the sea through a pipeline running alongside the seawater intake pipe along the right hand bank of the River Verde.

3.- DESCRIPTION OF THE INSTALLATIONS

The plant currently produces 55,000 m^3 / day, which could be increased to 61,875 m^3 / day. To this end, eight lines each having a capacity of 6,875 m^3 / day have been installed, with the possibility of adding one more. Conversion is at 45%, and the high pressure pumping system has a Pelton - type turbine to recover the energy of the waste brine.

a) The seawater intake

The seawater intake is designed to supply the water for the plant when enlarged as planned, which will require a total of 5,730 m^3 / hour. The seawater inlet consists of a 2,000-mm diameter glass fibber reinforced polyester submarine pipe, which runs 700 m into the sea. This pipe is connected to an inlet well, where three centrifugal pumps force the water up to the desalination plant, while one pump remains in reserve.

At the end of the submarine pipe, as well as in the inlet well, it is possible to carry out chloration by proportioning sodium hypochlorite in shock treatment dosages, for the purpose of desinfection as well as to prevent increases in the number of mollusks. Hypochlorite is also regularly added to the pipe taking seawater to the plant in controlled doses, such that at the outlet of the sand filter there is 1 ppm of free residual chlorine.

b) The processing plant

The Figure-1 shows the flow diagram o process. Sulfuric acid may be added at the point where the seawater inlet pipe enters the plant, with the aim of controlling

its pH. The seawater first enters an intermediate storage tank, which serves to regulate the water between the seawater inlet and the plant itself.

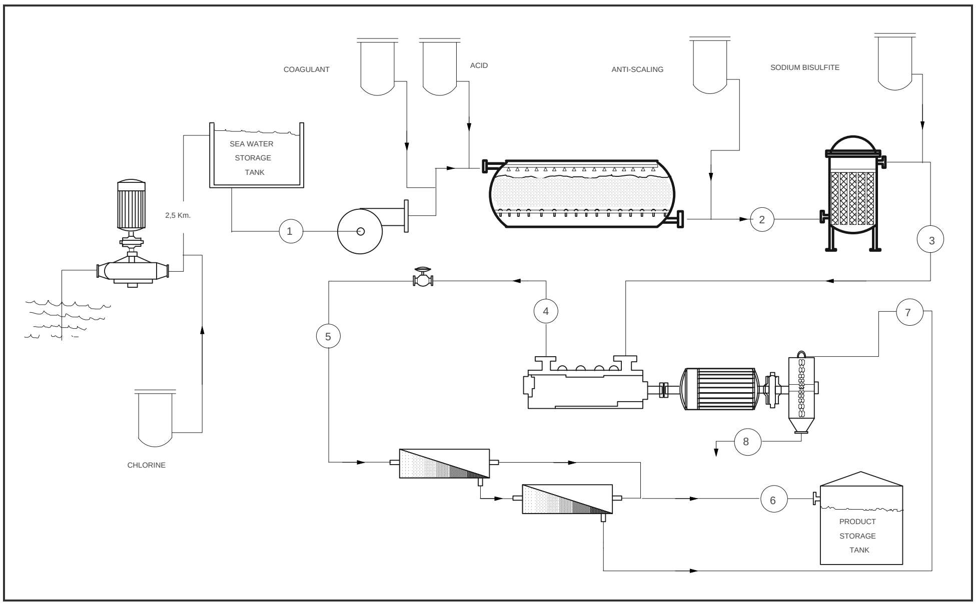
From this tank the water is pumped through 16 closed pressure type sand filters. Before it enters the sand filters it is possible to dose the seawater with a coagulant.

The design of the filters is such that the plant is able to work at 100% capacity with two sand filters in washing mode.

After passing through the filters the water is dosed with dispersant, Permatreat-191 in this case, after which it passes through 12 microfilters of FILTERITE polypropylene of the "Duo-Fine" type, 5 microns absolute. It is then dosed with sodium bisulphite to eliminate any residual chlorine and to attain a reducing atmosphere in the seawater before it enters the membranes.

All nine high pressure pumps share a single inlet. Eight of these pumps function while the ninth remains in reserve. They are manufactured by the INGERSOLL DRESSER PUMPS Company, and are made of IR-885. Each one pumps the seawater into a frame of membranes, each of which is formed of two stages of 81 permeators each, of the "TWIN" B-10 6882 TM type by DUPONT - PERMASET. Waste brine is piped to the PELTON type energy recovery turbine, designed by CALDER and made of DIN-1.4460. The high pressure pipes of the pump outlet and brine return system are made of AISI-904L with high molybdenum content.

Figure-1.- Flow Diagram of process.



The fresh water is collected and sent to a 3,000-m3-storage tank. Water is taken from this tank for plant services, for the chemical cleaning of permeators and for dissolving chemical products. Four pumps, one of them in reserve, have their inlets in this tank. They pump the water to the Potable Water Treatment Plant tank, where it is mixed with the other water used for supply, and from which it is then distributed to the municipalities belonging to the Regional Authority.

c) Control System

The Plant has a fully automatic control system, using a FISCHER - BAILY Distributed Control System. This supplies information on everything that happens in the installation, including the seawater inlet and the process. The system is equipped with a series of alarms and safety systems that simplify working, as well as being able to compensate for human error. It is able to take decisions in situations in which plant equipment is threatened, restoring a safe situation. It is also possible to carry out the start - up of all the equipment from the control room, and to this end sufficient data gathering sensors have been installed to provide all the information that is necessary for start - up, thereby reducing the cost of the water produced.

d) Other features

Given that the plant is located in one of the most important areas for tourism in Spain, and more specifically in an upper class area, special care was taken to ensure that environmental impact was kept to a minimum. To this end a great deal of acoustic insulation was added, so that outside the installations the noise level is no higher than is usual. On the other hand the visual impact of the installations was reduced to a minimum, using architecture to blend the buildings into their surroundings. An example of this was the channeling of the Tejar Stream under the process building, which was achieved by creating the appearance of a stone bridge. A "Water Information Center" installed in the Plant has the aim of making the Desalination Plant a center for research, education and tourism.

4.- MAIN CHARACTERISTICS

a) Seawater

The basic design of the reverse osmosis system was based upon chemical analysis of the seawater. The results of this analysis were as follows:

TABLE 1

PHYSICAL AND CHEMICAL ANALYSIS					
TURBIDITY		U.N.F.	pH	7.90	
COLOUR		PtCo	CONDUC. 20		mhos/cm
SMELL			T.D.S.		ppm
APPEARAN.			ALKALINITY		ppm CO3Ca
TEMP.	17 to 25	ºC	T.A.C.		ppm CO3Ca
CHEMICAL COMPOSITION					
ELEMENT	ppm	eq/l	ELEMENT	ppm	eq/l
Ca++	471.00	23.55	SO_4=	2,488.00	51.83
Mg++	1,355.00	111.98	Cl-	20,530.10	578.31
Na+	11.177.00	486.2	CO_3H-	208.00	3.41
K+	478.00	12.21	F-	2.20	0.12
Ba++	0.20	0.00	Br-	0.00	0.00
Sr++	7.50	0.17	I-	0.00	0.00
Fe++	0.00	0.00	NO_2-	0.00	0.00
NH_4+	0.00	0.00	NO_3-	8.00	0.13
Ag+	0.00	0.00	CO_3=	0.00	0.00
Mn++	0.00	0.00	PO_4=	0.00	0.00
Zn++	0.00	0.00	S=	0.00	0.00
Cu++	0.00	0.00	SiO_2	3.80	0.06
TOTAL	13,480.70	633.87	TOTAL	23,240.10	633.86

On the other hand, the Silt Density Index of this water (SDI) was measured with an automatic gauge before the sand filters, after the sand filters and after the cartridge filters, with the following results:

Point of measurement	SDI value
Before the sand filters	4.1
After the sand filters	2.5

After microfiltration 1.3

b) Energy consumption

This was one of the factors that it was wished to reduce to a minimum, and the whole design was optimized with this aim. Maximum efficiency pumping equipment was therefore installed, together with the above - mentioned PELTON turbines, which are more efficient than FRANCIS type turbines. They are able to recover all of the energy contained by the brine, over a broad range of rates of flow and outlet pressures, these varying during the working of the plant depending on how fouled the permeators have become. The specific consumption by pumps is shown below:

* **Process pumping .... 3.99 Kwh/m^3**
  - Intermediate pumping 0.36 Kwh/m^3
  - High pressure pumping 3.62 Kwh/m^3
  - Pretreatment and others 0.01 Kwh/m^3

In that figures we are discounted the consumption which arises due to the particular needs of the plant (as it is 2 km from the coast at a height of 24 m, and the product has to be pumped up to a height of 80 m) then the consumption of the process itself is less than 4 Kwh/m^3. This figure is very low in comparison with other plants of a similar size.

c) Chemical treatments

Although the plant is equipped to work with a range of chemical products, in practice it has functioned using the following additives:

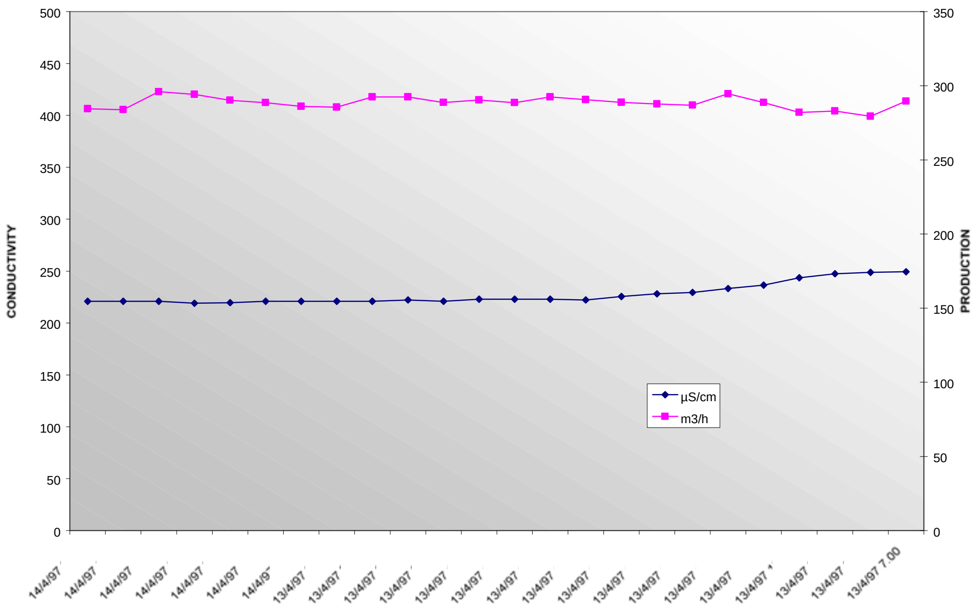
* Sodium hypochlorite for disinfecting the seawater.
* Sodium bisulphite for eliminating final residual chlorine and to correct the pH.
* Permatreat 191 anti-scaling agent.

Given the quality of the seawater obtained until now, it has not been necessary to add doses of coagulant or sulfuric acid, so that once the plant was brought into full working conditions the chemical treatment used was optimized in the way described. However in the next time, with the storm and other sea conditions, can be necessary to use the total pretreatment prior.

5.- OPERATIONAL DATA

Following we present several Figures with the Production flow and Conductivity of fresh water, stream by stream during the start-up period.

STREAM Nº 1



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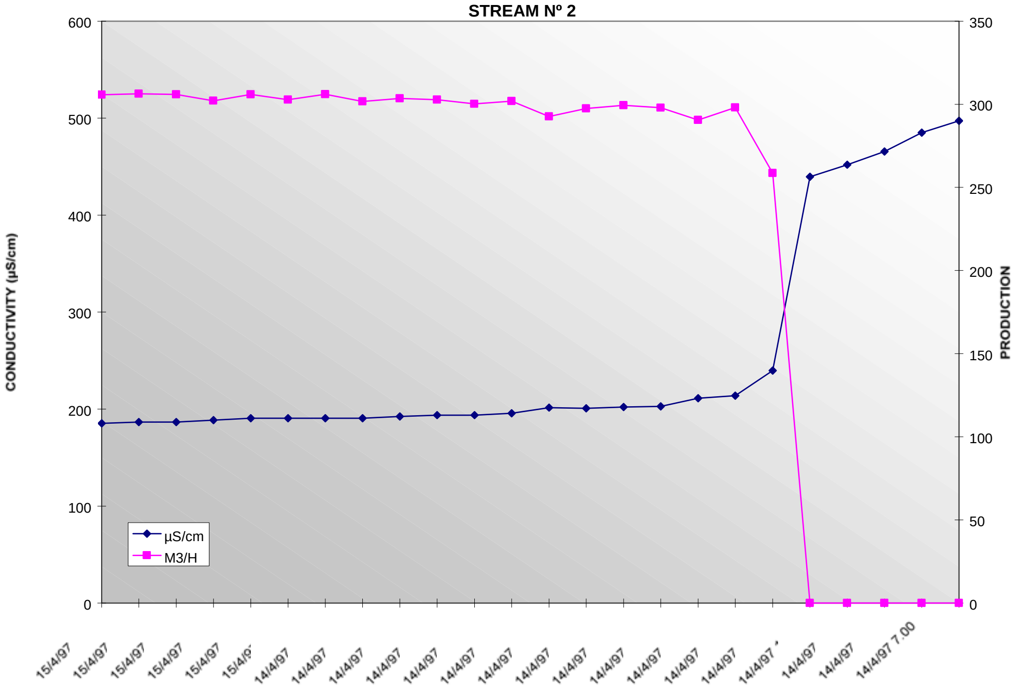

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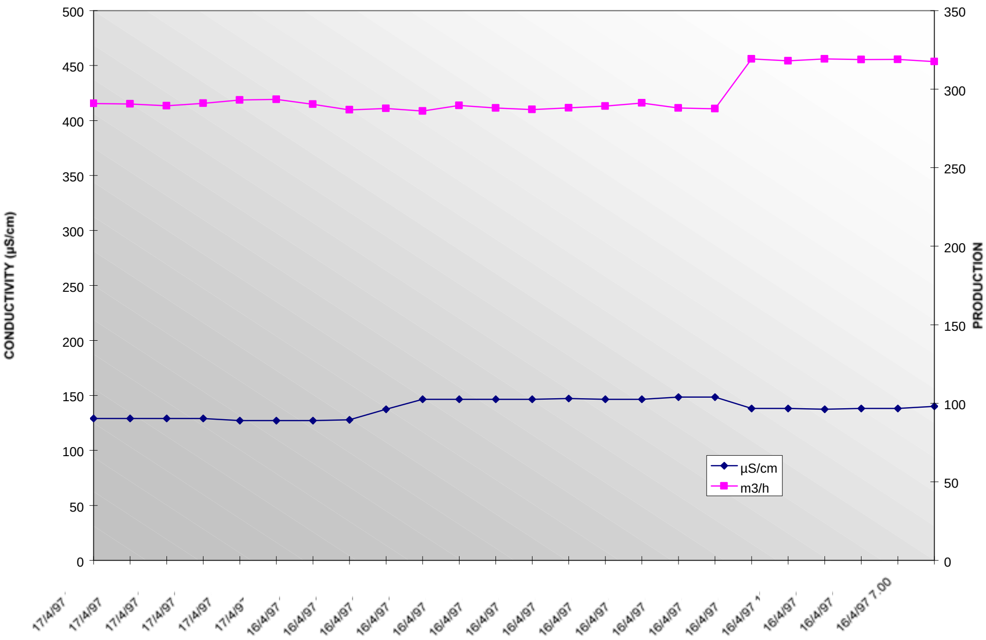

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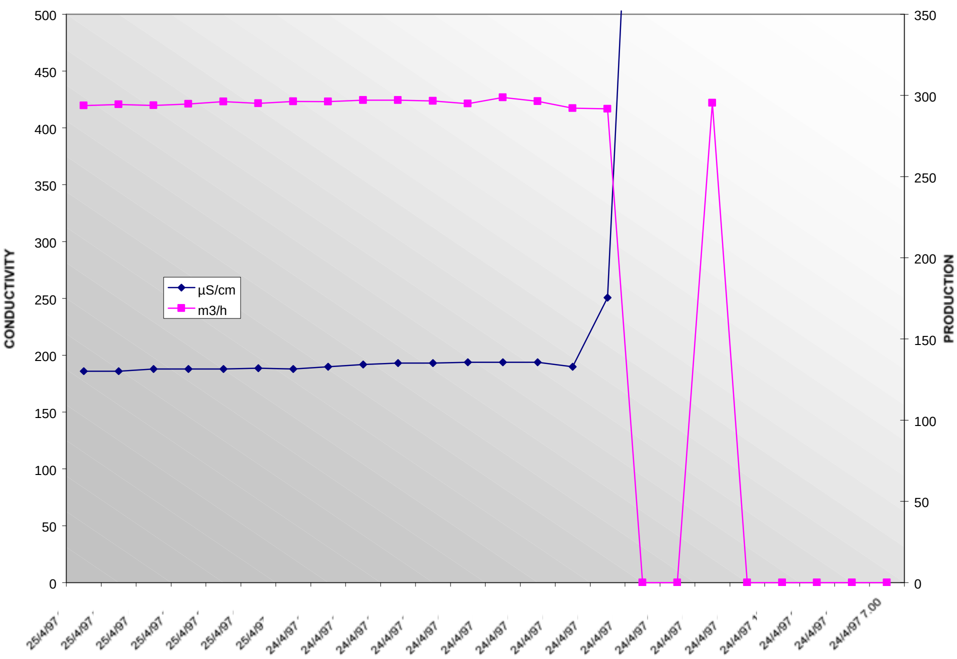

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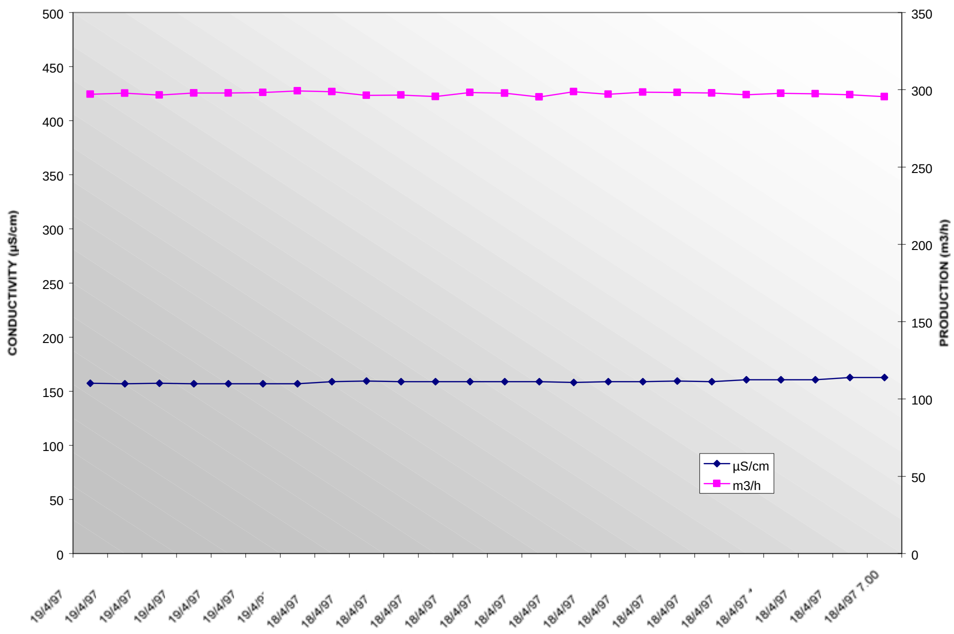

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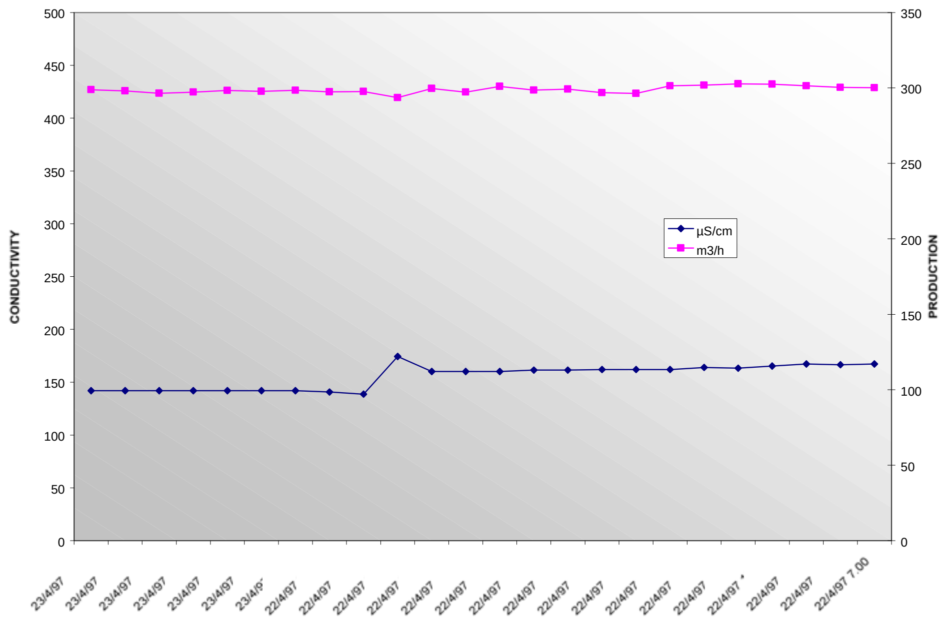

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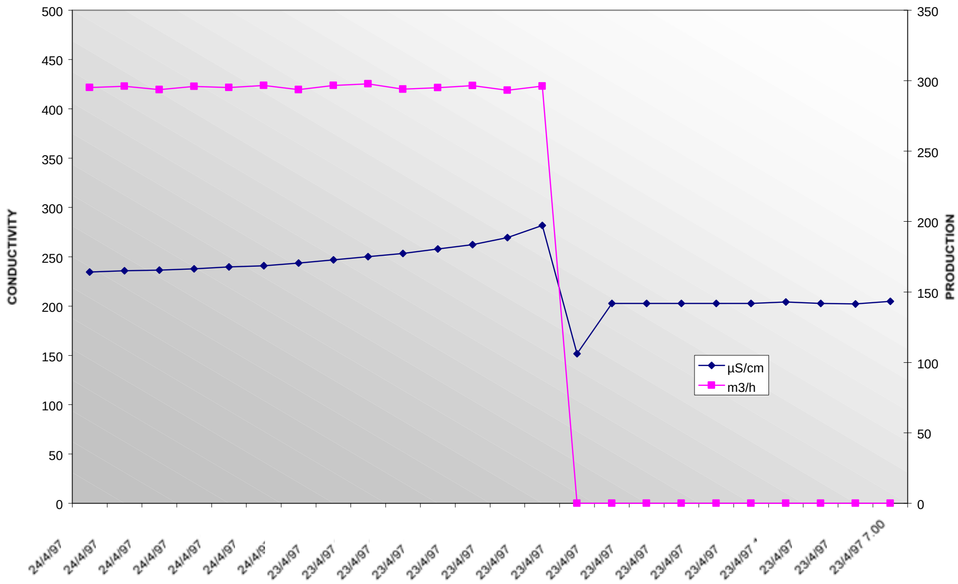

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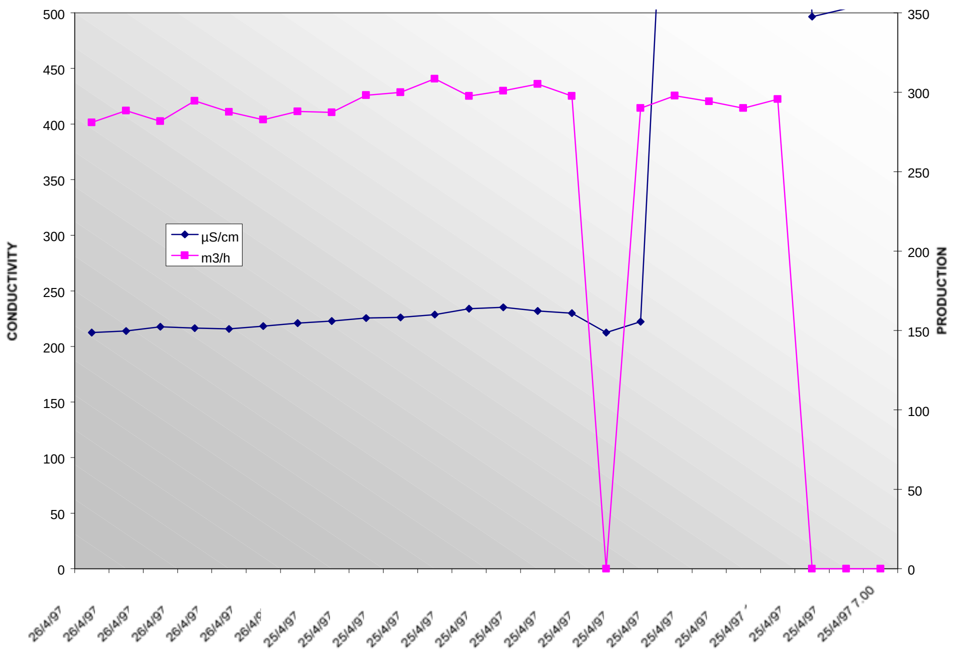

Plant operational data is shown per production line. The average values attained during the initial period of working were as follows:

* Production per line: 295 m^3/hr = 7,080 m^3/day
* Rate of flow of seawater: 676 m^3/hr.
* Conversion factor: 43.6 %
* Inlet pressure: 54.1 bar.
* Reject pressure: 51.7 bar.
* Product conductivity: 190 microsiemens/cm.
* Temperature at inlet: 20.1 ^oC
* Seawater pH: 7.2
* Seawater SDI: 1.3
* Seawater ORP: - 192
* Specific consumption: 3.89 Kwh/m^3 (only process)

The above data confirm the results which plant design was expected to provide, and the actual data are still a broad safety margin above guaranteed values.

Another outstanding aspect of this installation is the short period of time that was required for execution of the works involved: the contract was signed on December 28th, 1995, the building project was approved in January, 1996, and start - up of the first line occurred on September 19th, 1996, before nine months had elapsed since the signing of the contract.