Contract No: 14CK92144001-UK

1x2160 t/d MED Project

Technical Specification

1. Raw Data

1.1 Seawater Parameter

Item	Units	Value
Winter temperature	℃	26
Summer temperature	℃	33
(TDS)	μS/cm	57000
PH		8.5
Calcium hardness	PPM	400
Magnesium hardness	PPM	1850
Silica	PPM	700
Sulphates		3800
Total chlorides		2300 PPM nael
Total dissdvol souds		38900 PPM T.D.S
Carbonates		50 PPM CO
Bicarbonate		140 PPM HCO_3
Cupper		150 PPb CU
Iron		80 PPb FE

1.2 Steam

Steam pressure: 1.3MPa.a

Steam temperature: 271 deg.C

1.3 Power Supply

Voltage: 440V (3 phase)

Frequency: 50Hz

1.4 Instrument Air

Pressure: 4.14 - 4.83 bar(g)

2. Technical Conditions

2.1 Technical Conditions

No.	Description	Unit	Data

1	MED-TVC	trains	1
2	Net Capacity per Unit	t/d	2160
3	Distillate Quality		
	TDS	mg/L	<10
	Conductivity(@20 deg.C)	μs/cm	<15
4	Total steam consumption of MED-TVC under Design Working Condition	t/h	12.1
5	Water Flow of MED-TVC under Design Working Condition	t/h	340

To get more information about operating parameters for each MED-TVC unit, please refer to heat & mass balance diagram.

2.2 Description of Process

Each Multi-Effect Distillation with Thermal Vapor Compressor (MED-TVC) unit, based on two (2) horizontal-tubes, falling-film type evaporator and one (1) shell-and-tube condenser. Seawater is feed to each evaporator in parallel, and the thermal energy of brine is recovered by plate heat exchanger to preheat feed seawater when it is at winter condition, and thus the overall thermal efficiency is improved.

MED-TVC desalination system could be divided into a few subsystems according to individual main function, such as heating steam system, feed water system, sea water cooling system, distillate water system, and vacuum system. Cooperation of all above-mentioned subsystem guarantees the stable operation of MED-TVC for a long time, under the variable working conditions.

2.2.1 Heating Steam System

The main function of Heating Steam System is to control the operating parameter of input steam for the first effect evaporator, which includes TVC and desuperheating system. The motive steam for TVC is from power plant turbine.

Part of vapor produced in the second effect is extracted by TVC and mixed with motive steam, accordingly, its pressure and temperature is raised. Before it enter into the first evaporator, it is desuperheated by desuperheating cooling water which is in order to meet heating steam requirements.

2.2.2 Feed Water System

The Feed Water System consists of booster pump, spray nozzles, flow regulating valve and connection pipeline.

Before pumping into the MED-TVC system, seawater is filtered in a sea water make-up filter with precision of 500μm to remove large particle suspended solids. The filtered seawater is preheated by the vapor from the second effect evaporator in final condenser, and then, which is boosted and pumped into each evaporator simultaneously, and sprayed on the internal heat exchange tube bundle through the special nozzle, consequently, the feed water is distributed uniformly and falling film is formed gradually from top to bottom of bundle. The uniform feed water flow rate for each evaporator is accomplished by flow regulating valve. It should be noted that the temperature of feed water to first evaporator get further improvement by means of heat recovery from steam used by vacuum system.

2.2.3 Seawater Cooling System

Seawater Cooling System is used to provide cooling water to condense the steam distillated from last evaporator.

Pressure supplied should meet demands for discharge, after flowing through sea water make up filter, plate heat-exchanger, condenser and regulating valve.

A regulating valve is set at the outlet of condenser, controlling the flow rate of cooling water and the vacuum degree of condenser.

All cooling water is collected in a pipe and discharged from MED-TVC system.

2.2.4 Distillate Water System

The main function of Distillate Water System is collecting distillated water and transporting that to distillated water tank, which consists of pipeline connecting the evaporators, distillate pump and outlet flow regulating valve.

Starting from the first evaporator, the distillated water in evaporator flow into the next evaporator driven by the pressure difference through pipeline connecting adjacent evaporators. The flash evaporation of distillated water occurs due to the decrease of ambient pressure, thus, more steam is obtained and the thermal efficiency is improved. In the condenser, the distillated water from last evaporator is collected with condensate from condenser and pumped out of MED-TVC by distillate pump. Level of distillated water in MED-TVC is controlled by outlet flow regulating valve. The distillated discharging pipeline is set for unqualified distillated water distillated in start-up of MED-TVC.

The service water is required for desuperheating the superheated steam, which is supplied by Buyer during the period of first startup operations and until completion of commissioning phase or if all units are off. After startup, desuperheating water will be condensate extracted by the distillate pump. This flow shall be regarded as the internal consumption, and has no impact on the net product output.

2.2.5 Brine System

Brine System is similar to Distillate Water System, which is used to collecting the brine from each evaporator and consists of pipeline connecting the evaporators, brine pump and outlet flow regulating valve.

The flow of brine between adjacent evaporators is also driven by difference

pressure and is accompanied by the flash evaporation of brine. All the brine is collected in last evaporator and pumped out of MED-TVC by brine pump.

2.2.6 Vacuum System

The MED-TVC is operated under the vacuum state. NCG(Non-Condensable Gas) dissolved in feed water will release when the feed water is heated in vacuum state, additionally, inevitable air leakage of equipment result in accumulation of NCG in the evaporator, which cause the adverse impact to the heat transfer efficiency and normal operating status for MED –TVC. The Vacuum System, adopting vacuum ejectors, is set to exhaust NCG from inside of equipment by means of medium pressure steam.

2.3 Performance of Process

2.3.1 Operation Life

The operation life of the seawater desalination plant will be not less than thirty (30) years.

2.3.2 Material of Plant

The material of evaporator, heat transfer tubes, seawater pipe and all pumps will be able to withstand the corrosion of seawater and meet the requirements of coastal conditions. The Seller will ensure that the plant can be safely operated during its life.

2.3.3 Plant Availability

The seawater desalination plant will be able to operate continuously with availability of more than 95% (i.e. more than 8,322 h/year).

2.3.4 Operation and Maintenance

The seawater desalination plant will be started up, shutdown, controlled and adjusted in the remote control room. The plant will be easily maintainable. It may not be necessary to assign permanent shift operators locally.

2.4 Structure and System Configuration

2.4.1 Evaporator and Performance

The evaporator is cylinder-shaped with diameter of 5.3m. All welding of associated vessel are continuous for guaranteeing the shell's sealing performance and withstanding the maximum pressure and vacuum to be experienced during testing and operation. In order to ensure the safe operation under vacuum, the vessel is externally stiffened by Carbon steel beams.

Tube Bundle of evaporator is arranged inside the vessel. Tubes are assigned to two tube pass according to certain proportion, first upper 3 rows of tube bundles of each effect in contact with seawater sprays will be made of Titanium (φ25.4×0.5mm).

Each effect will be provided with its own drain lines and arranged to ensure convenient discharge of all accumulated water during equipment shutdown. Appropriate manholes will be provided for access to each effect for inspection, maintenance and replacement of demister, nozzles, and for internal cleaning and washing. Observation window will be provided for each effect to observe the spray of seawater and the upper tubes (during commissioning and maintenance operations) and for detecting and cleaning any obstruction or abnormal conditions of the spray system during cold operation.

Design of seawater nozzles and their distribution and arrangement for each effect will be such as to ensure thin film type distribution of water on the evaporating tubes and avoid inadequate flow or dry sections leading to scaling at the tube surfaces.

The heat transfer tube bundles and tube sheets of the evaporators supplied by the Seller will be able to ensure the normal operation of distillation process and will be made of tried and high quality corrosion resistant materials.

The demister is arranged at both sides of tube bundle, to remove brine droplet

from the steam distillated, and guarantee the quality of distillate water.

Two water chambers are installed at front tube sheet and back tube sheet respectively. The distillated water (condensates) from 1st tube pass is collected in the back water box, meanwhile, residual steam and NCG flows into 2nd tube pass of bundle, eventually, which is condensed and collected in front water box, and NCG is discharged to the atmosphere directly.

The main design principles technical parameter of evaporator is given in following table.

Evaporator Type	horizontal, two-pass
No. of effect of evaporator	2
Specification of Titanium tube	φ25.4×0.5mm(first top 3 rows), SB338 Grade 2
	φ25.4×0.4mm(others), SB338 Grade 2
Arrangement of tubes	equilateral triangle
Effective length of the tubes	7000mm
Material of vessel	SS2304
Material of tube sheet	SS2304
Material of support sheet	SS2304
Net weight of evaporator	~ 166ton

2.4.2 Thermal Vapor Compressor & Vacuum Ejector

Thermal Vapor Compressor (TVC) is adopted to increase the circulation

utilization rate of steam and the Gain Output Ratio (GOR), by means of recycling vapor from the second effect through motive steam.

Vacuum System could be divided into Hogging ejector and vacuum ejector. The former is used to establish the inside vacuum status in a short time (Normally, 30 minutes). The latter is used to exhaust NCG in time at the normal operating state to ensure the equipment run well, and the steam consumed by the latter is reused to preheat feed seawater for the first evaporator.

2.4.3 Acid Cleaning

In order to maintain the MED unit capacity up to its design value, The MED unit has an independent mobile acid cleaning system, which is to remove the scaling outside the surface of the tube bundle. The system includes permanent connection into the evaporator piping, acid pump, and acid tank. Normally, the acid cleaning is about 2 years, usually depends on actual operation conditions of the plant. The acid cleaning procedure will be carried out when the MED-TVC output reaches its 90% design capacity.

The pipe work shall be capable of isolation, venting, sampling and drainage. The acid cleaning system will be made of tried and high quality corrosion resistant materials.

2.4.4 Tubes and Valves

The Seller will supply all proper tubes, pipes and valves within the scope of desalination plant. The tubes, pipes and valves will be suitable for inner medium and the process requirements and will be made of tried and high quality corrosion resistant materials.

2.4.5 Pumps

The Seller will supply sea water pump, brine pump, distillate pump. The parameters of the pumps can ensure the normal and safe operation of the evaporator systems and the pumps will be made of high quality corrosion

resistant materials.

2.4.6 Condenser and Performance

The function of condenser is receiving the vapor from last effect and condensing it into water. Parts of seawater flows out of condenser, as feed water, is preheated and pumped into evaporator. Condenser is composed of vessel, tube bundle, and water chamber mainly. There are four exhaust pipes connected with evaporator on the top of condenser.

The tube bundle is arranged in the vessel, with a reasonable central steam passage and a side vent designed between the tube bundles.

The main design principles technical parameter of condenser is given in following table.

Condenser Type	single shell, four-pass, surface type
Design pressure of shell side	18.2 kPa.a
Volume of cycle water	340t/h
Designed velocity of cycle water inside the tube	2.3m/s
Coefficient of cleanness	0.9
Material of cooling tubes	SB338Gr2
specification of cooling tubes	Φ19×0.5mm/Φ19×0.7mm
Material of the tube shell	SS2304
Dimensions(length×width× height)	7987×2127×2127mm

Net weight	~ 8 ton

2.5 Auxiliary Equipment Configuration

2.5.1 Sea Water Make Up Filter

Before pumping into the MED-TVC system, seawater is filtered in a sea water make up filter with precision of 500μm to remove large particle suspended solids.

2.5.2 Plate Heat Exchanger

A heat exchanger is equipped in each unit to preheat the sea water by brine, which is made of titanium plates.

2.5.3 Chemical Dosing System

Chemicals such as antiscalant and antifoam are injected to prevent scale formation, eliminate foam and improve the surface wettability on the heat exchange tube.

Each chemical package includes dosing tank and two (2) dosing pumps, where one (1) of them is a common spare for the rest of the pumps in each chemical package.

2.5.4 Pipes and Valves of Auxiliary Equipment

The Seller will provide relevant pipes and valves in the auxiliary equipment.

2.5.5 Equipment Acid Cleaning and Washing

Equipment used in acid cleaning includes a tank, pump and relevant pipes and valves, all of which is integrated on a mobile skid. The purpose of acid cleaning procedure is to remove the scaling on the surface of tubes and maintain heat transfer efficiency.

2.5.6 Instrumentation and Control

The seller will supply one set of electrical instrumentation and control system to meet auto operation needs. Details can be seen in P&ID.

3. Table of Main Performance Parameters

No.	Description	Unit	Design value	Remark
1	Net capacity per unit	t/d	2160	
2	No. of effects		2	
3	Gain output ratio		7.4	
4	Electricity consumption	kWh/m^3	<1.2	
5	Steam Consumption for each unit	t/h	12.1	
6	Distillate quality			
6.1	TDS	mg/L	<10	
6.2	Conductivity(@20 deg.C)	μs/cm	<15	
7	Sea water inlet flow per unit under design working condition	t/h	340	

4. Scope of supply

4.1 Scope of Design

The engineering design for desalination plant includes three different stages,

which are design consideration, basic design, and detail design.

The design consideration means the technical parameters to be used for the basic design and detail design to be done by both parties, such as interface data, main descriptions, main introductions and conventional data.

The basic design represents all necessary design data for detail design, such as basic drawings, schematic diagrams, designated data, introduction of basic functions, requirements for basic media and electrical power, basic descriptions necessary for procurement of equipment.

The detail design stands for the design of construction drawings, including all technical documents, drawings, data and so on necessary for procurement, manufacture, assembly, erection/installation, adjustment and test of equipment and materials.

The Seller will take full technical responsibility for the design within the project scope. The Seller will be responsible for the basic design of all seawater desalination plant including: process, instrument and control, electrical.

The Buyer will be responsible for the detailed design of all the desalination plant, including following items: firefighting, communications, lighting, lightening protection for electrical and control building, cathodic protection, and grounding, etc.

The Buyer will be responsible for the basic and detailed design of peripheral systems such as seawater intake and brine discharge system outside the scope, storage and distribution system for product water and service water source, compressed air supply, etc.

The Seller will be responsible for technical services and will provide technical documents and information required.

Design to be provided by Seller will use KKS identification system. The principles, content and depth and details for KKS coding system will be discussed and finalized during design liaison meetings.

The Seller will be responsible for the detailed design of equipment and systems to be supplied within its scope of supply, which will include but will not be limited to the following:

a) Performance data of desalination plant;

b) P&I drawings, flow diagrams, logic diagrams, instrument tubes layout and cabinet terminal diagrams for all systems within the contract scope;

c) Selection data of all auxiliary equipment and materials within the scope of the system;

d) Layout for desalination plant;

e) Process piping drawing (diameter above 80mm only, for smaller diameter, sketch for installation only will be provided);

f) Information and data required for civil works design;

g) Interface specifications of all systems and equipment at the boundary limits of the desalination plant;

h) All necessary information for detail design;

i) I&C system design will include control, indication, interlock, protection, alarm, detection, and measurement instruments, programming of control equipment, etc.;

j) Operation manuals;

k) Calculation sheets.

The design boundary of seawater desalination plant is according to preliminary P&ID drawing.

The red line is defined to be 3 meters out of the footprint of Seller's scope of supply, the connection points between Buyer and Seller will be 1 meter inside the red line.

4.2 Scope of Services

The scope of services is as follows:

1) Engineering Design
2) Engineering coordination
3) Submission of design for approval by Buyer
4) Confirmation of sub-Seller
5) Manufacturing, expediting, and quality control
6) Supervision for installation at site
7) Supervision for commissioning and testing at site
8) Site training of operation and maintenance

4.3 Scope of Supply

The Seller will supply complete sets of seawater desalination process equipment, pipes, valves, instrumentation and control equipment, all cables between the equipment within Seller's scope of supply and other auxiliary system, spare parts, special tools (if applicable) as well as consumables for commissioning and startup.

The desalination plant shall be complete in every respect with all other equipment and accessories, whether specified herein or not, for the safe, efficient and reliable operation of the plant and shall include but not limited to the following:

No.	Equipment Description	Units	Quantity	Remark
1	**Process**			
1.1	**Evaporator**	set	1	
	Titanium Heat Exchange Tubes			
	Tube Sheets and Supports			
	Vessel Shell			
	Demisters			
1.2	**Condenser**	set	1	
1.3	**Plate Heat Exchanger**			
	Brine Heater	set	1	
1.4	**Pump**			
	Sea Water Pump	set	2	
	Brine Pump	set	2	
	Distillate Pump	set	2	
1.5	**Thermal Vapor Compressor**	set	1	
1.6	**Vacuum System**			
	Hoggine ejector	set	1	
	Vacuum ejector	set	1	
1.7	**Sea Water Make Up Filter**	set	1	500μm
1.8	**Anti-scale Dosing System**			

	Anti-scale Dosing Tank	set	1	
	Anti-scale Dosing Pump	set	2	
	Anti-scale Dosing Mixer	set	1	
1.9	**Anti-foam Dosing System**			
	Anti-foam Dosing Tank	set	1	
	Anti-foam Dosing Pump	set	2	
	Anti-foam Dosing Mixer	set	1	
1.11	**Acid Cleaning System**			Mobile Design
	Acid Cleaning Tank	Set	1	
	Acid Cleaning Pump	Set	1	
1.12	**Valves**	Set	1	Auto: Pneumatic
1.13	**Piping**	Set	1	
1.14	**Steel Structure**	Set	1	
1.15	**Heat Insulation Material and Covering Layer**	Set	1	
1.16	**Bolts and Nuts**	Set	1	
1.17	**Instrument Air System**	Set	1	
2	**Electrical**			
2.1	**Motor Local Control Box**	Set	1	
2.2	**MCC**	Set	1	
3	**Instrument and Control Facilities**			
3.1	**Control System Panel (incl. DCS, Software, Operation desk, IPC, Displayer, Printer etc.)**	Set	1	

3.2	**Local Instrumentation (incl. installation accessories)**	Set	1	
3.3	**Online Instrumentation (incl. installation accessories)**	Set	1	
3.4	**Solenoid Valve Local Control Box**	Set	1	

5. Preliminary Material List

5.1 Evaporator

Evaporator Vessel

Shell, partition walls SS2304

Deflectors SS2304

Manholes SS2304

External reinforcement and supports Carbon steel

Heat Tubes Bundles

Exchanger tubes (top 3 rows) Titanium SB338 Gr.2 (0.5mm thick nominal)

Exchanger tubes (other rows) Titanium SB338 Gr.2 (0.4mm thick nominal)

Tube sheets SS2304

Tube support plates SS2304

Vapor/Distillate boxes SS2304

Demisters (as applicable)

Demisters AISI 316L

Supports, bolts and nuts AISI 316L

Seawater Makeup Device

Manifolds Polypropylene

Spray nozzles ABS

5.2 Condenser

Exchanger tubes Titanium ASTM B338 Gr.2 (0.5mm thick nominal)

Tube sheets SS2205

Tube support plates SS2304

Water boxes SS2205L

External reinforcement Carbon steel

5.3 Thermal Vapor Compressor

Steam nozzles AISI 316L

Diffuser AISI 316L

Inlet and Outlet vapor pipes AISI 316L

5.4 Hoggine ejector

Steam nozzle AISI 316L

Diffuser AISI 316L

Silencer AISI 316L

5.5 Vacuum ejector

Steam nozzles AISI 316L

Diffuser upstream AISI 316L

Diffuser downstream AISI 316L

5.6 Condenser

Exchanger tubes Titanium SB338 Gr. 2 (0.5mm thick nominal)

Shell upstream AISI 316L

Shell downstream AISI 316L

Tubes support plates AISI 316L

Tube sheets AISI 316L

5.7 Seawater Make up Filter

Type Self-cleaning

Body 316L stainless steel

Filtering element SS2205 stainless steel

5.8 Plate Heat Exchanger

Heat exchange plate TA1

Frame Carbon steel

5.9 Pumps

Sea Water Pump transflux part SS2205 stainless steel

Brine Pump transflux part SS2205 stainless steel

Desalinate water Pump transflux part 304 stainless steel

Dosing Pump transflux part PVDF

5.10 Piping

Seawater GRP

Brine GRP

Distillate 304 stainless steel

Venting 316L stainless steel

Chemical injections UPVC

Steam Carbon steel

5.11 Valves

Seawater transflux part Duplex Stainless Steel

Brine transflux part Duplex Stainless Steel

Distillate transflux part 316 stainless steel

6. Inspection and test plan

NO.1: Evaporator

NO.	Quality Witness Item	Inspection Points	Remark
1	Shell		
1.1	Raw material certification	R	
1.2	The welding process and the evaluation report	R	
1.3	Nondestructive testing report	R	
1.4	Single shell check report（the surface quality, weld quality, size etc.）	R	

NO.	Quality Witness Item	Inspection Points	Remark
2	Baffle plate and tube plate		
2.1	Raw material certification	R	
2.2	Check report（The surface quality, hole accuracy, roughness and structure size）	R	
2.3	Acid cleaning and passivation report	R	
3	Heat exchange tube		
3.1	Raw material certification	R	
3.2	Performance report(Nondestructive testing, mechanics testing)	R	
4	Assembly		
4.1	Tube-tube plate expansion test	W	
4.2	Size check report	R	
5	Factory test		
5.1	Acid cleaning and passivation report	R	
5.2	The single effect gas leakage test	W	
5.3	Appearance inspection	W	

NO.2: Condenser

NO.	Quality Witness Item	Inspection Points	Remark
1	Water chamber, shell		
1.1	Raw material certification	R	
1.2	The welding process and the evaluation report	R	
1.3	Nondestructive testing report	R	
2	Baffle plate and tube plate		
2.1	Raw material certification	R	
2.2	Check report （The surface quality, hole accuracy, roughness and structure size）	R	
3	Heat exchange tube		
3.1	Raw material certification	R	
3.2	Performance report(Nondestructive testing, mechanics testing)	R	
4	Overall unit		
4.1	Full water test of the shell side	W	
4.2	Hydraulic pressure test of water chamber	W	
4.3	Appearance inspection	W	

NO.3: Assistant equipment

NO.	Quality Witness Item	Inspection Points	Remark
1	**Plate heat exchanger**		
(1)	Raw material certification	R	
(2)	Quality certification	R	
2	**Pump**		
(1)	Raw material certification	R	
(2)	Quality certification	R	
3	**Thermal vapor compressor**		
(1)	Raw material certification	R	
(2)	Quality certification	R	
4	**Vacuum equipment**		
(1)	Raw material certification	R	
(2)	Quality certification	R	
5	**Automatic cleaning filter**		
(1)	Raw material certification	R	
(2)	Quality certification	R	
6	**Chemical dosing equipment**		
(1)	Raw material certification	R	
(2)	Quality certification	R	
7	**Others**		
(1)	Quality certification (including valve, instrument etc.)	R	
(2)	Certificate of origin or customs declaration(Import parts)	R	

6.1 General

All equipment and plant to be supplied by Seller will be soundly packed prior to shipping and reliable measures will be taken for protection against humidity, rain, high temperature and low temperature, rusting, vibration as well as protection against any other damage that might occur during transportation so

that the goods can withstand multiple handling, loading and unloading and long distance sea and inland transportation. The protection measures will also be able to provide protection to equipment during site storage under site climatic conditions. The equipment surface will be cleaned and paint will be applied prior to packing.

Seller's detailed storage and transportation programs prior to packing and shipping will be approved by the Buyer. Buyer reserves the right to make final inspections of the packing before shipping, however, such inspections will not relieve the Seller from its responsibilities for any loss or damage due to improper packing.

6.2 Package

The packing for all equipment to be supplied by Seller will comply with relevant requirements and regulations (including KKS identification requirements). All equipment and materials will be marked prior to shipping to facilitate installation. Marks or labels will be made on or attached to equipment, components or packing based on order number, equipment number, component identification and name.

The valves will be marked according to valve number.

The outer packing of equipment will clearly indicate outgoing number, total number of packages and package number, receiving station or port, destination station or port, consignor, consignee, date of packing and other common international markings for equipment transportation and storage.

Skidding devices and lifting hooks will be provided for oversize and overweight equipment for ease of handling. The lifting hooks will be fixed at the lifting points.

Equipment weight and center of gravity will be indicated on the outer packing of the equipment and lifting point will be provided for the outer packing

(Without removing the outer packing).

The surface of equipment connection pipes and flanges will be protected and the surfaces of equipment or materials vulnerable to humidity or mildew will be

coated with anti-mildew paints for protection against damage.

Equipment and outer packing (if necessary) will have indications that welding is forbidden.

Spare parts and special tools will be separately packed with conspicuous markings to avoid being mixed up and packed with other equipment and materials. Small pieces of spare parts will be sealed in transparent plastic bags and desiccants will be provided in the bags if necessary.

7. Attachment

7.1 1x2160 t/d MED Project Heat&Mass Balance Diagram