ENGINEERING STANDARD

FOR

PROCESS DESIGN OF CRUDE OIL ELECTROSTATIC DESALTERS

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0. INTRODUCTION

The crude oil delivered to refineries for processing always contains salts in addition to other impurities. These salts occur mainly in dissolved form in the water and sometimes also in crystalline form in the crude oil. Due to the corrosive effects of the salts on metals damage can be caused in pipelines and downstream refineries. It is therefore essential in refineries to reduce the salt and water content of the crude oil. The crude oil is primarily desalted before being delivered to refineries.

As is well known, when oil is distilled the chloride salts dissociate and as a result hydrochloric acid (HCl) is formed, causing severe corrosion effects in refinery downstream Units.

Further forms of damage which can occur with inadequate desalting are deposits and blockages in heat exchangers, furnace tubes and distillation tower bottoms. This may reduce the throughput, change the degree of fractionation and finally impair the quality of some end products.

A further function of the desalter is to remove left-over impurities such as finely divided sand particles, clays, iron oxide, drilling muds, iron sulphide, arsenic, etc., form the crude oil.

Since, as already mentioned, the salt normally occurs dissolved in water and salt crystals are found only in a few types of crude oil, the desalter has to deal both with the aqueous solution and also with any soluble salt crystals. For this purpose water is normally added to the crude oil stream, which is preheated to the required temperature.

The two are then mixed to form an emulsion in order to dissolve the salt in the added water. The degree of mixing can be controlled by means of a mixing valve. A water-clarifying chemical (demulsifier) will be added to the crude oil charge ahead of the mixing valve, the demulsifier helps reducing the amount of the oil entrained (trapped) in the water, thus reducing the amount of oil carried out of the desalter with the effluent water. After mixing, the added wash water is as completely as possible removed in the desalting drum. This can be accomplished by electrical and/or chemical means.

In the electrical desalter, the water-oil emulsion is subjected to the action of a high voltage field. This breaks down the oil film which surrounds the individual water droplets, thus making possible the combination of a number of droplets.

Because of the higher relative density (specific gravity) of the droplets thus increased in size, they drop to the bottom of the drum and are withdrawn for disposal.

Relative densities (specific gravities), surface tension, chemical impurities of contaminants in the crude oil and water, determine the size, stability and distribution of the emulsion particles. Surface-affecting media such as asphalt, resins, waxes, solid bodies, clays or organic acids, which occur in the crude oil, can act as emulsion stabilizers. The desalter must therefore be able to dissociate even the most complex emulsions.

1. SCOPE

This Standard is intend to cover the minimum requirements for process engineers to specify proper type and prepare process data sheet for electrostatic desalters.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor/Consultant.

ASTM (AMERICAN SOCIETY FOR TESTING OF MATERIALS)

ASTM D96 "Centrifuge Method"

3. DEFINITIONS AND TERMINOLOGY

3.1 Water Content (of the Crud)

Water content of the crude is that water which is emulsified, entrained or free in the crude oil, excluding the water that is in solution at the operating temperature of the desalting system .

4. SYMBOLS AND ABBREVIATIONS

API	=	American Petroleum Institute
bbl/sd	=	Barrel per Stream Day
BS & W	=	Basic Sediment and Water; Bottom Settling and Water
CCR	=	Central Control Room
Eq	=	Equation
FCV	=	Flow Control Valve
FI	=	Flow Indicator
FIC	=	Flow Indicator and Controller
kg/1000 bbl	=	Kilograms per Thousand Barrels (kg/159 m^3)
LIC	=	Level Interface Controller
LICV	=	Level Interface Control Valve
LS	=	Level Switch
PI	=	Pressure Indicator
P & ID	=	Piping and Instrumentation Diagram
ppm	=	Parts per Million
PSV	=	Pressure Safety Valve
RVP	=	Reid Vapor Pressure
TDS	=	Total Dissolved Solids
TI	=	Temperature Indicator
vol%	=	Volume Percent.

5. UNITS

This Standard is based on International system of units (SI), except where otherwise specified.

6. GENERAL

6.1 System Parameters

Here are the major factors that affect how efficiently the system can remove salt crude oil:

1) Oil flow rate.
2) Wash water injection rate/type/temperature.
3) Mixing intensity.
4) Demulsifier type and amount.
5) Process temperature.
6) Process pressure.
7) Desalting voltage

It is often necessary to adjust more than one of these process parameters when adjusting the system for optimum performance.

The following paragraphs explain the effect on system performance of each of the factors named above.

6.1.1 Oil flow rate

If oil throughput is increased above the design capacity of the desalting system, a loss in desalting efficiency can be expected.

6.1.2 Wash water injection rate /type /temperature

As wash injection rate increased from the minimum rate to the maximum rate, the amount of salt remaining in the treated oil generally will decrease. For efficient salt removal wash water shall be injected at the optimum rate. It is desirable to use hot water. This minimizes loss of operating temperature. Non-scaling fresh water is recommended for use as wash water. Hard water is to be avoided for refinery applications. For production Units desalter, wash water (available raw water) has to be deaerated in a cold gas stripper, the remaining oxygen shall be removed by oxygen scavenger up to 0.01 mg/kg to prevent corrosion.

6.1.3 Mixing intensity

Mixing intensity refers to the degree of oil and water mixing that is achieved in a mixing valve due to the pressure drop across that valve. The greater the pressure drop, the greater the mixing intensity. Undermixing or overmixing can occur. Undermixing (an insufficient pressure drop) results in insufficient salt removal and low water carryover. Overmixing (too great pressure drop) can also occur. Too great a pressure drop at the mixer can result in a tight oil and water emulsion which can not be broken readily by the electric field in the desalter.

Indications that overmixing is occurring include unusually low voltage at the electrode zone and a higher than normal carryover of water into the treated oil.

Typical curves of desalted crude salt content and BS & W versus mixing valve pressure drop are shown in Appendix A.

6.1.4 Demulsifier type and amount

A change in demulsifier rate or type may precipitation more effective for the crude being treated. Either too little or too much demulsifier added to the untreated crude may increase the amount of salt in the treated oil. If for any reason the type of demulsifier chemical is changed, then chemical flow rates must be recalculated.

6.1.5 Process temperature

The system operating temperature should be maintained within the range for which the system is designed. A loss in desalting efficiency may be experienced outside this range. In other words, if the desalter plant experiences a higher than normal system temperature which causes "gassing" to occur in the vessel, desalting efficiency may be reduced. If the operating temperature is too low, emulsion resolution will not be as complete. Operation temperature should be above the melting point of the asphaltenes.

6.1.6 Process pressure

The back pressure valve for the system will normally be set to maintain a pressure at the vessel which is at least 140 kPa (1.4 bar) above the vapor pressure of the oil and water mixture in the vessel.

This prevents the oil and water from vaporizing, expanding and forming gas in the vessel. If system back pressure decreases for any reason, "gassing may occur in the vessel. Symptoms of excessive gassing are excessive water in the treated oil and poor salt removal. The normal operating values for system back pressure should prevent gassing.

6.1.7 Desalting voltage

For production Units desalters are sometimes designed for variable desalting voltage, in this case this parameter can be used to obtain optimum performance of the desalter.

7. DESIGN CRITERIA

7.1 Process Requirements

7.1.1 Crude properties

The following properties have to be specified for desalter design:

selected crude oil;
gravity, API;
BS & W, vol%;
salt content, kg/1000 bbl (kg/159 m^3);
viscosity at two temperatures, cSt;
sulfur content, mass %;
pour point, °C;
RVP at 38°C, kPa (abs.) or bar (abs.);
delivery pressure (at inlet of the mixing valve), kPa (ga) or bar (ga).

7.1.2 Process water properties

Water to refinery desalter can be supplied from sour water stripper. Vendor shall confirm suitability of wash water and recommend any change if necessary. Vendor shall specify the required water rate. Other wash water sources may also be specified. The following characteristics shall be specified for all specified types of water.

H_2S	**(mg/kg)**
NH_3	**(mg/kg)**
CN	**(mg/kg)**
Phenols	**(mg/kg)**
Thiocyanides	**(mg/kg)**
Free oil	**(mg/kg)**
Ca++	**(mg/kg as $CaCO_3$)**
Mg++	**(mg/kg as $CaCO_3$)**
Na+	**(mg/kg as $CaCO_3$)**
K +	**(mg/kg as $CaCO_3$)**
HCO_3-	**(mg/kg as $CaCO_3$)**
SO_4--	**(mg/kg as $CaCO_3$)**
Cl-	**(mg/kg as $CaCO_3$)**
NO_3-	**(mg/kg as $CaCO_3$)**
Free O_2	**(mg/kg)**
SiO_2	**(mg/kg)**
TDS	**(mg/kg)**
Iron	**(mg/kg)**
pH	

The expected water temperature at the injection point has to be specified by the Company.

A typical wash water injection rates may be between 3-7 (vol % of crude).

Injection point should be ahead of the mixing valve and /or ahead of heat exchanger train (not fired heater).

7.1.3 Operating and mechanical design conditions

The following conditions shall be specified by the Company:

7.1.3.1 Operating pressure of the desalter (minimum pressure must be sufficient to maintain desalter content in liquid state).

7.1.3.2 Operating temperature at the inlet of the desalter (range may be specified).

7.1.3.3 Allowable pressure drop for the desalter (including the mixing valve).

7.1.3.4 Design flow rate of crude oil (bbl/sd).

7.1.3.5 Maximum anticipated system pressure and temperature.

7.2 Performance Requirements

The desalter shall produce a treated crude, under steady state conditions, which conforms to the following requirements:

7.2.1 Specified design throughput (bbl/sd).

7.2.2 The salt content shall be as follows, when desalter is charged with the crude rate specified in 7.2.1 above: (as determined by desalter Vendor method, this method is subject to Company's approval)

INLET (kg/1000 bbl) (kg/159 m^3)	OUTLET (kg/1000 bbl) (kg/159 m^3)
up to 4.5	**0.45 (max.)**
4.5 to 18.1	**0.90 (max.)**
above 18.1	**2.25 (max.) mass% of the inlet salt content**

7.2.3 The desalted crude salt content will be specified by the Company where depending on this requirement, one or more desalter stages may be furnished.

7.2.4 The floatable oil content of the effluent water at operating temperature shall not exceed 250 mg/kg for refinery, as determined by Vendor method (this method is subject to Company's approval).

7.2.5 Desalter shall be able to perform its duty with specified water types.

7.3 Instrumentation and Control System

Independent of safety devices like safety valves, the instrumentation and control system shall protect all items of the system against maloperation by operators, equipment failure, etc., but also enable the operators to undertake suitable actions during operation. A typical Piping and Instrumentation Diagram (P & ID) for a refinery is also shown in Appendix B.

Vendor shall submit the proposed instrument and control schematic drawings, adequate to fullfill the requirements of his process and mechanical guarantees for Company's approval. All instrumentation shall be suitable for continuous working in the conditions of their location.

Provision shall be made for local tripping of critical equipment. The desalter Supplier shall be responsible for the satisfactory design and operating capability of the instruments, controls and safety equipment associated with the desalter and he shall submit details to the Company for approval.

The type of valves/control valves shall be selected according to the service. Special valves shall be used where cavitation, noise, flashing or erosion may occur. All shut-down systems shall be capable of full function testing from primary sensor up to final actuation device while the plant is on line. Test key-operated override switches shall be provided for this function. These shall override the minimum number of function components. Alarms shall be provided to show automatically when the trip circuit is being overriden for test. All override test facilities shall be mechanically protected and shall be accessible only to the personnel authorized to carry out testing.

The items listed below are regarded as the minimum required instrumentation/control components of the electrostatic desalting system.

7.3.1 Mixing valve

The desalter shall be furnished with a suitably sized valve in the crude oil entrance line. A local differential pressure indicator, connected to the upstream and downstream sides of the mixing valve, shall be provided for reading of the adjusted pressure drop. Pressure drop across the mixing valve shall also be monitored in CCR. This valve shall be manually operated for dispersion of process water into the crude oil. This mixing shall be accomplished with a minimum pressure drop for creating a water-in-oil emulsion.

7.3.2 Level interface controller (LIC)

Level interface controller shall receive measurement information from the level interface transmitter. The transmitter shall be connected to the displacer at the water/oil interface. The controller uses this measurement information to control the action of the level interface control valve and is provided with high and low level interface alarms. This control valve shall maintain the vessel's water-oil interface at the desired level.

7.3.3 Level interface control valve (LICV)

This control valve shall be installed in the vessels effluent water line to control the flow rate of water leaving the vessel. Signals transmitted by the level interface controller determine how much air is supplied to the control valve actuator.

7.3.4 Pressure indicator (PI)

A pressure indicator (local) shall be furnished to show the operating pressure of the vessel.

7.3.5 Temperature indicator (TI)

A Temperature indicator (local) shall be furnished to show the operating temperature of vessel.

7.3.6 Level switch (LS)

A level switch shall be provided for the purpose of switching off the power in case the vessel is not completely full of liquid (cut-off and alarm). In no case the power must be applied on the desalter if vessel is not totally filled with liquid.

7.3.7 Pressure safety valve (PSV)

Pressure safety valve(s) shall protect desalter in case of eventual overpressure in the system.

7.3.8 Process water flow indicator (FI)

This instrument shows the flow rate of the process water (local and in CCR).

7.3.9 Process water flow controller (FC)

This controller receives the measurement information from the process water flow transmitter. The controller uses this measurement information to control the action of the process water flow control valve.

7.3.10 Process water flow control valve (FCV)

This control valve shall be installed in the process water line. Signals transmitted by the process water flow controller determine how much air is supplied to the control valve actuator.

7.4 Local Control Panel

A local control panel shall be provided as a point for engaging or disengaging the electrical supply that energizes the desalter transformers.

7.5 Chemical Injection System

The injection facility of controlled addition for demulsifier chemical shall be provided (pump, tank, measuring column, etc.). Vendor shall advise the required injection rate of the demulsifier chemical. The pressure at the injection point of the demulsifying chemical shall be specified.

7.5.1 The demulsifiers are added to crude oil to be desalted to counter the effects of emulsifiers within the crude. To be effective the demulsifier must be distributed uniformly throughout the crude oil.

For a successful chemical treatment it is important to choose the proper demulsifier type via relevant tests and to add it in sufficient quantity at the right point of the system.

7.5.2 Caustic injection

Some crude oils contain traces of inorganic acid from acidizing operations in the field, along with H_2S and naphthenic acids. If tests for pH reveal that the effluent water from the desalter is corrosive, a small amount of caustic should be added to the desalter makeup water. Caustic must be added cautiously, because crudes containing high values of organic acidity (naphthenic acid) can react with the caustic to produce naphthenic soaps that are emulsion stabilizers. These soaps may prevent adequate water and oil separation.

7.5.3 Wash water pH adjustment

It is sometimes necessary to adjust the pH of the brine to obtain pH values of 7.0 or less in the water. If the pH of the brine exceeds 7.0, emulsions can be formed because of the sodium naphthenate and sodium sulfide present. For most crude oils it is desirable to keep the pH below 8.0.

Better dehydration is obtained in the pH range of 6.0 to 8.0 with the best dehydration obtained at a pH near 6.0.

7.6 Mud Washing System

An on-stream mud washing system shall be provided in the water phase of the desalter system to prevent the accumulation of undissolved solids at the bottom of the vessel.

The mud washing system shall incorporate solids removal piping that extend through the length of the settling zone near the bottom of the vessel.

An external pump shall recycle water from the effluent water discharge line and move it into the solids removal piping. Water from the nozzles stirs up solids at the bottom of the vessel, so the solids can be carried out with the effluent water.

7.7 Vent Line

The vent line shall be opened to a visible sewer so an operator can determine when the vessel is liquid full. If the desalter is to be shut down, the vent line must be opened to relieve the vacuum inside the vessel as the vessel is pumped out.

7.8 Steam-out Connection

A permanent steam-out connection shall be provided.

7.9 Sample Connections

Adequate sample connections should be provided. The Company may elect to install additional sampling lines and to route all lines to a central collection box. Sample coolers may be required at the collection point. If sample coolers are to be installed, one cooler should serve the desalted crude sampling line and another should serve the remaining sampling lines. The use of two coolers helps to prevent contamination of the desalted crude sample.

8. PROCESS GUARANTEE

Vendor shall guarantee the followings:

1) Desalter capacity under the specified operating conditions.
2) Equipment and accessories are of sufficient size to fulfill satisfactorily the specified operating conditions.
3) Desalter shall be able to perform its duty with either of the specified types of wash water.
4) Specified desalted crude salt content.

9. TESTING

Within 30 days after the plant has been placed into operation, Company may subject it to such tests as are necessary to demonstrate a 36-hours performance test to demonstrate that the plant will meet the process guarantees. These tests may be witnessed during this period by Company and Vendor's representative.

If during these tests the equipment fails to meet the specifications, the Vendor shall take the necessary steps at his expence, to make the equipment meet guaranteed performance.

Vendor shall propose the test methods by which operating results shall be measured. These methods are subject to Company's approval.

10. DOCUMENTATION

1) At quotation stage

Suppliers shall provide the following in the numbers requested at the time of quotation:

a) Comprehensive descriptive literature.
b) List of recommended commissioning spares with prices.
c) Details of any special tools required.

2) At ordering stage

Suppliers shall provide the following in quantities and at times as detailed in the order:

a) List of recommended spares for two years continuous operation.
b) Illustrated comprehensive spare parts manual with part numbers suitable for warehouse stocking.
c) Illustrated installation and operating instructions, e.g.,

- Desalter general drawing
- Desalter vessel fabrication drawing
- Desalter vessel internals drawing
- Desalter vessel external attachments drawings
- Desalter vessel internal electrode parts drawings
- Schematic control diagram
- Instruments data sheets
- Control panel wiring diagram
- Data sheet of chemical feed system
- Other relevant data sheets/diagrams/drawings manuals

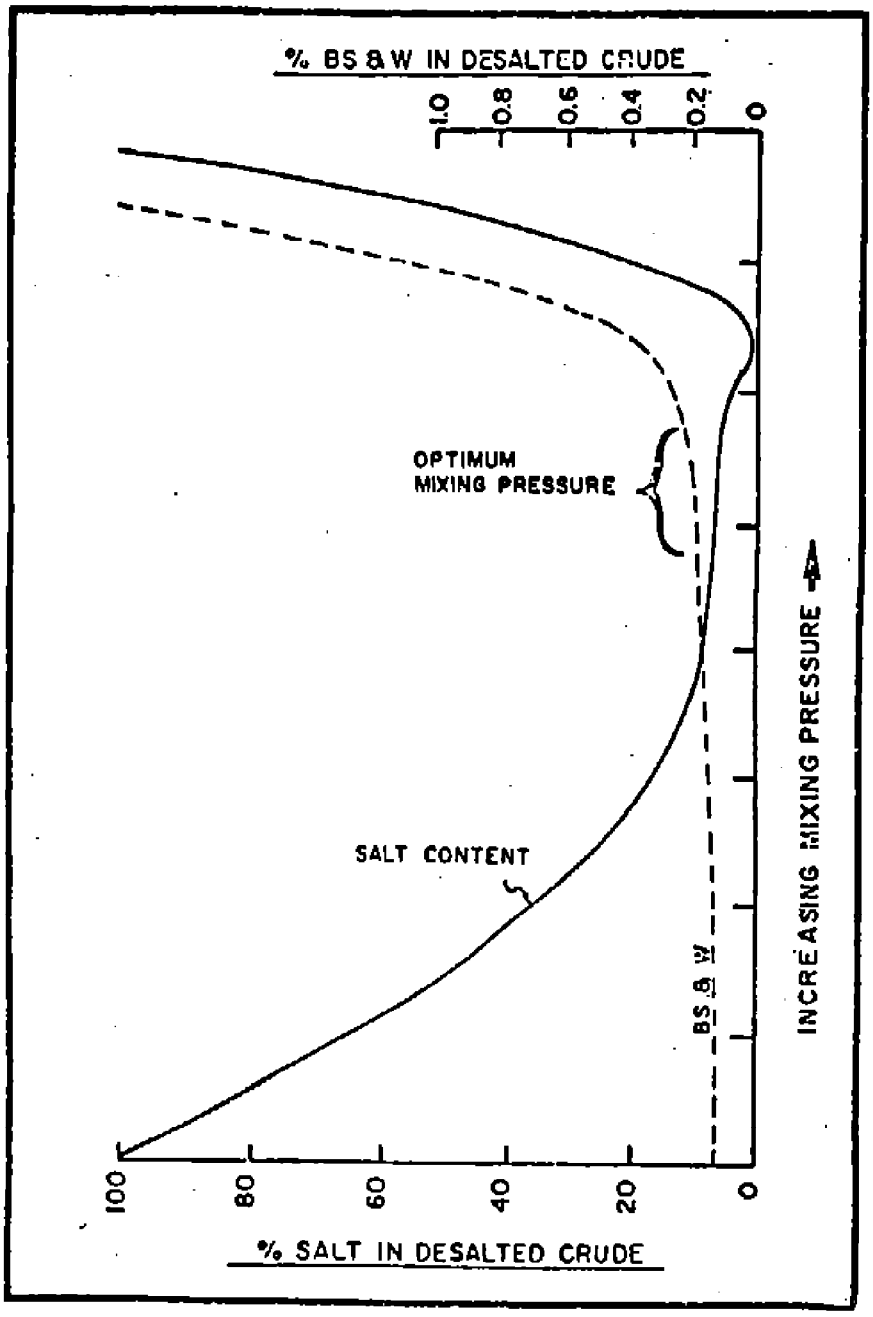
d) Maintenance manuals.

11. PACKING AND SHIPPING

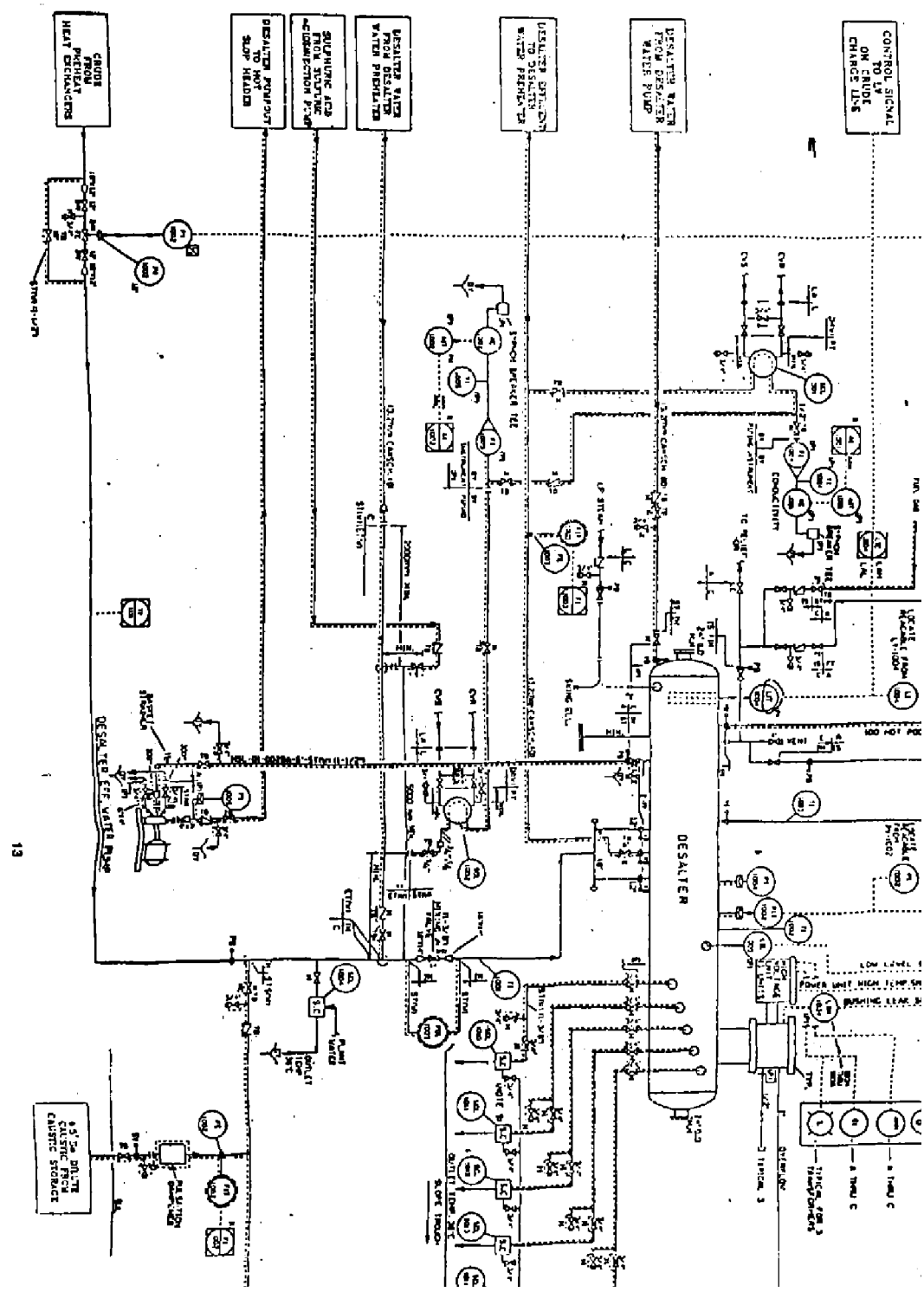
Equipment shall be carefully protected and packed to provide adequate protection during transit to destination and shall be in accordance with any special provision contained in the specification or order. Special attention shall be given to protection against corrosion during transit. All bright and machined parts must be painted with a rust preventative. Ancillary items forming an integral part of the equipment should be packed preferably in a separate container if the equipment is normally cased or crated. Alternatively the ancillary items should be fixed securely to the equipment and adequate precaution taken to ensure that the items do not come loose in transit or be otherwise damaged. Instruments having delicate movements and assembled into panels for inspection and test shall be replaced in makers special shock absorbing packages for transit, all connections being marked for remounting in IRAN. Such instruments shall be packed in same case as associated panel, but protected by a bulkhead or equivalent packing arrangement.

APPENDICES

APPENDIX A
TYPICAL CURVES FOR DESALTED CRUDE SALT CONTENT AND BS & W VERSUS MIXING VALVE PRESSURE DROP



APPENDIX B
TYPICAL PIPING AND INSTRUMENTATION DIAGRAM



(to be continued)

APPENDIX B (continued)