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1. Introduction of Gathering Center

Since the oil production of Kuwait oil fields began in the year of 1945.The oil, which is produced from the reservoir, flow through various well-down-hole equipment and surface facilities. It is collected in a place called a gathering center.

The oil gatherings system from the wells to the GC may consists of single flow line from a well to its separation equipment by 6" flow lines. Flow lines are usually terminated at headers. The crude oil processes, through grove valve and headers into separators. The separated gas is sent to the Booster Station, where the pressures is boosted up and send to (Liquefied Petroleum Gas) LPG plant. The crude oil either is routed to the dry tank or wet tank. The wet crude treated at the desalter plant, where water and salt removed. The treated crude is then routed to the dry tanks. Finally, crude oil is pumped from the dry tank to the AHMADI tank form and the tank vapor gas is routed to the Condensate Recovery Unit (CRU).

There were originally 26 gathering centers distributed in eight KOC (Kuwait Oil Company) oil fields. The first center to be commissioned was GC#1 at Burgan oil field and that was on June 7th 1946.

2.Oil Route From Wellhead To Main Headers

The crude oil from a wellhead flows into a GC through a flow line with many different valves and other equipment on its way, such as bull plug, remote control valve (RCV), orifice box, incoming manifold header and emergency shutdown valve.

2-1 Bull plug

It is located upstream of the (RCV). It is provided for two main reasons:

- To supply water to a new flow line for pressure testing the flow line at approximately 1800psig.
- To supply water to a drilling rig on a new well, if required

2-2 Remote control valve (RCV)

The RCV is provided on each incoming flow line at a remote place inside or outside a GC, it is used to isolate the well from the GC in case of emergence, maintenance and rig work.

2-3 Flow line sample point

Used for collecting a sample of oil for salt or water content check. It is normally use when the salt content in dry separator is very high.

2-4 Orifice box

This is device for measurement of oil flow and it is normally fitted inside with an orifice plate. But at most GC's these devices are no longer used.

2-5 Incoming manifold headers

This is a header pipe, which mixed crude oil from different oil wells and stabilized the pressure before sending the oil into a separator. There are up to six oil headers in some GS's such as:

- Header # 1 for Hp dry wells

Header # 2 for Hp wet wells
Lp header # 3 for Lp dry wells
Lp header # 4 for Lp wet wells

- Header # 5 for HP wet wells
- Test header for testing Hp & LP wells (Dry/ Wet) for back washing the flow line with water.

2-6 Emergency shutdown valves (ESDV)

At each header end there is an (ESDV) provided. It is air-operated valve. It closes automatically when there is a fault in the main plant such as high level in the separator or tanks. It will also close in case of emergency shutdown or low instrument air.

The grove valve will close in case of:

High level separators
High level main tank
Low instrument air
Operating of emergency air switch in control room when the plant on fail-safe.

When both grove valves shut the tank-pressurizing valve will open and the Condensate Recovery Unit (CRU) will shutdown on any of the main grove closes.

3. Oil Route From Separator To Main Tanks

The crude oil route from separators to main tanks flows through the following.

- Separators
- Tank filling line manifold
- Main Tanks

3-1 Separators

A separator is a vessel in which a mixture of two or more fluids that are not easily mixing in each other are separated from one another. In GC #1 have horizontal separator for Hp dry, Hp wet, Lp wet and vertical separator for Lp dry.

Details about the separators in GC # 1

Vertical separators

In this type there are two forces work to separate the oil and the gas Gravity Force (causes the heavier oil to drop to the lower part of the separator and this force is utilized by reducing velocity so the liquid can settle out in the space provided and Centrifugal force of the whirling action (causes the heavy oil particles to collect on the walls of the separator and this force is utilized by changing the direction of flow).

Horizontal separators

This type operates in much the same way as a vertical separator, the unit in a horizontal position instead of upright. The same gravity and centrifugal force are used, and the oil is removed from the bottom of the unit and the gas from the top. Horizontal separators may be of either the single –tube or double design.

High-Pressure Separators (1^{st} stage)

These separators are operating at high pressure. Pressure control valves (PCV's) keep the pressure in the separators at 280 psig fitted at the gas out let. From the incoming manifold headers the oil enters into these separators at near mid point of the vessels.

Low-pressure separators (2^{nd} stage)

These separators are operating at low-pressure control valves keep the pressure in the separators at 60 psig fitted at the gas outlet.

Separator instrument controls & setting

Main separator (Hp sep)
Level transmitter setting 50% of level normally maintaining
Level switch high high 4.4 ft setting for shutdown
Main separator (Lp sep)
Level transmitter setting 50% of level normally maintaining
Level switch high high 3.6 ft setting of shutdown

3-2 Tank filling line manifold:

Oil passes from separator through LCV's (Level Control Valves) and tank filling line are to the filling manifold. From filling manifold the oil go either direction tanks. Hp wet separators crude is going to wet tank, dry separator crude is going to dry tank.

3-3. Main tanks TK-1001/1002/1003 (Dry tank):

The purposes of main tanks are to store the Dry crude oil. It considered as 3rd stage separator where the pressure is kept 2.5" of water controlled by butterfly.
Gas 36" line connected to CRU and to Lp flare. Normally 10-12 feet's of level is maintaining in the dry tanks and this is to keep sufficient crude flow to the crude oil pumps.

1. Design Condition

Dry tank: tank capacity: 20,000 BBLS
Tank size: 60ft .42ft
High-level alarm: 32ft
High-level shutdown: 39ft
Low level alarm: 8ft
Low-level shutdown: 7ft

Main tanks equipped with the following Instruments and control units:

Varic unit: it is a relief valve to release the tank pressure at (4.0 for old tanks & 7.0" w.g for new tanks) to atmosphere, and enters air pressure (vacuum) if the pressure drops down around (5" w.g.)
High level alarm (LSH) and high level shut down (LSHH)
Low level alarm (LSL) and low level shut down (LSLL)
Mercury manometer: to measure tank level

- Level transmitter: to indicate level in DCS

2 pressure transmitter: one for CRU and the other for butterfly
Temperature transmitter: to measure tank temperature

4. Gas Route From Separators To Booster Station

The gas is routed from separators through the following

- Hp gas system
- Lp gas system

4-1 Hp gas system:

The amount of gas comes out from oil in Hp separators varies according to the amount of oil produced from the wells.

Hp gas outlet from each separator is connected in a common line. The common line is routed through the following.

Hp gas to Booster station
Hp gas to Hp flare

1. Hp gas to Booster station:

The Hp gas from Separators to booster station flows through the following.

Hp gas pressure control valve
Hp gas scrubber

* Hp gas system PCV (Pressure Control Valve) :
It is control the all Hp separators outlet gas with the set point of 260 psig. After the PCV gas will routed to scrubber.

Note:
Before the pressure control valve one CRU lean gas line is connected to Hp gas common line.

* Hp gas scrubber:

The purpose is to clean up the gas from oil before going to booster station where the gas is getting compressed and sent to the refinery.

2. Hp gas to Hp flare:

It consists of Hp gas pressure control valve and backpressure control valve
Hp gas will go to flare incase of:

Hp system valve close
Booster station shutdown

* Hp gas PCV to flare:
PCV to flare set at 285 psig open to back pressure and gas back presser is set at 150 psig it is going to Hp flare

* Back pressure PCV's (Pressure Control Valves) are fitted for:

To stop vibration in lines
Stop sound cutting
To prevent freezing in winter

Spill over connection:

It is a line connected from Hp to Lp system provided with PCV set at 45 psig.

Back up Lp system when its pressure decrease
Gas direction equipment
When Hp gas transfer line under maintenance

4-2 Lp gas System:

It is same as the Hp system. The LP gas comes from 1st stage separators to LP gas system

Lp gas outlet from each separator is connected in a common line. The common line is routed through the following.

Lp gas to Booster station
Lp gas to Hp flare

1. Lp gas to Booster station:

The Lp gas from Separators to booster station flows through the following.

Lp gas scrubber
Lp gas pressure control valve

Lp Gas Scrubber:
This function is same as Hp gas scrubber.

Lp gas system PCV (Pressure Control Valve) :
It is control the all Lp separators outlet gas with the set point of 55 psig. After the PCV gas will routed to booster station.

2. Lp gas to Hp flare:

Lp gas will go to flare incase through Pressure control valves

* Lp gas PCV to flare:
PCV to Hp flare set at 65 psig the valve will open incase of

Hp system valve close
Booster station shutdown

Note:
After the Lp gas scrubber by 4" Compensating gas line connected to tank filling line to maintain pressure in the main tanks set at 2.5" w.g.

5. Fuel gas system:

There are two type of fuel gas

- Lean gas
- Rich gas

*** Lean Gas:**

It is coming from Shuabia with the pressure of 500 psig. This gas is regulate the pressure control valve to 270 psig and sending the gas to engine gas scrubber.
Lean gas line is divided into three lines. The lines are going to the following

Desalter heaters
Engine gas scrubber
Tank pressuring valve

*** Rich Gas:**

This is back up to the engine gas pressure. If incase of shuabia gas pressure is getting drop the PCV from the Hp gas system will open and pressure will backup to engine gas scrubber.

*** Engine Gas Scrubber:**

Lean gas supplies to the Turbine and CRU from engine gas scrubber. The engine gas scrubber inlet PRV controls the pressure at 175 psig. And the outlet PRV controls the pressure to the engine at 125 psig.

5-1. Tank pressurizing valve:

It opens automatically when Hp headers (ESD) valves shut down due to any reasons to keep main tanks pressurized at all times through a 3/8 chock

- To prevent the Varic-unit from opening vacuum allowing air inside the tank and producing explosive mixture in the flare line of the tank.
- To prevent backfire from Lp flare.

6. Hp/Lp flare system:

Hp flare system consists of:

- Hot flare
- Cold flare

Hot Hp fare:
Gas from LP & Hp separators burns on Hp flare when booster station down or Hp system PCV (Pressure Control Valve) trips.
Cold Hp flare:
Gas routed to Flare when the GC is shutdown or flare line under maintenance.
Lp flare system:
The Lp flare consists of:

- Hot flare the stack type
- Cold flare pit type

7. Test plant

Test plant is used for:

- Production test of one zone or both
- Gas oil ratio (GOR) test of one zone or both.

De-killing a zone
De-pressurizing a flow line.

7-1. Oil Route From Test Header To Tanks

The oil route from test headers to test tanks flows through the following.
Test header to test separators.
Test plant.

1. Test headers:

Hp or Lp wells can flow through it.
ESDV: acts similar as main headers ESDV and it shuts on:
Line 80 valve: to use it when depressurizing a well
First stage separator
Second stage separator
LCV's
Test tank filling line

2. Test tank:

To measure oil production of a well on test, oil from test tank must be pumped back by the transfer pump to wet tank usually after each test

Test tank equipped with the following instruments:

Low level shut down (LSLL) for stopping the transfer pump.

- Level transmitter: to indicate level in DCS

Pressure transmitter for measuring the tank vapors
Temperature transmitter: to measure tank temperature

Note: Transfer pump is pumping the oil in test tank to Wet tank.

8. Plant Area Chemicals

There are two types of chemical used to inject the headers

Demulsifier system.

Scale Inhibitor system

Demulsifier system:

All headers area Demulsifier storage in two tanks TK-008 A, B and 8 demulsifier pumps are used to pump the chemicals into headers.

Demulsifier pump P-011 A to HP Wet header.

Demulsifier pump P-011 C to HP Dry / Wet header.

Demulsifier pump P-011 B is spare pump to P-011 A, C.

Demulsifier pump P-011 D to Test header.

Demulsifier pump P-011 E is spare pump to P-011 D.

Demulsifier pump P-011 F to LP Wet header.

Demulsifier pump P-011 G to LP Dry / Wet header.

Demulsifier pump P-011 H is spare pump to P-011 F, H.

Scale Inhibitor system:

All headers area Scale Inhibitor is storage in tank TK-009 and 5 Scale Inhibitor pumps are used to pump the chemicals into headers.

Scale Inhibitor pump P-012 A to HP Wet header.

Scale Inhibitor pump P-012 B to HP Dry / Wet header.

Scale Inhibitor pump P-012 C to LP Wet header.

Scale Inhibitor pump P-012 D to LP Dry / Wet header.

Scale Inhibitor pump P-012 E is spare pump for P-012 A, B, C, D.

9. Instrument air system And Fire Water System

Instrument Air System:

The instrument air system for plant is maintaining the 60 psig of dry air is used to operate instruments and equipments.

Note:
This system is having one pressure switch. The set point of the switch is 38 psig. If the pressure is coming bellow 38 psig the will shutdown the gathering center.

Instrument Air Compressors:

There are two instrument air compressor are supplying the air to the system. If one is on duty the other one will be on stand by. Before the instrument air is sent to system tit passes through humid dryer to dry the air.

The both compressor has it individual pressure switches for operating the compressors cut off and cut on.

Fire Water System:

The use of fire water system is incase of any emergency situation in the gathering center.

Fire Water Tank:

The use of this water for fire fighting and tanks are kept full.
The water is filled through the (A&C valve) and it must be full at all times, when tank is full shut the (A&C valve) and inform to the operator.

Fire Water Pumps:

These pumps are operated by diesel engine. It is used to pump the fire water incase of emergency.

Desalter Phase - IV

Introduction:

Till recently wet production was a problem and work over were required to shut off the wet zones. This was locking up recoverable reserve and affecting proper production. As a solution to this, dehydration/desalting plants were installed in those mostly affected GC's to handle the wet production.

Desalting process is achieved by various combination of treatment such as:

Gravity separation
Chemical treatment
Heating
Washing with water (dilution)
Mixing wash water (agitation)
Electrical treatment (electrostatic coalescing)

A certain amount of each of these factors working together can give a required result of the treated crude.

1-1. Gravity separation:

The removal of free water or unemulsified water from crude oil, the free water when given opportunity i.e. residence time and enough space, It readily separates by gravitational method. The gravity settling out of this free water is mainly accomplished in separators, wet tanks and desalter vessels.

1-2. Chemical Treatment:

Demulsifies chemical is added into water in oil emulsion to break or weaken the thick film of emulsifying agents around water droplets, the breaking of the film allows the water droplets to come much closer together by the natural of molecular attraction, forming a large droplet witch is easily separates from oil and settles down faster.

1-3. Heating:

Advantage of heating is to help weaken or break the film around the droplets by:

- Helps to dissolve, weaken or break the skin around the droplet by expanding the water drop it self

Reduces oil viscosity i.e. making the oil thinner to help water droplets fall faster (reducing settling time)
Help to spread demulsifier and increasing chemical reactivity in the emulsion
Creates thermal currents that force water droplets to collide thus improving the rate of emulsion breaking and joining together of droplets.
Softening and melting the skin around the droplet and make it easily soluble in the crude oil.

Disadvantage of heating:

Higher operating temperature increases fuel costs
Higher maintenance problems and costs
Increase scaling through desalting units
Increase risk of injury
Increase volume and API gravity loss of the treated crude. When oil is heated, vapor pressure increase and light ends like Ethane, Methane, Butane, evaporate (flash out) resulting to the above loses.

1-4. Washing with water (Dilution water)

Addition of less salt water into wet crude is very important and helps to dilute its highly salt water content.
When wash water is well distributed in crude, it helps join together smaller droplets and speed up this separation form the crude.
Dissolve crystal salts

1-5. Mixing wash water (Agitation)

To mix chemical with emulsion
To help smaller droplets to join together

- To break the free injected volume of Wash water into emulsion and distribute it evenly. So wash water must be distributed in every direction inside the wet crude in order to let wash water do.

1-6. Electrical treatment (Electrostatic coalescing):

It is the most effective method that provides a strong driving force for removing salt water from crude oil.

Basics of electrostatic theory:

The natural composition of the water droplet itself is the basis of this theory. The water droplet is made up of many polar molecules. Each water molecule has one part oxygen and two parts of hydrogen. Oxygen has a negative end and hydrogen a positive end. These polar forces are arranged in a shape very much like a bar magnet and easily responds to an applied electrical force field.

2. Methods of dehydration

When the produced water in crude is very salty as in our case then, straight dehydration is not the only solution and so the crude has also to be desalted.

2-1 Dehydration:

Simply it means removing of salt water from crude oil to at least 0.1 of 1 %. This is accomplished by gravitational method through 3 phases' separators, wet tanks and desalter vessels. Gravity settling of free water can easily be achieved if sufficient retention time is given to the emulsion in the vessels.

2-2 Desalting:

Means removing salt from crude oil by adding less salty water. The less salty water is relatively fresh than the highly salty formation water produced with the crude. Addition of this, so called fresh water dilutes and lowers the salt concentration of the formation water remaining in the crude to an acceptable level. The less salty water added into crude is known as wash water or dilution water.
The formation water produced with the Kuwaiti cruds normally contains salts in range of 150,000 to 200,000ppm.

The main objectives of install dehydration/-desalting plant:

- To maintain field production potential
- Clean up drilled and worked over wells
- To provide an effective controlling method that will allow a better reservoir production distribution.
- Allow produce wet wells caused by injection of water or steam of help recovery.
- To increase the final recoverable receives.

In Kuwait oil fields, KOC used a mobile desalter as test and that was in 1978

3. Theory of emulsion:

An emulsion is a combination of tow liquids that do not mix together under normal conditions. Three conditions are necessary to make a real and stable emulsion, they are:

- The liquids must be agreeable to mix
- There must be enough breaking force to spread one liquid as droplets in the other
- There must be an emulsifying agent or emulsifier present.

Types of emulsion: normally, there are two types of water in oil emulsion

Tight emulsion
Loose emulsion.

3-1. Tight emulsion:

Small water droplets spread in the crude oil, this violent mixing of water in oil can be caused by submersible pumps big differential pressure drop at well head or at mixing valve in the desalter plant.
Tight emulsion is very easy to make but difficult to break one because it requires higher operating temperature, higher chemical injection rates and higher efforts.

3-2. Loose emulsion:

Formed of large water droplets and it caused by moderate and sufficient mixing and it is not difficult to treat.

4. Desalter phase 1V process route:

- **Degassing boot (V-004)**
- **Wet tank (TK-oo1)**
- **Feed pumps (P-001 A, B, C)**
- **Crude heat exchanger (E-101/201) cold side**
- **Water bath heater (F-101/201)**
- **1st – stage (Recycle water injection nozzle - mixing v/v - vessel)**
- **2nd – stage (Wash water injection nozzle - mixing v/v - vessel)**
- **Trivolted electrostatic desalting**
- **Crude heat exchanger (E-101/201) hot side**
- **Oil back pressure (PV-103/203)**
- **B.S.&W. Analyzer (Basic Sediment And Water)**
- **Diverting valves.**

4-1 Degassing Boot (V-004)

- The degassing boot provides separation of gas from crude oil before entering the wet tank. At the 24" feeding line to degassing boot 4" line connected from make up gas. (Compensating)
- Gas from top of degassing boot flow into wet tank TK-001 through 36' line.

4-2 Wet tank TK-001

1. Design condition

Diameter	108.3 ft
Height	49.3 ft
Capacity	80,000 Barrels
Design pressure	10.0 W.G
Design Temp	200^0F
Factor	1640 barrels/ft

2. Advantages of having a wet tank:

- To remove the remaining gas from the crude oil
- To provide enough residence time and enough space for free water to separate and settle down
- To provide extra storage capacity in case of desalter shut down or dealters circulating.

3. Wet tank TK-001 is equipped with the following control instruments:

- Oil-water interface level transmitter LIT-001 is showing the interface level on DCS. The normal set point of interface level is 8 feet.
- Crude oil level transmitters and indicator LIT-003 to control the crude oil flow to desalter.
- Crude oil level transmitter LT005 recording the oil level in control room DCS and signaling high-level alarm LAH-005 at 47.2 feet. And Low Level alarm will give set level of LAL-005 at29.5 feet.
- Crude oil high high level LSHH 002 at 48.1ft signaling TK001 very high level on DCS and interlock panel in control room LAHH 002 and causing trip of all wet crude tank actual filling sources as selected by operator by HS-065, 006,067 and also trip all chemical feeding pumps in headers manifold area.
- Crude oil low level switch LSLL-004, at 26.7ft signaling TK 001 very low level on interlock panel and DCS in control room LALL-004and causing shut down of desalter TR1 & TR2.
- Pressure indicator and transmitter PIT-001 with local indicator PI-001 acting on PIC-001 witch control the tank pressure by PV-001 on wet tank make up gas line

Pressure /vacuum safety valves veric units PSV-A, B, C, D to protect the tank against over pressure or vacuum in case of failure of tank pressure controlling system

Lifting at 7.0” w.g and Vacuum at 1.0” w.g

4-3 Crude Oil Feed Pumps A, B, C:

The purpose of feed pumps is to be pumped the wet crude from wet tank to desalter trains.

- Crude oil from wet tank TK 001 flows to the crude oil feed pumps suction through 24” line
- At each feed pump suction and discharge valves fitted at 16” suction and 10” discharge lines

Each feed pump maximum flow rate 55,000 BPD
Demulsifier ¾” line injected into the stream of each feed pump.
At the 24” suction line low suction pressure alarm PAL 002 at 8.0 psi and low suction pressure shutdown PSLL 003 at 6.8psi that will stop both trains.
Feed pump high discharge pressure alarm PAH 101/201 at 230psi and high discharge pressure shutdown PSHH 102/202 at 240 psi are provided
FX 101 A/ 201 A provides reset for FRC-102/202 on wash water pump discharge to control wash water flow rate at fixed ratio between crude oil and wash water flow rate.

- Feed pump P-001A will automatically stopped if in case of train 1 shutdown and pump P-001 C will stopped incase of train 2 shutdown.

The spare pump P-001 B can be selected for either of trains by HS-001B and it stopped by shutdown of selected train.

1. Design condition

Feed pump capacity: 1650 IGPM
Dich/pressure: 195 psi
Drives: 295 HP

2. Feed pump flow control valve FV-101/201

It function is to control the feed pump flow rate.
FT 101A-201A is giving signal to the DCS and FIC 101A/201 A is controlling the set point by the operator selection through FV 101/201 will control the flow rate.
The flow control valves FV 101/201 will automatically close incase of train shutdown (solenoid valve to be reset for taking normal condition).
Low flow alarm FAL 101/201 at 25,000 BPD and low flow shutdown FSLL 101/201 at 24,000 BPD.

4-4 Crude Heat Exchanger E 101/201 cold side

After the feed pump control valve crude oil flow through 10” line is preheated in heat exchanger E 101/201
Heat exchanger is plate type with 10” manual by pass valve and back flashing facilities on both charge product side.

4-5. Water Bath Heater (F-101/201)

The water bath heater makes use of convective type heat transfer. The water bath is maintained at a pre-set temperature by firing hydrocarbon fuel into a U type fire tube immersed in the bath. A coil bundle of carbon steel pipe or tubing in a serpentine arrangement is immersed in the heater bath. The process flow through the coil and heat is transferred from the bath to the process.
The heater is designed with a coil bundle, which is removable from one end of the vessel and a U type fire tube removable from other end.

Crude oil after heat exchanger is fed through 12" line to the water bath heater.
Fresh water is used for both heaters; the bath heater must be always full with fresh water.
The desatler process stream crude oil temp is controlled at above 140^0 F at the outlet line from bath heater

2. Water bath heater is equipped with the following instrument control and settings:

TIT 102/202 (temp transmitter) is measuring the inlet temperature.

- Normally bath heater temp is 140 F to 150 F, high temp alarm TAH 104/204 at 200^0 F and high temp shutdown TSHH 103/203 at 203^0 F.

TIT 101/201 is sending signal to DCS. From the DCS TIC 101/201 is giving signal to TCV 101/201 to control valve for controlling the fuel gas flow rate to heater burner.
At crude oil line inlet to water bath heater low oil flow alarm FAL 103/203 at 25,000BPD and low flow shutdown FSLL 103 at 24,000 BPD

3. Fuel gas system to bath heater:

Fuel gas is taken directly from Shuaibah fuel gas through 1 ½ " line with pressure of 250 to 270 psig.
The reducer valves PCV 107/108 are controlled by DCS PIC 107/108 at Train A and PV 207/208 at train B. These valves are reducing the pressure from 270 to 160 psig.
Fuel gas 1 ½ " line entering to fuel gas knock out pot V 101/201.
At knock out pot safety valves PSV 105/205 A, B set at 75 psi open to relief flash vessel V002.
After knock out pot high pressure alarm PAH 104/204 at 75 psi and low pressure alarm PAL 105/205 at 48 psi
Fuel gas enters to fuel gas filter FL 101/201.
1 ½ " fuel gas line enters the pre-heating coil inside the water bath heater.

After pre-heating the fuel gas divided in two streams one is pilot gas and other one is fuel gas to main burner.

4. Fuel gas to Pilot:

The pilot gas pressure reduced at 15 psi by PCV113/114. Line size is ¾" and control valves 213/214 train 2.

Incase of heater shutdown two shut off valves XV 103A/103 C at train1 and XV 203 A/203B train 2 will closed and stop pilot gas flow, while XV 103B/203B open to vent the gas to atmosphere.

Low pilot pressure alarm PAL 111/211 at 4.0 psi and low pilot pressure shutdown PSLL 112/212 at 3.0 psi.

5. Fuel gas to main burner: (line size 1 ½")

Fuel gas pressure to heater burner reduced to 40 psi by control valves PV 119/120 by signal from local pressure controller PIC119/120 from train 1.

The control valves PV 219/220 by signal from local pressure controller PIC 219/220 from train2.

In case of heater shutdown two shut of valves XV140A/104C at train 1, and 204 A/204C at train 2 will closed and stop fuel gas flow, while XV 104B/ 204B will open to vent the gas to atmosphere.

6. Water bath heater S/D and alarm setting

	Signal from	Tag #	Set point	Action
1	Low fuel press. alarm	PAL-116/216	35 PSI	Alarm
2	Low fuel press. S/D	PSU-115/215	30 PSI	Shut down
3	High fuel press. alarm	PAH-117/217	40 PSI	Alarm
4	High fuel press. S/D	PSHH-118/218	45 PSI	Shut down
5	Low pilot press. alarm	PAL-111/211	4.0 PSI	Alarm
6	Low pilot press. S/D	PSU-112/212	3.0 PSI	Shut down
7	High bath temp. alarm	TAH-104/204	200^0 F	Alarm
8	High bath temp. S/D	TSHH-103/203	203^0F	Shut down
9	Low bath temp. alarm	LAL-101/201	10.5 Ft	Alarm
10	High bath temp. S/D	LSU-102/202	9.5 Ft	Shut down
11	Low air press alarm	PAL-109/209	0.4 w.g	Alarm
12	Low air press S/D	PSU-110/210	0.35 w.g	Shut down
13	Flame failure	BE-101/201		Shut down
14	High stake temp alarm	TAH-105/205	752^0 F	Alarm
15	Outlet oil high temp	TAH-101/201	160^0 F	Alarm
16	Outlet oil low temp	TAL-101/201	140^0 F	Alarm
17	Inlet oil low flow alarm	FAL-103/203	25,000 BPD	Alarm
18	Inlet oil low flow S/D	FSU-103/203	24,000 BPD	Shut down

4-6. 1st Stage (Recycle water injection nozzle - mixing v/v - vessel)

1. Injection Nozzle:

- A 3" recycle water injection line is taken from 2nd stage vessel by recycle pumps P-003 A, B, C to 1st stage vessel injection spool into crude oil system.
- The injection nozzle is to make the wash water spread well with the crude oil.

2. 1st stage mixing valve PDV-121/221:

Crude oil and recycle water deeply mixed by making differential pressure (10 to15 psi).
The mixing valve PDV 121/221 is connected by PDIC-121/221. Its set point is at DCS in control room setting between 10-15 psi.

Too low pressure drop a cross the mixing valve will cause of efficiency of desalting operation, due to intimate contact between wash water and crude oil, in this case an higher salt content in the treated crude stream can be expected.

Too high pressure drop will create a mixture between water and oil with a very high stability, which will be difficult to separate even in the high voltages electrostatics field inside the desater, in this case a higher water content in the treated crude stream can be expected.

3. 1st stage desalter vessel S-101/201:

Crude oil mixed with water enters to 1st stage vessel through 10" line.
The oil water emulsion is removed by introducing it into a high voltage electrostatic field by three transformers.
Oily-water interface out from 1st stage S-101/201 through two 3" lines and send to water /water heat exchanger and then to waste water treatment unit or to wet tank.
At the top of the vessel 1" drain line to be used for degassing the vessel and to check that the vessel is full of crude oil before starting the transformer.
Two 3" drain line at the vessel bottom connected to sump vessel V-001.
4" sludge drains line connected to line 80 pit or to sump vessel.

The 1st stage vessel is equipped with the following instrument:

- Oil-water interface level transmitter LIT-106/206 is sending the signal to LIC-106/206 at DCS.

LIC-106/206 will control the signal to Level control valve LCV 106/206 Normally interface level set at 45-50%.

- Low crude oil level alarm switch LSL-105/205 at 13.ft.

Low crude oil level shutdown switch LSLL-104/204 at 12.0 ft. HS-186/286 at local panel to over ride the shutdown switch.
Pressure transmitter PT-123/223 send signal to DCS at control room (normal pressure 100 psi).
High-pressure alarm PAH-123/223 set at 120 psi.
Temp: transmitter TIT-107/207 send signal to DCS at control room (normal temp: 145^0 F).
Two safety relief valves PSV-106/206 A, B set at 250 psi connected to relief flash vessel V-002.

4-7. 2nd Stage (Wash water injection nozzle - mixing v/v - vessel)

1. Wash water Injection Nozzle:

Crude oil flows from 1st stage vessel to 2nd stage vessel. Before entering the crude oil to 2nd stage vessel the wash water from wash water pumps P-002 A, B,C is injected into 2nd stage injection nozzle.
The injection nozzle is to make the water spread well with the crude oil.
To make more mixing of water with crude oil before entering the 2nd stage vessel. It is called static mixing.
2nd stage vessel oil-water emulsion is removed by introducing it into a high voltage electro static field by 3 transformer.

2. 2nd stage mixing valve PDV-112/222:

Crude oil and wash water or deeply mixed by making differential pressure (10-15 psi). By the mixing valve PDV-112/222. It is controlled by PDIC-112/222 on DCS depending on signal from PDIT-112/222.

3. 2nd stage vessel equipped with following instrument.

Oil-water interface level transmitter LIT-109/209 and sent signal to LIC-109/209 at DCS. LIC-109/209 acting on the level control valve LV-109/209.
Low crude oil level alarm switch LSL-108/208 at 13.6 ft.
Low crude oil level shutdown switch LSLL-107/207 at 12.0 ft, HS-187/287 at local panel to over ride the shutdown switch.
Pressure and temperature indicator.
Interface level sight glass.
Pressure transmitter PT-124/224 send signal to DCS at control room. (Normal pressure set at 70 psi).

Interface level:

The oil water interface level is an important operating parameter since high level can cause poor oil-water separation.
Increase the water level will reduce oil retention time and increase water retention time. And in case of low interface level it will increase the AC electrostatic field between the electrodes and oil-water interface. Also low level can cause higher content of sludge in discharged of recycle water to 1st stage vessel.

4-8. Trivolted Electrostatic Desalting:

At each desalter vessel electric power system used inside desalter vessel is the trivolted electrostatic desalting.
Three transformers are provided for each vessel.
Each transformer is connected across two phases of a three-phase power supply, to ensuring a balanced electrical load.

The transforms have two important design features:
Full reactance:

To ensure that the transformer and the electrical supply system cannot be over loaded.
The desalter can remain on line under upset operation condition; in these case water or emulsion may enter the electrodes system a transient short circuit condition.

Variable output voltage:
It is an off-load tap changes to the desalters voltage level to be divine
This allows the optimum voltage level to be selected for good desalting at minimum power consumption.
Trivolted electrostatic grid is installed on the centerline of the vessel and extends into the vessel heads to give the minimum electrode area available for desalting.
In the three girds the residence time in the electrostatic field is approximately double that allowing more efficient coalescing and improved desalting.
Trivolted system connects a signal output from each transformer to each grid inside the vessel.

Transformer:
High temperature resistant insulating oil and if it is provided with an insulting oil drain.

4-9. Crude Heat Exchangers (E-101/201) Hot side:

After the 2nd stage vessel product crude oil through 10" line and flows to heat exchanger E-101/201(hot side)

4-10. Oil Back Pressure (PV-103/203):

The plant backpressure is maintained at about 80 psig, to prevent release of vapor by the heated wet crude oil inside the desalter vessel or heat exchanger.
The treated crude pressure transmitter PT-103/203 is sending the signal to DCS.
The treated crude pressure controller PIC-103/203 at CCS control the crude pressure in the train by the control valves PV-103/203.
The controllers PEC-103/203 are set at 80 psi at SCS on control room.

4-11. B.S.&W. Analyzer (Basic Sediment And Water):

1. Purpose:
To give a continuous indication of the B.S.&W content in the dry crude line by measuring the dielectric constant of the product as it possess through a special probe in the fluid stream. Changes in the dielectric constant are caused by variations in the amount of water in the product rather than of solids.
To provide an automatic control, to assure crude oil is recycled to the wet tank, any time water content exceeds 0.1% (salt content over 5PTB; pounds per thousand barrels).

The system consists of three parts:

Probe
Sensor
Analyzer indicator/recorder.

2. Salt and water content analyzer:

The quality of treated crude oil is monitored by the analyzer AIT-101/201 (to measure the water content in crude) B.S&W.
The analyzer AT-102/202 in is for measuring the salt content in crude.

4-12. Diverting valves:

Diverting valves are installed down stream of the backpressure control valve. The purpose of the diverting valves is to automatically divert the crude oil flow from the dry tanks into the wet tanks, any time the salt content exceeds 5 PTB (0.1 volume % water cut). Diverting signal comes from the B.S&W analyzer transmitter.

The AV-101/201, A. are open to circulate the crude oil through 10" line to wet tank.

- The AV-101/201 B. is open to sent crude oil through 10" line to dry tank.

5. Wash water & Recycle system:

Wash water system:

This system consists of the following

Wash water tank TK-002
Wash water pumps P-002 A, B and C.
Flow control valve (FV-102/202)
Water heat exchanger E-102/202 cold side.

- Filling line to wash water tank through 4" line from brackish water ring main system.
- At filling line LCV-006 to control the wash water tank level by tacking the signal from LIC-006 at DCS normal set pint at 29.0 ft.
- At filling line biocide is injected by ¾" line.
- 12" line to fire raiser connected to wash water tank.
- 6" line from wash water tank connected to fire pumps.
- All the 6" outlet line from wash water tank, ¾" line of oxygen scavenger is injected.

2. Wash water tank levels settings:

High level alarm	33.5 ft
High level shutdown	35.5 ft will close inlet valve

Low level alarm	7.5 ft
Low level shutdown	3.5 ft will shutdown desalter plant

3. Wash water pumps P-002 A,B &C. and flow control instruments:

- To pump the wash water from wash water tank to 2nd stage vessel.
- At the 4" suction line of each pump ¾" scale inhibitor and ¾" biocide are injected.
- Strainers at each pump suction, and differential gauge pressure fitted to check if the strainers is dirty.

Wash water pump P-002 A will stopped if train 1 shutdown.

- Wash water P-002 C will stop if trains 2 shutdown.
- Spare pump P-002B can be selected by selector hand switch HS-002 B and it stopped by shutdown of selected train.
- At the 3" discharge line Flow Transmitter FIT-102/202 is sending the signal to flow recorder and controller FRC-102/202 at DCS.
- The FRC-102/202 is to give the set point to the flow control valve FV-102/202 depending on the ratio set from FX-101A / FX-201 A with the feed pump flow rate.
- The flow control valves FV-102/202 are fitted at the 3" discharge line from wash water pump to control the wash water flow.
- The water flow is controlled at set ration with feed pumps crude oil flow rate by a flow ratio controller, and the required ratio is normally set at 4.0 to 5.0 % and it can be change.

4. Wash water-heat exchanger E-102/202 cold side:

- The wash water pump into the wash water heat exchanger pumps cold wash water from the wash water tank. Disposal hot effluent water from 1st stage deslter vessel enters water heat exchanger through the interface level control valve to exchange heat with the cold wash water before injection into the 2nd stage desalter vessel.
- 3" wash water line is injected with crude oil inlet line to 2nd stage vessel.

Recycle water system:

- The recycle water pumps taken their suction from the 2nd stage vessel through 4" line and pumped by recycle pump to 1st stage vessel.
- Three pumps are provided, one for TR,A , one for TR, B and C in common stand by.
- At the 4" suction line to recycle pump strainer is fitted, and pressure differential gauge to check if the strainer is dirty.
- Recycle water pump P-002 A will stopped if train 1 shutdown, and the pump P-002 C will stopped if train 2 shutdown.
- Spare pump P-002 B can be selected by selection hand switch HS-002 B and will stopped with select train.

- Local hand switch HS-103, HS-003 A, HS-203 for starting and stopping the recycle pumps.
- At recycle pump 3" discharge line orifice plate FE-108/208 is sending signal to flow recorder FR-108/208 at DCS. (Low flow alarm FAL-108/208 at 1510 BPD).

Level indicator transmitter LIT-109/209 at 2nd stagevessel sends the signal to level controller LIC-109/209 at DCS, which send the signal to level control valve LV-109/209. (Level set point 45-50%).

Water-water heat exchanger E-102/202 hot side:

Effluent water from 1st stage by 4" line and flows to heat exchanger E-102/202 hot side.

6. Waste water treatment unit (W.W.T)

The purpose of wastewater treatment system is to remove oily droplets from wastewater coming out from desalter plants before it is sent to disposal pits located outside the GC.

- The WWT system receives waste water from the following sources:
  Wet tank interface level
  1st stage vessel S-101 train 1
  1st stage vessel S-201 train 2
  Recycle pump train 1 & 2.

- The effluent water to WWT system is treated in two stages. In 1st stage (CPI) large oil particles are being separated by gravity separation inside a special designed tank. In 2nd stage small oil particles are separated by using air flotation unit.

  WWT units are provided in all desalter plants to reduce the oily particles to less then 10 ppm. WWT units working on the basic of gravity separation and flotation principles.

- There are two type of oil in waters one is free oil and the other is emulsified oil.
- At the 14" inlet line to waste water treatment unit, two valves are fitted inlet valve to (CPI) XSV-050 A, and by pass valve XSV-050 B will by pass the WWT system and open to disposal pit.

At the 14" inlet line flow recorder FE-009 with flow transmitter FIT-009 sent signal to FR-009 at DCS.

Types of plate used in WWT system:

There are 4 types of plate interceptors used in waste water treatment units.

API: alternate plate interceptor
SPI: Square plate interceptor
CPI: Corrugated plate interceptor
PPI: Parallel plate interceptor

Air flotation unit W-060:

The flotation process is improved by adding coagulant chemical into the effluent water at inlet of the flotator unit. This chemical breaks oil in-water emulsion, gather suspended solid, and stabilize the air bubbles from froth that floats on the surface.

The capacity of W-060 is 60,000BPD.
The outlet from CPI-W50 through 12" line enters to flotation unit W-050 that will reduce the oil water content to less than 10 ppm.
The sump tank is equipped with a level switch that operates a scum pumps automatically. The scum pump P-016, A, B returns the scum to SPI separator at the effluent water inlet.

7. Chemicals

There are 4 types of chemicals mainly using phase IV desalter plant.

1- Demulsifier chemical
2- Oxygen scavenger
3- Scale inhibitor
4- Coagulant chemical

1. Demulsifier:

Demulsifier chemical is injected into water-in-oil emulsion to break and remove a thick film of emulsifying agents around water droplets. The dosage ppm of demulsifier is 20 ppm.

At demlsifier plant area demulsifier store in two tanks TK-003 A&B. and 4 demulsifier pumps P-004 A, B, C & D.
Demulsifier pumps A&B used at
- Normally at train 1 feed pump P-001 A suction line
- At train A 2nd stage vessel S-102 inlet line.
- At bath heater F-101 inlet line.

Demulsifier pumps P-004 C, D used at
- Normally used at train 2 feed pump P-001C suction line
- At train B 2nd stage vessel S-202 inlet line
- At bath heater f-101 inlet line.

2. Oxygen scavenger:

It is injected into wash water system to remove free oxygen to prevent oxygen corrosion. The dosage ppm of oxygen scavenges is 64ppm.
Oxygen scavenger is stored in tank TKK-005 and two oxygen scavenger pumps P-007 A&B.
Oxygen scavenger pump P-007 A at wash water tank TK-002 outlet line and pump P-007 B is spare.

3- scale inhibitor:

It is injected into both wash water system and wet oil system in order to prevent formation of scale deposits. The dosage ppm of scale inhibitor is 20-30ppm.

At desalter plant scale inhibitor is storage in tank TK-004 and four scale inhibitor pumps P-006 A, B, C & D. The design condition of TK-004 is same as TK-005.

Scale inhibitor pump P-006 A at train 1 wash water pump P-002 A and Pump P-006 B at train 2 wash water pump P-002C.

Pump P-006 C at wastewater treatment system inlet line and P-006b is spare pump for P-006 A, B, C.

4. coagulant chemical:

It is infected into wash water treatment unit at the floatator inlet line. Its purpose is to break oil in water emulsion.

At desalter plant area coagulant is stored in tank TK-007 and two coagulant pumps P-008 A,B. the design condition TK-007 is same as TK-005.

Coagulant pump P-008 B is spare pump for P-008 A

8. Closed Drains And Sump Vessels System

Sump Vessel:

The drain sump is designed to receive only stabilized liquid flows by gravity and not surge flows under high pressure. The following drain lines are connected to the sump vessel.

- Desalter Plant
- Wet Tank
- Test Tank
- Relief Flash Vessel
- Plant Drain Flash Vessel

The main inlet of the sump is connected parallel to the sump tank and line 80 pit. In normal condition the sump inlet valve XV-027A is opened to sump and XV-027B is closed to line 80 pit.

If incase of emergency condition or sump level very high comes the high level switch will actuate and it will give signal to XV-027A sump line will get close, XV-027A line 80 pit valve will open.

Sump Pumps (P-017A, B):

There are two pumps is pumping the oil from sump vessel to the wet tank.

9. Startup Procedure Of Desalter

1. Startup procedure of Desalter feed pump:

Control room:

- Press RESET push button (HS-100 / 200A).

At DCS Console:

- Select alarm history page and verify status of all equipments and process points
- Select group display (199 / 200) and put the following settings
- Select Feed pump discharge flow controller FIC 101 / 201 to put in manual and set the
  out put at 30 %.
- Select the 1st stage and 2nd stage mixing valves controller(PDIC-121 / 221for train A, PDIC-112 / 222 for train B) to put in manual and set the output at 50%.
- Select the backpressure controller PIC-103 / 203 to put in manual and set the output at 75%.
- Select 1st and 2nd stages interface level controllers LIC-106 / 206 and put the set point at 45%.
- Select the wash water flow controller FIC-102 / 202 and keep in remote.
- Select Heater temperature controller TIC-101 / 201 to be put in manual and set the o/p at 0%.

Electrical Sub-Station and field side:

- RESET the feed pump (P-001 A, B, C) power supply circuit breaker in the electrical sub-station and check the fault indication should get OFF.
- In the field manually RESET the following yard solenoid switches
  - FSY-101 / 201 (Wet crude flow controller)
  - FSY-102 / 202 (Wash water flow controller)
  - FSY-106 / 206 (1st stage interface controllers)
  - FSY-101B / 201B (Treated crude diverting valves)

Start the feed pump (P-001A / C) and establish oil circulation through desalter plant

- Start the Wash water pump (P-002 A / C) it is injected with crude oil inlet line to 2nd stage desalter vessel.
- Start the transformers for both stages

- At DCS control station check 2nd stage train A / B water interface level after reaching 45% of water level start the recycle pump(P-003 A / C).

Chemical Pump:

- Start the oxygen scavenger pumps (P-007 A / B) to wash water tank TK-002 and set injection stroke rate percentage as required.
- Start Biocide pumps(P-005 A / B or C / D) and corrosion-cum scale inhibitor pumps(P-006A / B or C / D) to wash water pumps P-002A & B and set injection stroke rate percentage as required.

Control room:

- Select the group display (199 / 200) and put the following settings.
- Select and slowly adjust the crude flow rate on FIC-101/201 to required rates. Raise the set point to match the actual flow and then switch FIC on Auto.

- Set the mixing valve as follows.
  1st stage PDIC121/221 12 psi. For 2nd stage PDIC-122/222 put 12 psi set point ensure the PDI controllers are on auto.
- Select the backpressure controllers PIC-103/203 and slowly decrease the output to get 80-psi process value, and then switch PIC on auto.

2. Startup procedure of Bath Heater:

- Select the desalter heater graphic and switch TIC-101/201 to manual and set TCV Output at 25%.
- Press Shutdown RESET pushbutton on the heater control logic panel.
- After press the RESET button wait until timer moves at zero position. Then press the burner START button
- Heater start sequence will begin
- Wait until main flame ON lights comes on the heater panel
- In DCS check the heater status should be running indication comes
- In DCS switch temperature controller TIC-101/201 to auto and set at 145 degree F.
- After two hours collect samples from 2nd stage crude outlet if result –0.1% or less (Water Cut) –5 BTP or less salt.
- RESET the diverting valve HS-110/210
- RESET solenoid valves of diverting classes

:Trouble Shooting Of Desalter

CONDITION	POSSIABLE FAULTS	CORRECTIVE ACTION
1. Fluctuating Voltage/Current	1. Damaged entrance bushing, transformer bushing, electrode insulator or transformer.	1. Call maintenance to carry out the following. a) Disconnect power to unit open bushing housing and disconnect the copper wire between the entrance bushing and transformer bushing b) When done with the above re-energize transformer/reactor. It fault has cleared; the problem is either the entrance bushing, or an insulator. If fault doesn't clear, the problem is probably the transformer bushing or the transformer/reactor unit.
	2. Emulsion layer interface	2. Check try cocks, if emulsion layer is indicated in upper two try cocks, lower water level as much as possible and increase chemical rate. If layer is not cleared in 8-12 hrs dump water and emulsion layer to pit and re-establish level.
	3. High differential pressure drop at mixing valve.	3. Open mixing valve completely. Allow voltage to return to a steady state and re-establish optimum mix valve setting.
2. High salt content in the desalted crude.	1. Water carry over high 2. Feed salt content high. 3. Wash water injection rate low.	1. Check water level and lower as required. 2. Increase wash water rate. 3. Increase wash water rate.

	4. Crude oil flow rate exceeded design capacity. 5. Insufficient mixing of crude oil and wash water.	4. Reduce crude flow rate to increase retention time. 5. Increase mix valve differential pressure. 6.
3. High BS&W content in the desalted crude.	1. Insufficient mixing of wash water in the crude. 2. High interface level. 3. High water-cut in crude. 4. Bad sampling.	1. Increase mix valve differential pressure. 2. Check these following. i. Check water level using try cocks. Lower level if necessary. ii. Check water injection rate. Reduce if necessary. iii. Check water dump valve and adjust if required. 3. Check these following. i. Water injection rate, if too high, decrease the rate. ii. Chemical injection rate to headers. If low, increase. iii. Check wet tank for possible emulsion layer formed above interface level, uses try cocks. iv. Following wells for abnormal change. (i.e. high water-cut or tight emulsion. 4. Flush sample points, use clean sample bottles and take fresh sample.

1. Introduction Of CRU

The process of liquefying the tank vapors/gas is done within a unit, known as C.R.U (condensate recovery unit). The purpose of CRU is to recover tank vapors in the form of condensate/ liquid that would otherwise have been flared.

CRU is manly consists of muti-stage compressors a driver and cooling system. The driver is an internal combustion engine. The engine type mostly used in SEK is a cooper Bessemer GMWA-8 "V" integral gas engine driving 3 stage compressors. Inter-stage cooling of compressed process gases is done through shell and tube heat exchanger. Crude oil from the transit pump system or from the separators is used as the process-cooling medium. Two forced air draft fans are used to provide cooling duty for the compressor lube oil and for the engine jacket water.
In this 34 stage compressor the feed gas inlet pressure is normally 2.5"w.g. and out let pressure is about 600 psig. After 2nd stage some gases change into liquid (condensate), this liquid or condensate is pumped to the refinery for farther processing into Butan Propane and KNG (Kuwait Natural Gasoline) products. These by-products are then stored in special LPG tank within the refinery area before they are exported the LPG tanks are designed to maintain the products in their liquid form for long period of time.

2. Process Flow Route

CRU production flow:

- Flow tanks
- Lp flare line
- 36" valve
- Vessel C-101
- Suction bottle
- 1st stage compressor
- Discharge bottle
- E-101 cooler

Vessel C-102

- Suction bottle

2nd stage compressor

- Discharge bottle

E-102 cooler
Vessel C-103

- Suction bottle,
- 3rd stage compressor
- Discharge bottle
- G-101
- E-103 cooler
- Vessel C-104
- G-102

2-1. G-101 pumps:

It pumps the liquid from C103 through E 103 to C104. Discharge pressure is approximately 700 psig. G101 has a circulating line connected from the pump discharge line back to vessel C103.

The circulating liquid passes through a small hole 7/64" in an orifice plate fitted in the circulating line.
The CRU will not shutdown when G101 stops. But if not restarted soon, units will shutdown on (high level C103).
An auto dump is fitted on each suction of G101 pump if G101 stops and C103 level reaches a certain high point, auto dump will open dumping extra liquid to main tank filling line through "K" valve. This is to avoid high-level shutdown.
The check valve fitted on G101 discharge line is to stop the gas in E103 from going back to C103 when G101 is not running.

2-2. G –102 Pump:

It function is also same as G-101 pump. But it pumps out condensate from C-104 to condensate pipeline system. The discharge pressure is approximately 1000psig
Note:

3. CB GMWA-8 Engine Description

The Cooper-Bessemer GMWA-8 is a stroke cycle "V" type engine using gas as fuel. 8 nos. power cylinders are arranged in 2 banks at an angle of 36 degree between the centerline of the 2 banks. Thus the name V type being given.

Facing the flywheel end the power cylinders are designated left bank and right bank and is numbered L1, R1 starting from the end opposite to the flywheel.

The engine rotation is clockwise facing the flywheel. The engine is rated at 2000 HP at 250 RPM. 4 nos compressor cylinders, 2 on either side of the engine are driven by connecting rods direct from the engine crankshaft. The engine/compressor unit (K707) is designed to compress 9 MMCF/day of tank vapors in 3 stages to 595 psi.

The quantity of condensate produced from 9MMCF/day of tank vapor varies considerably with the quality of the vapors, but a fair average would be 4500Bbls/day.
Each cylinder head is equipped with a gas ignition valve, starting air valve, indicator cock and two spark plugs.
Two camshafts, one for each cylinder bank are chain driven from the crankshaft. Cam followers operate the gas injection valves through push rods and rocker arms. Rocker arm pins are lubricated by a special feed from engine lube-oil system. Pistons are internally cooled by a continuous spray of oil through a drilled passage in each connecting rod.

3-1. Definition Of CB GMWA-8 Engine:

CB: Stands for Cooper Bessemer

G: Stands for gas engine

M: Stands for integral engine (i.e. engine and compressor built together into one unit).

W: Stands for bore and stroke size(i.e. 18" bore x 20" stroke

A: Stands for types of scavenger (i.e. air blower type).

8: Stands for 8 cylinders engine.

3-2. Power Cylinder operating principle:

It provides in the essential power force required to drive the engine by burning in the correct ratio of fuel air mixture. The cylinder has gas injection valve, two spark plugs, air intake ports and gas exhaust ports.
The fuel gas injected into the cylinder head at the proper time and is mixed with the supply of fresh air that has just been admitted. Since the two ports(intake and exhaust) are closed, the gas –air mixture is compressed and the pressure inside the cylinder is increased. This is called the "Compression stroke". As the piston moves further toward the cylinder head, the compression of the fuel gas-air mixture continuous until reaches near top dead center (TDC) where it is ignited by the twin spark plugs, after which the piston is forced back to the crank end as the combustion charge expands. This is the " power stroke". As the piston approaches the end of this power stroke, bottom dead end(BDC) the exhaust ports are uncovered again to push out the burnt gases as mentioned above completing the cycle.

3-3. Lube Oil System:

The system lubricating the engine supplies lube oil to all internal moving part accept power cylinder, air blower and compressor cylinders.
The power cylinder linear and compressor cylinder are lubricated by mechanical force, feed lubricators and sequential distribution system. (Tarpon lubricator system). The lubricating oil is stored and collected in the under ground tank and the engine crank case sump. The engine lubricating system in pressured by Aux. Lube oil pump, pre lube oil pump and main lube oil pump during engine running.

* Pre lube oil pump:

Before the start up lube oil is supplied to all parts of the engine by pre lube oil pump, which is air driven. This pump will give 3-5 psi pressure to the system before start up.

*** Mine lube oil pump:**

It is a rotary gear type; self lubricated pump and chin driven from the engine gas. It is mounted on the opposite end of ht flywheel. Relief valve set at 75 psig protects the pump and system against excessive pressure.
The lube oil is pumped from the engine sump through a thermostat to the oil cooler (fin fan). After the cooler lube oil passes through filter, and strainer to the main lube oil header. Header in the engine base. Form the gallery lube oil is supplied to all lubrication point accepts power cylinder, air blower and compressor cylinder.

*** Thermostat wall:**

According to the temperature it allows oil to by pass or be cooled by the cooler, and so automatically regulates the temperature.

*** Fin fan:**

A serous of lube, through which the lube oil and water passé. A fan blower air over the tube and cools the lube oil.

The cooler consists of two sections. One section is for cooling the water, and the other section is for cooling the lube oil. The fan is driven by electric motor. If vibration occurs because of a broken blade, vibration switch will stop the fin fan. Rest button must be pressed before restarting.

*** Power cylinder lubricator ICH 40:**
The power cylinders are lubricated from flange type lubricator. A common shaft driven by the engine actuates the lubricator.
Lube oil ICH 40 settings:

Pressure	30-35 psig
Low pressure trip	15 psig
Temp	160-170 F
Shutdown	205 F

Compressor cylinder lube oil (GEC-460):

Compressor cylinders are lubricated by GEC 460. And the normal pressure is 100-120 psi. The low pressure set at 40 psi.
If either the power or compressor lubricator reservoirs are fond to be empty, don not restart the unit, because in this case plungers will be air locked and require maintenance dept. to disconnect and prime each plunger and lubricating point.

3-4. Fuel gas system:

Fuel gas supply to the CRU is from engine gas scrubber at 135 pos. the fisher 99 regulating valve is reduces fuel gas pressure 240 psi and the sensing line is connected with filter outlet. This filter has an auto dump.

*** Vessel C-109:**

This vessel is a scrubber to ensure no liquid is allows into the engine. If liquid from that will dump with the normal drain to a pit. It has a relief valve set at 90 psi.

*** Fuel gas plug valve:**

This valve is used to shutdown the engine manually or emergency case.

*** Fuel shut off valve:**

It shuts off gas supply and vents the fuel gas from the engine during normal and emergency shutdown. (ESD). During start up, when ignition indicator comes on at FT-50 panel, instrument air is applied to the diaphragm of the valve to open the gas port and close the vent port of the valve.

*** Fuel control valve:**

This is the main control valve that regulates the fuel gas pressure to the engine. In other words it is the valve, which controls the speed of the engine increase or decrease. It is remotely and manually controlled from the FT-50panel.
During start-up the fuel gas control valve is at the minimum open position (set to regulate to the light up pressure of 10-12 psi fuel gas). In order to run the engine at minimum speed of 165 RPM.

*** Gas injection valves:**

They are operated by cam-followers through push rods and rocker arms. A burnt out gas injection valve will result in heavy smoke and detonation of the engine.

3-5. Ignition system:

The purpose of ignition system is to furnish is spark in the combustion chamber of the cylinder to the fire the air/ fuel mixture at the proper point in the stroke sequence to maintain smooth engine firing. In each cylinder has two spark plugs fired simultaneously to provide continuous and relay able ignition. Twin spark plugs in each power cylinder head provide source of ignition at all loads and speed to the engine. Twin spark means a system in which the two spark plugs fire at the same time. In the twin spark system, if one of the plugs fail the other plug will fire. The purpose of the twin spark is to permit more efficient combustion and improve reliability of the system though base-up ignition.

Ultrasonic 11-CPV-ignition system:

This new system consists of an ultrasonic generator unit, the ultrasonic unit provides adequate starting out put at an engine speed 30-50 RPM and ensures free operating

during running period. This ignition system operated during start up, the engine is cranked for 7 second for purging sequence. After this period a relay on FT-50 panel is energized and sends out a 24 volt DC signal to the ultrasonic CPV via a really box.

The coils step up the primary voltage from low to high tensioned charge the spark plugs for a 2 second period. When the ignition on indicator light is on the FT-50 panel during start up, the following events take place:

- The relay box is energized and the ignition switch inside is open to remove grounding of the ignitions system.

- The fuel shut off valve is signaled to open to indicate the ignition firing sequence. The ignition CPV is programmed with the engine firing sequence logic derived from 360 bar holes drilled along the perimeters edge of the flywheel, each hole representing one degree. Four magnetic pick-ups are fixed opposite the rotating side of the flywheel and at opposite the rotating side of the flywheel and at a distance of 0.15" air gap from the rotating path of the flywheel to obtain optimum sensing of pluses. Each pick up has its own separator function, as described below.

Probe 1- transmits rotational signals to FT-50 panel for speed induction on tachometers and for over speed protection.
Probe 2- signals altronic ignition control unit to initiate firing sequence through altronci CPU.
Probe 3- sends ignition timing signal to the altronic CPV by measuring revolution of the flywheel to indicate which power cylinder is ready and in the firing line.
Probe 4- transmits signal to FT-50 panel speed cars, as a back up for speed indication and for over speed trip relay

4. Gas Compressor

The compressor:

A reciprocating compressor is positive displacement equipment and an integral part of a CB engine, sharing the same crankshaft. The crankshaft transmits the produced energy from the power pistons to the compressor pistons. The compressor cylinders arranged horizontally and connected in such a way that the piston movement is perpendicular to the crankshaft. In this way the crankshaft converts the rotary motion into reciprocating movement.

Compressor operation:

The 1st stage has two cylinders, horizontally opposed. The inlet gas is drawn from C-101 at 2.5"w.g, which is connected to the tank vapor hader.ithe1st stage compressor the gas and discharges at approximately 58 psig into vessel C-102. The pressure depends on engine speed and number of unloaders screwed in or out.

The gas is drawn from C-102 at approximately 55 psig into the 2nd stage compressor and compressed up to 19 psig. The 2nd stage has only one cylinder. The gas is discharged into vessel C-104. This 3rd stage also has only one cylinder.

5.Operating Procedures

CRU Pre Start-up Check List:

Separator area:

- Separator plant production not less than 60,000 Bbls/day
- Second stage separate pressure 60 psi.

CRU process system:

- 1.36" suction valve to C-101 open.
- C101 vessel drained and drain shut
- Gas recycle valve 6" from 3rd stage compressor discharge valve open.
- Four unloaders out

All vent valves are shut

- C102 manual drains shut and auto dump set for correct operation
- C103/C104 auto water dump set for correct operation
- C103/104 extra dumps and set for correct operation
- Open the suction valves and G101/G102
- Valve on circulating line from G102 discharge to C104 open
- Isolating valve on transit line to refinery open
- C104 PRV U/s and D/S valves open and by-pass shut
- Quick drain U/S valve open
- Suction and discharge bottle drains are shut

Crude oil cooling system:

- E 101 crude oil outlet valve is set to give approximitaly120^0 F outlet temperature. Open manual drain to check for cooler tubes leak.
- E 102 crude oil outlet valve is fully open. Open manual drain.
- E103 crude oil outlet valve is fully open. Open manual drain automatic temperature controller U/S and D/S valve open, and set at 90^0 F.

The pressure drop of the crude oil across the cller inlet to outlet shoud not exceeds 2.5 psi. As this puts unnecessary load on the pumps. The trimming valve controls. This does not apply to CRU's where hot oil system is used for cooling.

Scavenge air system:

Sand blower switched on
Water and mercury manometers are service able.

Fuel system

Valve on engine gas scrubbers is open
Gas valve U/ stream fisher 99 (Big Jo) open

- Pressure down stream of (fisher 99" regulator is 40 psi)
- C109 drained of any liquid
- Fuel gas plug valve open
- Governor gas valve is shut position.

DCS Control Room:

- Press CRU RESET pushbutton at the operator console.
- At the DCS check and ensure the following:
    - C-103 & C-104 level controllers set points are correctly set
    - Lean gas pressure controller PIC-525 put the set point at 550psi
    - Compensating gas pressure controller PIC – 527 for dry tank and PIC-001 for wet tank set points are set at 2.8" WG.
- LP header butterfly valve set to control at 3.8" WG.

FT-50 Panel:

- At FT-50 control panel turn "ACK-RESET" knob to RESET position and check the following.

    - Unit shutdown start permissive.
    - Class B shutdown start permissive
    - Start air pressure start permissive
    - Fuel gas pressure start permissive
    - DCS start permissive

NOTE: Class B shutdown consists of the following points

- Low lube oil pressure shutdown
- Jacket water low-pressure shutdown
- Power cylinder low flow shutdown
- Compressor cylinder low flow shutdown.

Put STOP / RUN switch on stating panel on RUN position.

Start-up Procedure of CRU:

1. Press "AUTO START" button.
    - Pre lube oil pump start
    - Class B shutdowns are overridden (by-passed) for 180 sec.
    - Sequence progress light comes ON
    - 90 sec after oil pressure reaches 5 psi crank permissive comes ON
2. " Crankcase ON "
    - Starting motor cranks the engine for 7 sec(purge time)

3. " IGNITION ON "
Ignition coils charge spark plugs for 2 sec period and ignition indication comes ON

4. " FUEL ON "
- Fuel shut off valve opens
- Fuel control valve allows 10 to 12 psi gas flow to the engine to attain minimum speed of 165 RPM.
- LP quick vent valve close automatically
- At 90 RPM speed starter motor auxiliary and pre lube oil pumps stops
- Class B shutdown override indicators are cleared

5. " WARN UP ON ".
- Warn up timer is energized for 180 sec
- Engine remains running on ideal speed 165 RPM during this period
- When lube oil temperature reaches 110 degree F "ACCEL PERMISSIVE" light comes ON.

6. " UNIT READY TO LOAD ON".
- The engine is now ready to increase speed and for loading up
- After unit ready to load comes ON normally close the starter motor isolating valve.

7. "LOADING UP".
Increase the engine speed to 220 RPM using the raise pushbutton
Slowly close the 6" bypass valve from third stage filling
Put unloaders in as required and watch C-101 pressure
When liquid appears in C-103, prime the G-101 pump and Start the G-101 pump
When liquid appears in C-104, prime the G-102 pump and Start the G-102 pump
Manually stroke C-102 auto dump valve and C-103 and C-104 water dump valves to ensure they are in working order.
Check the controllers status on the DCS and ensure that C-103, C-104 levels and C-104 pressure controls are OK.

:Trouble Shooting Of CRU

CONDITION	POSSIABLE FAULTS	CORRECTIVE ACTION
1. C-101 Pressure low. (Less then 0.7"WG.)	1. Butter valve or compensating valve not working properly. 2. Production is less	1. Take one or more un loaders out. 2. Report to

	then before. 3. Switch is faulty.	instrument department. (For checking fault no 2&3)
2. 2nd stage compressor high discharge temperature.	1. E-101 outlet temperature is too high. 2. Compressor suction or discharge valves or leaking.	1. Lower E-101 temperature. 2. Report to maintenance department.
3. Liquid level in C-102.	1. E-101 outlet temperature is too low. 2. Auto dump is not working properly.	1. Raise E-101 temperature. 2. Check auto dump valve drain the C-102.
4. Low liquid level in C-103.	1. Auto water dump is stuck open. 2. C-103 LCV is not working properly.	1. Shut auto water dump upstream valve. 2. Report to instrument department.
5. High liquid level in C-103 .	5. C-103 LCV is not working properly or Switch is faulty. 6. G-102 is not pumping.	1. Report to instrument department to check the LCV & switch. 2. Report to maintenance to check the prime the pump.
6. High Pressure in C-103.	1. 3rd stage compressor suction valves are leaking.	1. Report to maintenance department.
7. High Pressure in C-104.	1.Automatic pressure controller is not working properly. 2. C-104 pressure control valve frozen. 3. Lean gas line to Hp gas system is frozen.	C-104 pressure controller put on manual. Check C-103 outlet temperature. It must be above 80^0 F. Report to instrument department.
8. G-101 pump is U/S (not pumping) and more condensate is needed.	Broken pump impeller.	Open C-103 drain to pit. Shut G-101 suction valve. Raise E-102 temperature watching 3rd stage compressor discharge

	Sheared coupling. Electric motor is U/S.	temperature not exceeded 260^0F. Report to maintenance department. Report to electrician.
9. G-102 motor amps are too high.	Ampere meter is faulty. G-102 motor is overloaded.	Electrician to check the ampere meter. Take one or more un loaders out.
10. G -101/G -102 pump capacity decreased.	Suction head or level low. High discharge pressure. Low suction pressure. Impeller damaged.	1. Check C-103 / C-104 levels and adjust if necessary. 2. Check the C-103 / C-104 LCV's down stream valves. 3. Stop pump report to maintenance.
11. Water pressure is low.	1. Air lock in the water system 2. Surge tank level is low.	1. Open bleed points. 2. Fill up surge tank.
12. Lube oil pressure is low.	1. Full flow filter is very dirty. 2. Engine sump level is low.	1. Report to maintenance department to clean filter. 2. Fill up to normal level manually if float is U/S.
13. Lube oil or water outlet temperature is high.	1. Fin fan stopper. 2. Fin fan on low speed. 3. Thermostat is not operating correctly.	1. Call electrician and restart fan. 2. Change to high speed. 3. Report to maintenance department.
14. Compressor cylinder lube oil pressure low.	1. Lubricator reservoir is empty. 2. Shaft drive is sheared. 3. Shutdown switch is faulty.	1. Don't start the unit, plungers are checked and require maintenance. 2. Report to maintenance

		department. 3. Hand prime the system, system to test fail safe shutdown switch.
15. Engine is detonating.	1. Low scavenges air pressure. 2. A burnt gas injection valve.	1. Take un loaders out and report to maintenance department. 2. Stop the unit and report to maintenance department.
16. Power cylinder temperature is low.	1. Spark plug is faulty. 2. Gas valve is not working properly. 3. Ignition CPU may not be giving output to the spark plug or particular wire is loose.	1. Report to maintenance department to check the gas valve. 2. Report to auto electrician. 3. Report to Instrument department.
17. Engine over speed.	1. Fuel gas valve is not working properly. 2. Speed sensor faulty.	1. Report to instrument department to Check the fuel gas valve, and speed sensor.
18. Incomplete sequence.	1. During g start up if any procedures are not completed an in complete sequence trip is generated.	1. Report to instrument department.
19. UV detector engine / pump actuated.	1. Welding work is going inside the G.C. 2. UV is faulty.	1. Stop the UV detectors supply. When welding is going inside the G.C. 2. Report to instrument department.

20. Engine vibration High.	1. Switch can be faulty. 2. Any damages inside the engine.	1. Report to instrument department. 2. Report to maintenance Dept.

1. Introduction Of Ruston Turbine TA-1500

The Ruston mark TA 1500 gas turbine is used to drive the main crude oil pumps. It operates on an open cycle. The gas turbine has a power rating of 1260 Break hours power.
The turbine has the advantage of being able to run for long periods, with little maintenance cost. It is having a long service life can be obtained by reducing number of starts and by not exceeding the recommended gas temperatures. The gas turbine produces continuous flow of compressed air from the air compressor, continuous combustion within the combustion chamber and continuous power delivery from the turbine section.

In GC#1 has two transit pumps are driven by gas turbine for dispatching the crude oil. Both turbines are operating with different control systems. One is Servo oil control system and other one is equipped with Wood Word excel 250 PLC control system (programmable logic control). The pump sets is composed of main pump and Booster pump. Which are arranged in series with each other.

1-1. Operating cycle:

As the air passes to the 13 stages compressor is driven by starter motor. The moving blades increase the pressure and the velocity of the air, whiles the starter blades convert some of the increased velocity into further increase of pressure. The compressed air leaves the compressor at 193 C and at 61 Psi.
The high-pressure airflows through the cross over duct it enters the combustion chamber. When the main burner is on the heat of energy will be produced by combustion. The force of this hot stream of gas 754^0 C at 60 psi is used to drive the compressor turbine and power turbine before being released to atmosphere through the exhaust duct.

The temperature at the power turbine drops to about 551^0 C at 24 Psi and the temperature after the power turbine drops to 450^0 C at 14.7 psi.

T.Max & inter-duct temperatures.

1- Inter duct temp:
- 8 thermo couples fitted around the inter-duct.
- It's # 2 on the Cambridge indicator.

2- T. Max Temp:
- It is obtained by the following combination:

- Average inter duct temp + (compressor outlet temp- compressor inlet temp)= T.Max

Example: comp. Inlet temp = 18^0 C
Comp. Outlet temp = 193^0 C
Average inter-duct temp = 551^0 C
T. Max = 551 + (193-18) = 726^0 C
T. Max should not be more than 772^0 C, load must be reduced.

2. Turbine Main Parts

Turbine Main Parts:

Air filter
Mesh screen filters
Compressor inlet casing
Air compressor 13 stages
Crosse over duct
combustion chamber (Elbow type)
Ignition system
Main burner
Compressor turbine
Inter mediate-duct
Power turbine
Reduction gear
Exhaust
Starter motor
Blow-off valve
Over speed trip
Governor
Control unit.

Air filter: It is a self-cleaning type and design to clean the air before entering the air compressor. The screen is rotated through a bath of viscosene oil. The AC motor is driven and turns for 8 second every 12 minutes.

Mesh screen filter: A mesh screen is fitted between the inlet air ducting and the compressor air inlet casing to prevent any solid material from entering the compressor.

Compressor inlet casing: It is forming the connection between the air inlet ducting and the 13 stages compressor entry.

Air compressor 13 stages: The 13-stage compressor is connected to the air filter by ducting. It is an axial flow type compressor. The compression is ration of 4:1. The air enters the compressor at atmospheric pressure and temperature and leaves at 61 psi at a temperature of 193^0 C the speed range is between 8500 to 1100 RPM depending on load. The 13-stage compressor is first starting by a starter motor and the air outlet passes through a diffuser. It reduces a velocity of air and increase the pressure.

Crossover duct: It transfers the air from the outlet of the compressor to the combustion chamber. Flexible bellows are fitted to allow for expansion with out causing any damage.

Combustion chamber- Elbow type: It consists of an outer casing, inner flame tube and a diffuser cone. The incoming air from air compressor is divided into three streams.

- Primary airflow through the diffuser to stabilizes the flame.
- Secondary air is controlled by vanes to give an even temperature
- Cooling air passes between the flame tube and the outer casing to cool the internal walls. The normal pressure, temperature is (60 psi / 754^0 C)

Ignition system: It consists of small burner and a spark plug. The spark plug is supplied with high-tension current from ignition coil (5000 volts). This solenoid valve is to control the fuel gas flow to small burners its supply the pressure at (2-3 psig).

Main burner: It is a round tube fitted with a nozzle with holes in and screwed into the combustion chamber, to allow gas to pass into the combustion chamber through the nozzles. The main burner gas pressure is usually 40 to 60 psig depending on load. Nozzles partly blocked cause hot spots.

Compressor turbine: It drives the 13-stage compressor directly through a garden shaft each stage consist of 83 rotor blades and 76 starter blades. Hot gas from combustion chamber flow into rotor blades that makes turbine spin and driving the 13-stage compressor at the same time.

Inter-mediate duct: (Inter-duct) This consists of outer casing and inner cone. It is fitted between the compressor turbine and the power turbine. The hot gasses flows along the annulus formed between the cone and the outer casing into the power turbine. The normal pressure and temperature is (24 psi / 551^0C).

Power turbine: It has 97 rotor blades and 92 stator blades on each stage. It is connected to the reduction gear by a garden shaft. Power turbine speed is 6000RPM, reduce to 1500RPM by the reduction gear to drive the main crude oil pump through the output shaft.

Reduction gear: It is fitted between the power turbine and the output shaft. The gears are lubricated from the main lubricating oil system. Drives the main lube oil pump, governor and over speed trip. The reduction gearbox reduces the speed of power turbine to output shaft as flow for turbine TA-1500 -6,600 to 6,600 RPM.

Exhaust: There are two exhaust ducts, which release the burnt gases to atmosphere. The normal exhaust pressure and temperature is (14.7 psia / 450^0 C).

Starter motor: It is connected to the directly 13-stage compressor air compressor by a starting dog (clutch). The starter motor drives the air compressor during the starting sequence at about 2500 to 3000 RPM. Starter motor is stopped when compressor outlet pressure (P2 pressure reaches 6 Pisa) and compressor speed is (4500RPM). At GC # 1 the starter motor is started by air taken from CRU start air vessel.

Blow-off valves: Two blow-off valves are fitted on cross over duct. They are always shut when turbine is turning on normal speed. The small airline is taken from the cross over duct to flexible diaphragm to close or open the blow-off valves. When open, they allow the some of the outlet air compressor to go to atmosphere. The two micro switches are operated: when speed is exceeded the selected set speed by 40 to 60 RPM. Micro switches will be energized and send a signal to air maxseal valve to vent the air blow off valves will open. When the speed drops to with in 40 RPM of the set speed air maxseal valve will stop venting and blow off valves will close.

The blow-off valve are opened when ever any of the following condition accrue:

- During starting: one blow-off valve is held open by a spring. After the main burner is light and compressor outlet pressure rises to 5-psia pressures will force the blow-off valve to close. This is to prevent a compressor surge and possible damage.
- Blow-off valve without spring is closed as soon as the 13-stage compressor is turning.

Large load reduction: both blow-off valves are opened when load is reduced suddenly. This is carried out by signal from the governor (two micro switches) to air vessel valve to vent the airline on the diaphragm blow-off valves. To open the blow-off valves, and vent the air from the crossover duct. The dropping of compressor pressure will reduce turbine speed, and prevent over speed trip

Over speed trip: Gears drive it from output shaft. The over speed trip will happen if the load decreases so much and speed reaches the over speed set 6200RPM. The unbalanced ring will over come the forces of the spring and moves to driving shaft, the trip leaver handle moves down words causing the servo oil to spill. The loss of servo oil will close the fuel gas shut-off valve, turbine stops. Also the mechanical air valve opens and went the holding air pressure from the blow-off valves to open. This is occurred when the micro switches failed to operate.

Governor: The governor fuel valve regulates the gas supply to the main burner to control the turbine speed.
Governor speed motor: It is a small DC motor, used to increase or decrease the turbine speed. It is operated by hand switch in control unit panel. It is gear mechanical which increase and decrease the speed spring forces to regulate the speed as require.

Speed limit switches: Two micro switches limit the output shaft speed. They open to de-energize the governor speeder motor when the minimum or maximum speed limits are reached.

Control unit: The control unit controls the operation of the turbine during starting cycle.
Electrical section: The control unit contains 8 series of switches operated by cames on the hand wheel spindle. These switches control the electric circuits necessary for starting the turbine.

3. Main Systems Of Turbine TA-1500

This includes the following Systems

- Lube Oil System
- Fuel Gas System
- Servo Oil System
- Starting Air System

3-1. Lube oil system:

Lubricating oil is supplied to the system by the three pumps Main lube oil pump, D.C auxiliary lube oil pump. And A.C aux. Lube oil pump. The normal lube oil pressure is (20 psi) it is controlled by relief valve. The lube oil type is THB 68. The lube oil is to supply and lubricating the 13-stage compressor bearing, compressor turbine bearings, power turbine bearings, main crude oil pumps bearings and gearbox. The operating control and safety devices in using servo oil system.

Main lube oil pump:

It's supplies to the oil lubricating can servo systems during normal running of the turbine. The main lube oil pump driven by the gearbox. The 5 psig NRV opens to allow oil to by pass the main pump, when the DC Aux. Lube oil pump is running.

DC Aux. Lube oil pump:

It is driven by an electric motor it discharges the oil into the suction line of the main lube oil pump through the 5-psi NRV to ensure that the main pump is always primed on start-up. The Aux pump has built in relief valve set at 80 psig. It runs after any shutdown and hand wheel on (Run) position, only for 30 minutes.

AC Aux lube oil pump:

It runs when the hand wheel on aux. On position. It runs and stops by pressure switch (28 psi). When the pressure in the cross over duct is less than 28 psi, the AC lubes oil pump will continuous running. If it is more than 28 psi it will stop.

Note:
In case of power failure, AC pumps and lube oil cooler will not starts, only DC pump will not continuous running.

3-2. Fuel Gas System:

Lean gas supplies to the turbine from engine gas scrubber. The engine gas scrubber inlet PRV controls the pressure at 175 psig. And the outlet PRV controls the pressure to the engine at 125 psig.

- Normal fuel gas pressure is (40-60psig) after governor.
- Low fuel gas pressure shutdown is 80psi.

Before starting the turbine open the drain by pass valve manually to prevent liquids entering the combustion chamber.

Engine gas scrubber:

This scrubber is to ensure no liquid is allowed into the turbine. An auto dump to line 80 can damp any liquid formed automatically.

Demister:

It consists of two chambers upper and lower. A float inside the lower chamber shuts off the gas flow to stop the turbine if there is a high level. Each chamber has an auto dump routed to sump tank. From the demister gas outlet, a small supply line is taken to the igniter through a reducer and a solenoid valve.

Governor gas valve:

It is connected into the main gas line to the burner and acts as a throttle valve to control the fuel supply to the burner. It is fully open at the beginning of the starting sequence.

Fuel shut off valve:

It is located near the main burner and opened by servo oil pressure when the aux. Lube oil pump is first started. It is fitted near the main burner to ensure a quick shut down of the turbine, should any of the safety devices operate.

Manual shut off valve:

This valve can be shut to stop the turbine in case of an emergency. It should be kept shut when the turbine is not running to prevent gas leaking into the combustion chamber.

3-3. Servo Oil System:

The servo oil system is used in operating the safety devices of the turbine. It is taken from main lube oil supply just before the pressuring valve, which keeps servo pressure about 60 psig. The servo oil supply is divided into the following points.

- Governor
- Control unit
- Load and start limiters
- Two fuel shut off valves
- Low servo oil pressure shut down switch 30 psig
- Solenoid servo valve trip (max seal valve)
- Low lube oil pressure shutdown switch (13psig)
- Over speed trip (6,200 RPM)

It consists of the following parts.

1- Filter: cleans the servo oil

2- Restrictors: They ensure quick drop in servo pressure when any of the safety device operates. The relief valve set at 60 psig and it opened to the sump.

3- Max seal servo release valve (solenoid operated): It is fitted in the servo oil line and is used by electrically operated safety devices to shut down the turbine by spilling the servo oil pressure. The solenoid is de-energized to open the valve.

3-4. Starting air system:

The system consists of the following.

- Starter motor
- Reducer
- Solenoid valve
- Diaphragm valve
- 60 psig pressure switch and 15 seconds timer.

Starter motor: The starter motor is turned by air supplied from the CRU starting compressor vessel. When the starter is turned, its teeth and rotor dogs engage to connect the starter motor with the 13-stage air compressor.

Reducer: It reduces the gas pressure to 90psig for the diaphragm valve.

Solenoid valve: This solenoid is energized to open the valve by a signal from a cam switch, when the hand wheel is moved to starter on, and allows staring air to open diaphragm valve.

Diaphragm valve: Diaphragm valve is to regulate the pressure supply. It is opened by air or gas supply through ¼ " small pipe taken from the inlet to system. And reduced to 90psig by reducer to solenoid valve to open the diaphragm valve.

60-psig pressure switches and 15 seconds timer: It is to prevent the hand wheel being move to the ignition on position until the turbine is completely purged with air. This is done when the pressure reaches 60 psig in the down stream of the diaphragm before the starter motor, a ¼ " small pip is supplying the 60 psig switch to energize it , and the 60 psig switch will energized 15 seconds timer relay to delay before (2^{nd} inter lock) is free.

4. Transit Pump Unit

Introduction

In GC# 1 has two transit pump sets per dispatching the crude oil to Ahmadi tank form. A pump set is pump housed of main pump and Booster pump, which are arranged in series with each other.
The number of pumps in commission depends upon the amount of crude oil to be dispatch and the pressure in the transit line. The transit pumps are driven by a gas turbine. The oil flows by gravity from the main tank to the inlet of the Booster pump (at a pressure of 3-5 psig depending on dry tank oil level) where its pressure is increased by the centrifugal force, it then passes through to the inlet of main pump where its pressure is further increased to a high pressure enough to force it into the transit line.

4-1. Booster pumps:

The booster pump have to reduction gear boxes, the first one is fitted between the main pump outlet and the booster pump to reduce the output shaft speed from 6000 RPM to 1400 RPM, and the second one is fitted on the booster pump to reduce the output shaft speed 1400RPM to 1000RPM at booster pump. The gearbox lubrication is taken from the main lube oil system.

Booster pump description:

Maximum range	About 1000 RPM
Suction pressure	3-5 psig normal
Discharge pressure	35-40 psig normal
Low gear oil pressure	15 psig shutdown
High lube oil temp	150^0 F

Table 1

4-2. Main pump:

It is taking suction pressure from booster pump at 35-40 psi and it is giving discharge pressure to transit line.

Minimum speed	4400 RPM
Maximum speed	5700 RPM
Over speed trip	6200 RPM
Suction pressure	35-40 psig normal
Maximum casing pressure	500 psig
Casing temp Shutdown	150^0 F

5. Turbine Pre-Start Check List

Pre-start checklist:

* Control room:
  - Check the dry tank level in normal (12 ft).
  - Reset the turbine on emergency shutdown panel.
  - Check the engine gas scrubber outlet pressure control valve set at 130 psig.

* Main plant area:
  - Check the dry tank suction valve is to be opened
  - Check the engine gas scrubber isolating valve are opened
  - Check the main starting air valve to turbine is opened.
  - Check the main fuel gas supply valve to turbine is opened.

* Electrical sub-station room:
  - Switch battery charger selector switch from auto to manual position.
  - Check AC lube oil pump switch is on auto.
  - Check lube oil cooler switch is on auto.
  - Start the ventilation fan.

* Turbine room:
  - Check the screen filter is running (clean)
  - Check the lube oil level in turbine room
  - Check fuel pressure is demister in 120 psig and drain manually (check all isolating valves to auto dumps are opened).
  - Open insolating fuel valve upstream of main burner.
  - Open isolating fuel valve of small burner
  - Open isolating starting air valve.

* Control unit and relay panel:
  - Switch (on) AC and DC isolator's switches.
  - Switch Cambridge indicator is on position.(No. 2 inter-duct temp).
  - Reduce governor speeds to minimum set speed.
  - Control hand wheel on (Off) position.

- Reset emergency shutdown push button on relay control panel.

* Pump room:
- Check suction valve to booster pump is open
- Check suction pressure is 3-5 psig
- Check and open main crude pump discharge valve ¼ “ open.
- Prime main crude oil pump
- Check all valves to CRU in and out are opened and by pass is closed (cold system only).
- Check crude oil pump circulating valve is closed.
- Replace old chart with new chart of crude oil dispatch.

6. Start Up Procedures

6-1. Servo Oil Operated Control System Start up procedure:

1. RESET Fail Safe Panel, ('Ready to Run' light light comes ON)

1. Aux. On:

Lift hand wheel catch and move wheel from Off to Aux. Pump on position.

- AC and DC Aux. Lube oil pumps will start and red indication light will shows on the controller.
- Wait for lube oil pressure to build up to 20 psig (first interlock withdraws by teddengton pressure switch when lube oil pressure reaches 13 psig)
- Servo oil pressure will be 60-80 psi.

2. Starter On:

Move the hand wheel to ‘Start position’.

- Electric signal from hand wheel to starting air solenoid valve to passes 90-psig air pressure from reducer to diaphragm valve force to open.

- Diaphragm valve will pass starting air of 90 psig to starter motor.

- Starter moves will become on and drive the air compressor and 13-stage compressor turbine at 2500-3000 RPM.

Do not attempt to start the turbine if the compressor does not reach 1800 RPM on the starter.

3. 'IGNITER ON'

- Move Hand wheel to 'IGNITER ON' position. Check that the Igniter is lit.
- 24 volts signal from hand wheel to coil to supply 5 KV to spark plug.

- When the Igniter is lit, move Hand wheel to 'MAIN BURNER ON'. Control Inter duct Temperature below 575 °C.

2. Move Hand wheel to 'START' Position.

- Starter Motor stops at 5000 rpm.

- A.C. Aux Lube Oil will stop if Crossover Duct pressure is above 30 Psig.

3. Move Hand wheel to 'RUN' Position.

- DC Aux Lube Oil pump will stop.

Set Pump rate to suit requirement by:

a. Adjusting Turbine Speed to Minimum possible.

b. Wide open Discharge Valve to maximum possible.

6-1. Woodward Control System Start up procedure:

This system is operating by Excel 250 PLC (Programmable Logic Control System).

PGI-100 Operator Interface Station, call 'OVERVIEW' screen display. (Touch the Screen Display to clear out Screen Saver Active).

From 'OVERVIEW' Display, select 'MAIN MENU' display.

From the 'MAIN MENU' Display, select 'START PERM' object to display start Permissive Screen. From the 'START PERMISSIVE' displayed Screen, verify the following Permissive are satisfied:

- Re-start Timer (5 Mins.) completed
- GG reference at Lower Limit (3,800 rpm)
- PT Reference at Lower Limit (3,800 rpm)
- No Shutdowns Active
- No Light-off (Flame) Detected
- GS-3 Valve at Minimum position (5%)
- Mode Set (Local/Remote)
- Start Permissive from DCS - OK

2. From 'START PERMISSIVE' display, select 'NEXT' to display 'START SEQUENCE' display.

3. From the Turbine Local Control Panel (LOCP), verify 'READY TO START' Green light is ON.

4. From the Turbine Local Control Panel (LOCP), press Start Pushbutton and 'MASTER RUN RELAY' will energize the Start sequence as follows:

- Start-up Overall Sequence Timer (Watchdog Timer) of 120 seconds is energized.
- Auxiliary AC/DC Lube Oil Pumps will start and Low Lube Oil Pressure Shutdown signal is bypassed for 10 Seconds.
- Starter Motor is energized to engage and rotate the turbine 13th Stage Air Compressor. Starter Motor Timer is activated for 15 Seconds count down.

  Note: *If the Turbine fails to reach above 700 RPM of GG Speed within the 15 Secs period, the Start-up sequence is aborted.*

b.When GG Speed reaches above 700 RPM, the following will happen:

- Ventilation and Filter Fan start.
- Lube Oil Cooler Fan Starts.

c.When GG Speed reaches 1,750 RPM, the Pilot Ignition System is energized and the Pilot comes ON. A 15 Second Ignition Timer is energized for Pilot flame confirmation.

d.When the Pilot Flame is detected, Ignition Timer is de-energized and the GG Acceleration Timer of 30 Seconds is started and the following take place:

- Maxseal 2-Way Shut-off Valve in the fuel gas line is open.
- Woodward Governor Fuel Valve is energized.
- Ramp Start Limiter & EGT Limiter are energized. GG Speed acceleration is controlled not to exceed 4% Per Second

.

e.When GG Speed reaches 4,500 RPM (or 7.5 Psi Cross-Over Duct Pressure), the following take place:

- Acceleration Timer is de-energized (timed out)
- The Power Turbine starts to breakaway.
- Starter Motor stops.

f.When the PT Speed reaches above 3,800 RPM, PT Control Delay Timer of 5 Seconds is energized for 'Sequence Complete' events, ie:

- Overall Watchdog Timer is de-energized (timed out).
- EGT Control Point is switched from Startup Value Control (1292 °F) to Normal Value Control (1454 °F).

- EGT Spread Set point is switched from Startup Value (500 °F) to Normal Value (140 °F).
- Vibration Monitoring System (Bentley Nevada) is re-activated (normally at GG Speed above 5000 rpm).
- Auxiliary AC Lube Oil Pump is switched 'OFF'.

  Note: *DC Lube Oil Pump will stop when Lube Oil Pressure in the System is above 15 - 16 Psig.*

- Sequence Complete Green Light comes ON at LOCP.

7. Alarm & shutdown settings:

Turbine side.

Description	Setting	Action
Turbine high T.Max	790^0C	Alarm
Turbine high T.Max	810^0 C	Shutdown
Low lube oil pressure	15 psig	Alarm
Low lube oil pressure	13 psig	Shutdown
High lube oil temp	150^0 F	Alarm
High lube oil temp	165^0 F	Shutdown
Low servo oil pressure	30 psig	Shutdown
Low fuel pressure	80 psig	Shutdown
Low starting air pressure	40 psig	No start
Low battery voltage	18 volts	Shutdown
Over-speed trip	6,200 RMP	Shutdown

Table 2

Pump Unit Side:

Mine pump formal drive end	180^0F	Shutdown
Mine pump formal free end	180^0 F	Shutdown
Booster pump journal drive end	180^0 F	Shutdown
Booster pump journal free end	180^0 F	Shutdown
Maine pump casing temp	175 ^{0}F	Shutdown
Maine pump high discharge pressure	450 psig	Shutdown
Booster pump low suction pressure	2.2 psig	Shutdown
Gearbox oil low pressure	14 psig	Shutdown

Instruments air low pressure	50 psig	Shutdown
Crude pump lube oil low pressure	10 psig	Shutdown

Table 3

Distributed Control System

1. Introduction Of DCS:

It is a process control system that is controlled by a network of small computers known as “nodes” or controlling files. A large process plant, like a G.C’s. it may have as many as eight or more areas to distribute control. Each area node can have 32 control or monitoring loops that can also communicate with each other and exchange date. The communication between nodes is made possible through special lined known as “Bus” or “Data” highway. Normally two highways are provided, one as back up in the event of failure of one.

The DCS is therefore the most effective and safer control system available in the industry today. This system is better than having a single large computer controlling many loops in a process plant. The control by a single computer in a process plant can be risky because if it fails the whole plant also fails, and this is just like putting all your eggs in one basket and loose them all. The DCS system therefore avoids this type of problem.

1-1. Purpose & function of D.C.S:

- It provides intelligent control and on line monitoring function of process plants at a remote centralized plant.

- It functions as an operator workstation for display and access to all plant parameters including graphic display, control elements and alarms.

- It stores and reports all necessary plant data. i.e.. Trending, shift reports, periodical logging of crude and gas production figures, data acquisition condition monitoring of process plant and all main equipments.

2. Rosemount DCS

The control system to be supplied by FRS (Fisher Rosemount System) is based on the established and proven RS3 distributed control system and its associated technologies. This will be an integrated system comprising of standard RS3 equipment. The primary operational objectives of the complete system are as follows.

i- To provide plant wide monitoring and alarming by fast data acquisition

ii- To ensure comprehensive, reliable and secure automatic and remote manual control.

iii- To enable the systematic and comprehensible display of plant conditions and major operating parameters to the operators.
iv- To provide a means of recording and storing currant or calculated data for subsequent retrieval or analysis.
v- To provide means of reporting.
vi- To provide a sound platform for advanced control implementation.

2-1. Rosemount System description:

The RS3 system consists of the following main devices inter-connected via a peerway.

- MTCC: multi-tube command console 2 no's.
- Control file 2-3 no's.
- HIA: highway interface adapter I no.

These main stations are further connected with separate groups of devices that make up the total Rosemount RS3 system. The devices are connected under each station one is follows:

* MTCC:

- Printer
- Hard disk
- Tape drive
- CRT cathode ray tube
- Key board

* Control file:

- Analog flex term
- Contact flex term
- Analog marshalling panel
- Contact marshalling panel.

All the devices are linked via a "Peerway" witch is a data transmission cable or better known with other system as "data Highway". There are normally two peer ways for every GC system. One operates as the main and the other as a stand by. Failure of one peerway will cause all information to be sent over the stand by one automatically.

2-2. RS-3 hardware descriptions:

Analog marshalling panel:

All field signals like LT, PT, TT, LY, PY, TY, etc are connected to this panel. It is factions are to direct and commutate these messages received to analog flex term. It has both input and output channels. Signals received here are analog type.

Digital marshalling panel:

It has the same function as the analog marshalling panel. The only difference is the type of signals received. It mainly handles digital signals of status condition such as shutdown and alarm or control signal to energize or de-energize Sov's (0V/110VAC). It is received both digital input and output signals.

Control file:

This is the heart of the Rosemount system all devices an line depends on it to pass them information. It is an electronic card located in cage with control and commutation section built inside it.
One control file normally has 8 cards with power supply board. And each card has 99 no's of controller devices which control the process plant and transfers information to other devices.
The control file is the place where the process control schemes and logics are built. Instrument engineers create the control schemes required and put them into the control file for operation use. A simple example of this is when the operator wants to change the set point of a control loop. The valve of changed memory is stored into controller memory and compared with the actual process value input. The control file then process and communicate out put signals to field devices via field buses and analog or digital Marshalling panels.

Control file is all is all responsible for running:

- All of the configured programs including process valves details and graphic displays.
- The data base management program that keeps all of the various system databases in orders.
- The system management program that monitors are health and condition of the Rosemount system.

MTCC:

This is the operator interface. It provides the interface between process sensors or actuator and the operator wok station. When operator makes change on process plant, i.e.. Changing set point or switching controller in manual/auto mode. These information are handled through MTCC.

MTCC also connects the operator workstation; printer, floppy drive, hard disk and tape drive with the control file and process plant via the peerway. MTCC has electronic cords to handle all information that is passed through it. It also temporally stores process data.

Peerway:

This is a coaxial cable that passes communication messages between MTCC and control file. The information are transmitted at a speed of 1 million bits per second. The transmission is in pulse type signals.

Floppy disk:
It stores all information of process plant and Rosemount system details in BIT form. It has limited capacity.

Tape drive:
It also stores all information of process plant and system details but with high capacity memory.

Hard disk:
This is the main storage bank for all data of process plant and system details. It stores Configured graphics and other details such as tags, trends, alarm points, scale range and son on.
Also stores system details such as control files information, analog flex term details number of peer ways connected and configuration data. All this information is also stored in a form of bit.

Power back up unit:

The RS-3 system is provided with power back up unit. It generates 30 Volts DC power supply to all electronic cards located in MTCC, control files and flex term during power failure. The duration of supply to the electronic cards is between 30 second to 5 minute maximum. The purpose for this back up supply is to allow all shutdown and alarms conditions and last process parameters to be stored and saved in the hard disk.
The power back up unit is provided with long life batteries witch may last for 2 years. When the battery life is near its end, alarm will be given on the operator workstation and on the back up unit itself. Red fault light comes on.
Operator should be aware of power back up capabilities at this system and what effect a power failure or surge will have on their process plant.

Components of control file:

Analog flex term

- Contact flex term
- Controllers
- Co-ordinate processor
- N.V memory cards
- Power supply card
- Peerway buffer card

Control process card:
Control processor card is the ”HEART” which co-ordinates with analog and contact flexterm for process information.
Predefined flexible control blocks reside in the controller, which integrates input and output blocks. Totally 126 control blocks resides in each controller. Maximum 4-flex

term can be connected to each controller and flexterm can be analog contact or PLC. 8 controllers can be connected in each control file.

Co-ordinate processor card:

This card is responsible for transfer of information between controller card and NV memory card and Peerway buffer card. This information transfer between one controller to other is taking place through this card. Two cards are provided in the system one is back up to other. Switch is provided to disable the card. Red indication is provided for failure of card.

NV memory card:

NV memory card holds all user configuration details. It holds system configuration details inter communication takes place between controller and NV memory card continuously. The information is backed up lithium battery.

Power supply card:

The system requires 12V, 5V supply for all control file cards. These are generated by power supply card. Normally two power supply cards exist. One is back up to other. These cards can be removed in energized condition. Red indication is provided for failure of card.

Peerway buffer card:

Peerway buffer card basically used to communicate information between node devices. Normally two peerway buffer cards are installed in the control file. Peerway cable is connected to peerway cards between nodes through peerway tap. Information transfer in peerway cable is 1 million bits per second.

2-2. Control Block Details

15 Analog inputs can be linked in each control block. Analog inputs are linked from either input block or any control blocks to inputs designated as “A to O”.

16 Digital inputs can be linked in each control block. Digital input are linked from either input blocks or any control block to inputs designated as “@ a to @ o”.

16 Digital outputs are available and designated “a to p”

Input Blocks:

The functions of these blocks are

- Assign tag names to incoming signals from the field
- Conditioning / Filtering of output signals from Thermocouples and Orifice plates.

- Assign and adjust alarms to process variables
- Allow Communication with SMART field instruments (Transmitters and PLC's).

Flow

Fluid flow:

Since most liquids are considered to be incompressible there is a definite relationship between the quantity of liquid flowing in a conduit and the velocity of flow. This relationship is expressed:

$$Q = A \times V$$

Where
Q= Capacity in cubic feet per second.
A= Area of conduit in square feet
V= Velocity of flow in feet per second.

Pipe Friction:

Friction in pipe will vary with pipe size, capacity, length, and viscosity.
Tables for calculating the friction through a piping system are available in the hydraulic institute standards; pump manufactures literature, and many handbooks.

Pipe line flow control:

Pipeline hydraulics:

In order to positively control pipeline operation and internal conditions, the way liquids behave with in pipe line system (liquid hydraulics principles) must be basically explained

Definition of hydraulics:

- Hydraulics is the study of fluids in motion and fluids at rest. In pipe line operations, it repairs to the movement of liquids through a pipe line.
- Steady-state hydraulics repairs to the state where at any points along the pipeline pressure and flow rate are constant over time.
- Transient hydraulics repairs to the state where the pressure and flow rate and at any point can change, instantaneously, with time (such as just after a pump is started or a valve is closed).

Density:

- Density (or mass density) is defined as the mass of liquid(or other substance) per unit volume(Kg/m^3).
- Weight density (specific weight) is defined as the weight of a liquid per unit volume, it is related to mass density. It is the product of mass density and the acceleration due to gravity.

(Eq-01) Weight density = $\frac{\text{mass Kg} * \text{acceleration due to gravity (g)}}{\text{Unit volume}(m^3)} = Kg/m^3$

- An increase in pressure will cause a decrease in volume and, there fore, an increase in density (very small, usually negligible).
- An increase in temperature results in an increase in volume and a corresponding decrease in density.

Specific gravity:

Specific gravity is dimensionless number; which is a ratio of the density of a liquid to the density of water, at 60^0 F.

(Eq-02): Specific gravity = $\frac{\text{Density of any liquid (@ } 60^0 \text{ F)}}{\text{Density of water (@ } 60^0 \text{ F)}}$

API gravity:

API gravity is an arbitrary scale device by the American Petroleum institute to expend the gravity scale for crude oil and petroleum products. With this scale, gravity is measured in degrees API.

(Eq-03): API gravity (API) = $\frac{141.5}{\text{Specific gravity @ } 60^0 \text{ F}} - 131.5$

- API gravity is inversely proportional to specific gravity, as specific gravity increases, API gravity decreases and vise versa.
- The API gravity water is 10
- API gravity measurement is made with a hydrometer, which conforms, to an ASTM slandered.

Viscosity:

- Viscosity is a measure of fluids internal distance to flow or its internal friction.
- Viscosity can be expressed in two ways, absolute viscosity(centipoises) and kinematics viscosity(centistokes).

(Eq-04): Kinematics viscosity = $\frac{\text{absolute viscosity}}{\text{Density (mass)}}$

- The viscosity of a liquid is very dependent upon its temperature. As the temperature of petroleum fluid increases the viscosity decreases an vice versa.

Reynolds number:

The Reynolds number (Re) is a dimension less number used to determine the type of liquid flow (laminar, turbulent or critical) occurring inside a pipeline. It is calculated as follows.

(Eq05): $Re = \frac{2214 * Q}{d * v}$

Q = flow rate in barrels per hour(BPH)
d = pipe inside diameter in inches(in)
v = fluid kinematics viscosity in centistokes(cs)

- Laminar flow occurs when Re < 2000
- Turbulent flow occurs when Re > 4000
- Critical or transitional flow occurs for 2000 < Re < 4000.

Friction loss:

- The energy lost when fluid particles in motion rub against each other and the pipe wall is called friction loss. A pressure drop in the direction of flow can see this friction loss

Friction loss depends on the following factors: (fluid gravity, fluid viscosity, flow rate of the fluid, internal pipe diameter, pipe length, internal roughness of the pipe, losses through fittings such as valves and meters)

Convertion factors:

Volume

1 Litre	= 0.22 IMPERIAL GALLONS
1 Litre	= 0.26 U.S GALLONS
1 Barrel	= 42 U.S GALLONS
1 Barrel	= 35 IMPERIAL GALLONS
1USG	= 3.786 Litres.

Pressure:

1 BAR	= 14.5038 PSIG.

Salt in crude analysis:

Crude oil from the reservoir is produced, containing varying amount of water. The volume of water produced along with the crude oil may contain as low as traces of water and some times as high as 50% or more. This water contains varying quantities of salts. Sodium, magnesium, and calcium are most common cautious of the salts. Chlorides, sulphites and carbonates are the typical anions associated with the captious. The composition and concentration of such salts depends upon the nature of geological formations from which the oil steams.

Water containing salts in the crude is under sireable as it causes corrosion in the process equipment and foul heat exchangers etc..
Therefore a limit has been fixed on the amount of salt content.

In KOC maximum permissible salt in the crude dispatch lines from GC's is 10.0 PTB(pounds per thousand barrels).

Salt content of water in crude:

The amount of salt content of produced water in crude can be found out as shown in the following examples.

Ex.
If produced oil contains I% cut of salt water and the salt content of the salt water is 60,000 PPM. What is the salt content in PTB?

Method 1:

60,000 x 0.35 x 1 / 100 = 210 PTB
Note: 1PPM = 0.35 PTB.

Method 2:

60,000 / 2.857 x 1 / 100 = 210 PTB.
Note: 1 PTB = 2.857 PPM.

b) If wet crude is dehydrated to a maximum actable level of 0.1%. what will be thesalt content of the remaining water in treated crude.

Ans: 60,000 x 0.35 x 0.1 / 100 = 21 PTB.

C) considering the maximum limit of salt content of Kuwaiti crudes, the above result of 21 PTB still shows that the desalted crude is far from the actable limit i.e 5PTB. This means that the crude needs further desalting process and this can only be achived by adding dilution water to wash out the remaining salt. The effect of wash water is shown in the following examples.

If 4% dilution water of 8, 000 PPM salinity is added to this same crude, then what will be the final salt content of the remaining water in dehydrated crude.

- Produced water cut ……. 1%
- Salt in water cut…… 60,000 PPM
- Dilution water add…… 4%
- Salt in dilution water…… 8, 000PPM
- Crude dehydrated to…… 0.1%

Ans:
Total salt of water in crude = 60,000 + 8.000 / 2.857 x 5 / 100 = 1,190PTB.

But the crude is dehydrated to 0.1%, therefore the salt content in it is

1,190 x 0.1 / 100 = 1.19 PTB.

Generally the amount of wash water needed in desalting process is 3 to 8% of treated crude and this depends on

- B.S&W content of the treated crude
- Salt content of the produced formation water
- Salt content of the wash water
- Number of the treating stages
- Mixing method.

Conversion factors for concentration of salts in crude oils:

One Barrel = 42 U.S Gallons.

Mg/liter (Mg/1)	**Pounds/1000 Bbls(PTB).**
0.35	
2. 85	1.00
6.00	
5.00	

Mg/liter is equivalent to gms / killoliter

Mg/liter can be converted to parts per million (ppm) by dividing Mg/l by the specific gravity of the oil.

Ppm is also equivalent to gms/metric ton.

API GRAVITY OF CRUDE OIL (IP-160/82):

API is a scale to determine the gravity of crude oil as recommended by American Petroleum Institute. API gravity is expressed in degrees and may be converted to specific gravity, by using the following formula.

$$\text{API gravity (Degrees @ } 60^0 \text{ F} = \left[\frac{141.5}{\text{Sp.gravity at } 60^0 \text{ F}} \right] 131.5$$

API gravity is an important information related to the quality of crude oil.

Units for expression of water analysis result:

1. Parts Per Million (PPM)

It is most commonly used unit for reporting water analysis data. It is measure of portion of weight, equivalent to a unit weight of dissolved substance per million unit weights in solution.

2. Milligram Per Liter (Mg/l):

It expresses a weight –volume relationship over the temperature range found in most laboratories. It is independent of the specific gravity
A low concentration of dissolved material less then 7000-PPM Mg/l are substantially equal to PPM.
The relation ship between the two units, by definition is

PPM = (Mg/l) / (Sp.gr.)
(Or)
Mg/l = (PPM). (Sp.Gr.)

For water with a specific gravity of near one, Mg/l and PPM, for all practical purposes are interchangeable.