Crude oil production and equipment's

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Abstract:

Oil/Gas production process are divided to two main steps upstream and downstream.

Upstream: - exploration, drilling wells, production of crude oil and natural gas, transportation and storage of crude oil and natural gas

Downstream: - from refinery up to hand of customer, or conversion of crude oil and natural gas into thousands of finished products.

In this Paper present the most important and used equipment that use in crude oil production (CPF) in order to produce best crude in a safe manner, also will describe the job of the required equipment's,

As crude oil production is one of the most difficult processes, continuously equipment will develop or/and change in order to proceed on standard bases, however we discuss here the most sophisticated equipment that presently used in overall word.

Selecting equipment on oil/gas production mostly depend on three points (increase productivity, increase safety, reduce maintenance cost)

Keywords:

Three phase separator, WHCP (wellhead control panel), PSV, instrument compressor, injection skids, and storage tanks.

Introduction:

Throughout history, stories have been passed down about never-ending fires caused by the ignition of oil and gas seeps. An illustration of this is the location where the renowned oracle of Delphi was constructed circa 1,000 B.C. Records dating back to 500 B.C. detail the Chinese practice of utilizing natural gas for boiling water.

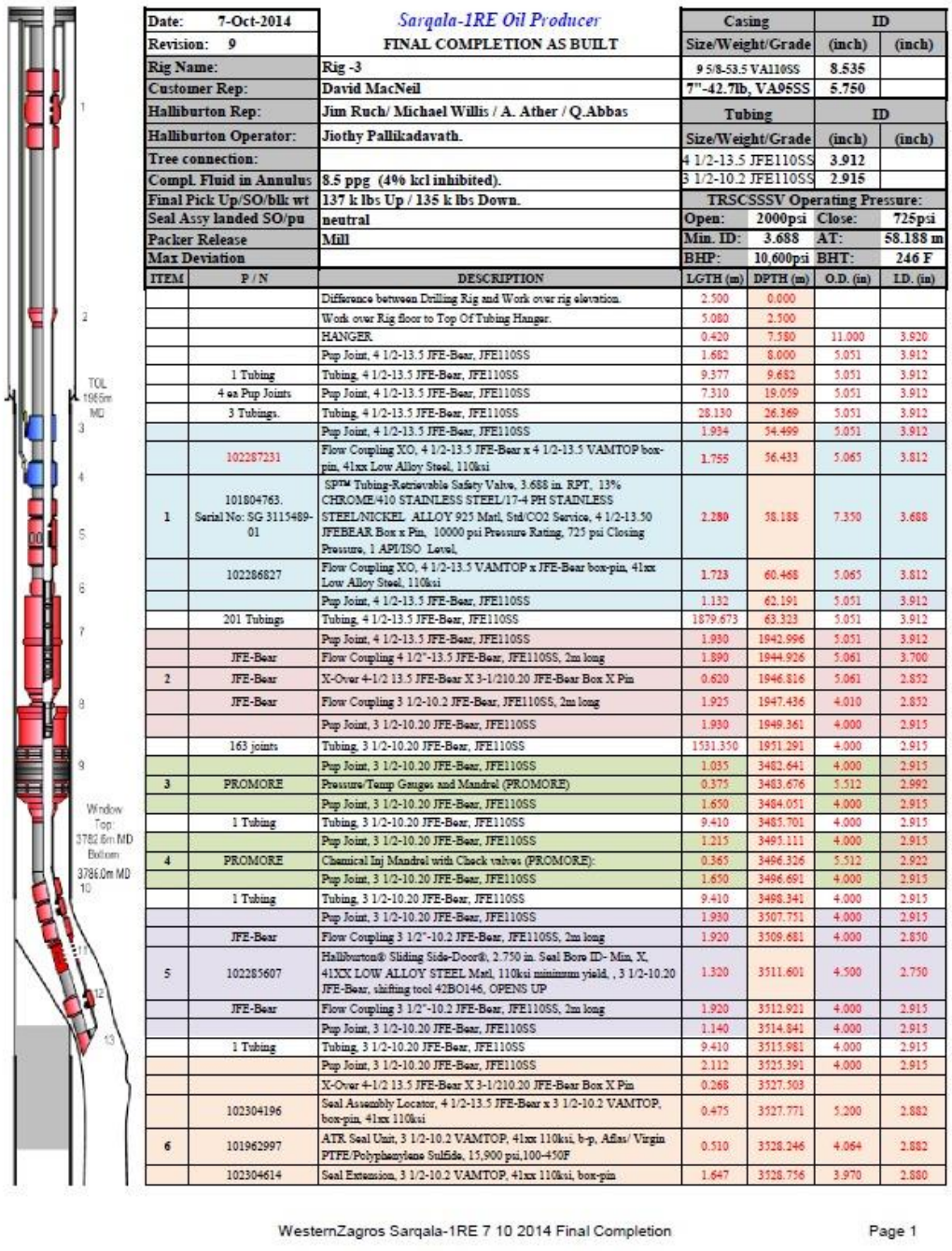
It was not until 1859 that "Colonel" Edwin Drake drilled the first successful oil well, with the sole purpose of finding oil. The Drake Well was located in the middle of quiet farm country in northwestern Pennsylvania, and sparked the international search for an industrial use for petroleum.

Crude oil production refers to the amount of oil extracted from the ground after removing any inert matter or impurities. It encompasses crude oil, natural gas liquids (NGLs), and additives. This measurement is expressed in thousand tons of oil equivalent (toe). Crude oil is a mineral oil composed of a mixture of naturally occurring hydrocarbons. It ranges in color from yellow to black and varies in density and viscosity. NGLs are the liquid or liquefied hydrocarbons produced during the processing, purification, and stabilization of natural gas. Additives are non-hydrocarbon substances that are incorporated into or mixed with a product to alter its properties.

In crude oil production facility used hundreds of equipment’s as developed from first well since 1859, here will introduce some most important equipment on CPF facility.

Oil well sketch

Figure (1) Show the design of oil well.



westernZAGROS HALLIBURTON

Sarqala-1RE Oil Producer

FINAL COMPLETION AS BUILT

Date:	7-Oct-2014
Revision:	9
Rig Name:	Rig -3
Customer Rep:	David MacNeil
Halliburton Rep:	Jim Ruch/ Michael Willis / A. Ather / Q.Abbas
Halliburton Operator:	Jiothy Pallikadavath.
Tree connection:	
Compl. Fluid in Annulus	8.5 ppg (4% kcl inhibited).
Final Pick Up/SO/blk wt	137 k lbs Up / 135 k lbs Down.
Seal Assy landed SO/pu	neutral
Packer Release	Mill
Max Deviation	

Casing	ID
Size/Weight/Grade	(inch) (inch)
9 5/8-53.5 VA110SS	8.535
7"-42.7lb, VA95SS	5.750

Tubing	ID
Size/Weight/Grade	(inch) (inch)
4 1/2-13.5 JFE110SS	3.912
3 1/2-10.2 JFE110SS	2.915

TRSCSSSV Operating Pressure:			
Open:	2000psi	Close:	725psi
Min. ID:	3.688	AT:	58.188 m
BHP:	10,600psi	BHT:	246 F

ITEM	P / N	DESCRIPTION	LGTH (m)	DPTH (m)	O.D. (in)	I.D. (in)
		Difference between Drilling Rig and Work over rig elevation.	2.500	0.000		
		Work over Rig floor to Top Of Tubing Hanger.	5.080	2.500		
		HANGER	0.420	7.580	11.000	3.920
		Pup Joint, 4 1/2-13.5 JFE-Bear, JFE110SS	1.682	8.000	5.051	3.912
	1 Tubing	Tubing, 4 1/2-13.5 JFE-Bear, JFE110SS	9.377	9.682	5.051	3.912
	4 ea Pup Joints	Pup Joint, 4 1/2-13.5 JFE-Bear, JFE110SS	7.310	19.059	5.051	3.912
	3 Tubings.	Tubing, 4 1/2-13.5 JFE-Bear, JFE110SS	28.130	26.369	5.051	3.912
		Pup Joint, 4 1/2-13.5 JFE-Bear, JFE110SS	1.934	54.499	5.051	3.912
	102287231	Flow Coupling XO, 4 1/2-13.5 JFE-Bear x 4 1/2-13.5 VAMTOP box-pin, 41xx Low Alloy Steel, 110ksi	1.755	56.433	5.065	3.812
1	101804763. Serial No: SG 3115489-01	SPM Tubing-Retrievable Safety Valve, 3.688 in. RPT, 13% CHROME/410 STAINLESS STEEL/17-4 PH STAINLESS STEEL/NICKEL ALLOY 925 Matl, Std/CO2 Service, 4 1/2-13.50 JFEBEAR Box x Pin, 10000 psi Pressure Rating, 725 psi Closing Pressure, 1 API/ISO Level,	2.280	58.188	7.350	3.688
	102286827	Flow Coupling XO, 4 1/2-13.5 VAMTOP x JFE-Bear box-pin, 41xx Low Alloy Steel, 110ksi	1.723	60.468	5.065	3.812
		Pup Joint, 4 1/2-13.5 JFE-Bear, JFE110SS	1.132	62.191	5.051	3.912
	201 Tubings	Tubing, 4 1/2-13.5 JFE-Bear, JFE110SS	1879.673	63.323	5.051	3.912
		Pup Joint, 4 1/2-13.5 JFE-Bear, JFE110SS	1.930	1942.996	5.051	3.912
	JFE-Bear	Flow Coupling 4 1/2"-13.5 JFE-Bear, JFE110SS, 2m long	1.890	1944.926	5.061	3.700
2	JFE-Bear	X-Over 4-1/2 13.5 JFE-Bear X 3-1/210.20 JFE-Bear Box X Pin	0.620	1946.816	5.061	2.852
	JFE-Bear	Flow Coupling 3 1/2-10.2 JFE-Bear, JFE110SS, 2m long	1.925	1947.436	4.010	2.852
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	1.930	1949.361	4.000	2.915
	163 joints	Tubing, 3 1/2-10.20 JFE-Bear, JFE110SS	1531.350	1951.291	4.000	2.915
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	1.035	3482.641	4.000	2.915
3	PROMORE	Pressure/Temp Gauges and Mandrel (PROMORE)	0.375	3483.676	5.512	2.992
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	1.650	3484.051	4.000	2.915
	1 Tubing	Tubing, 3 1/2-10.20 JFE-Bear, JFE110SS	9.410	3485.701	4.000	2.915
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	1.215	3495.111	4.000	2.915
4	PROMORE	Chemical Inj Mandrel with Check valves (PROMORE):	0.365	3496.326	5.512	2.922
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	1.650	3496.691	4.000	2.915
	1 Tubing	Tubing, 3 1/2-10.20 JFE-Bear, JFE110SS	9.410	3498.341	4.000	2.915
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	1.930	3507.751	4.000	2.915
	JFE-Bear	Flow Coupling 3 1/2"-10.2 JFE-Bear, JFE110SS, 2m long	1.920	3509.681	4.000	2.850
5	102285607	Halliburton® Sliding Side-Door®, 2.750 in. Seal Bore ID- Min. X, 41XX LOW ALLOY STEEL Matl, 110ksi minimum yield, , 3 1/2-10.20 JFE-Bear, shifting tool 42BO146, OPENS UP	1.320	3511.601	4.500	2.750
	JFE-Bear	Flow Coupling 3 1/2"-10.2 JFE-Bear, JFE110SS, 2m long	1.920	3512.921	4.000	2.915
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	1.140	3514.841	4.000	2.915
	1 Tubing	Tubing, 3 1/2-10.20 JFE-Bear, JFE110SS	9.410	3515.981	4.000	2.915
		Pup Joint, 3 1/2-10.20 JFE-Bear, JFE110SS	2.112	3525.391	4.000	2.915
		X-Over 4-1/2 13.5 JFE-Bear X 3-1/210.20 JFE-Bear Box X Pin	0.268	3527.503		
	102304196	Seal Assembly Locator, 4 1/2-13.5 JFE-Bear x 3 1/2-10.2 VAMTOP, box-pin, 41xx 110ksi	0.475	3527.771	5.200	2.882
6	101962997	ATR Seal Unit, 3 1/2-10.2 VAMTOP, 41xx 110ksi, b-p, Aflas/ Virgin PTFE/Polyphenylene Sulfide, 15,900 psi,100-450F	0.510	3528.246	4.064	2.882
	102304614	Seal Extension, 3 1/2-10.2 VAMTOP, 41xx 110ksi, box-pin	1.647	3528.756	3.970	2.880

Figure (1)

I. X-mass tree

In oil/gas production wells there is a Christmas tree, or tree, is a piece of equipment, valves, casing spools, and fittings used to regulate flow according to process requirements.

On Christmas tree there are ESV, for emergency stop flow, injection points to inject required chemicals, and gauges to now details of flow such as (pressure and temperature)

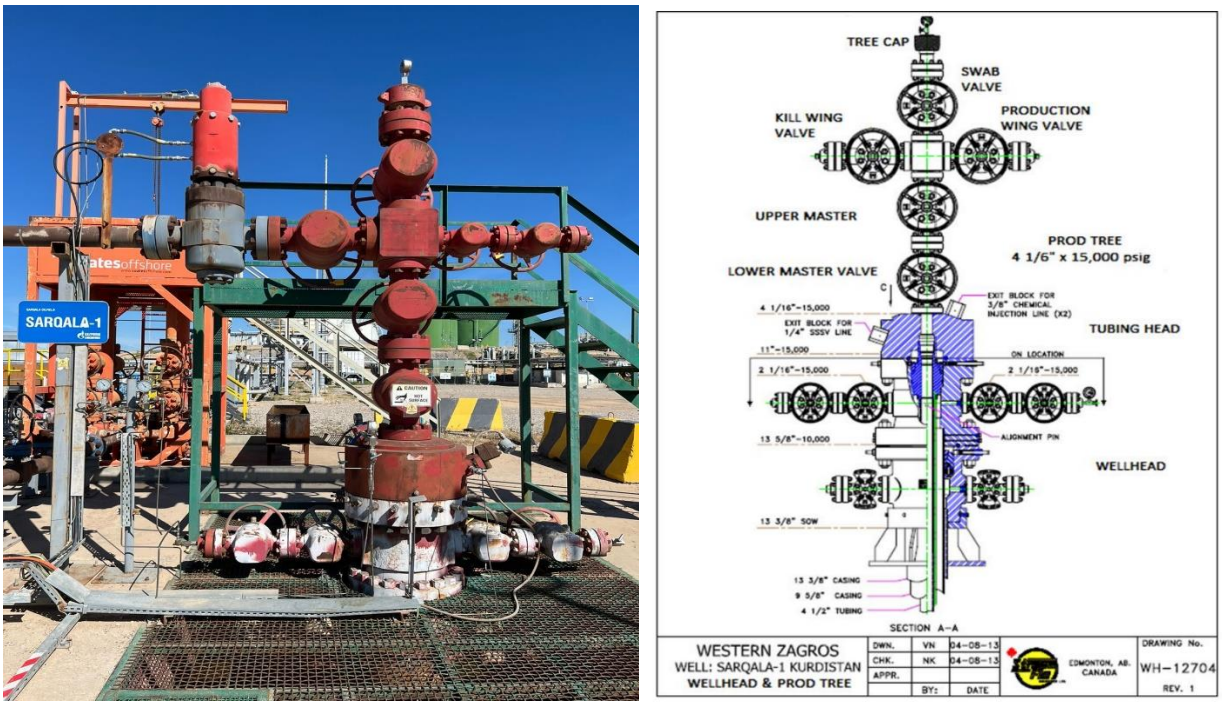


Figure (2)

II. SSV

Surface Safety Valve, is a remote actuated valve that installed to outlet on flow cross, mostly gate type and working by hydraulic, it's functioning in case of unplanned release well or any emergency (high pressure, high temperature, High level on vessels, and excessive amount of flow).

The Surface Safety Valve is a Reverse Acting, Hydraulically Actuated Gate Valve. Being Reverse Acting the valve is normally in the 'UP' Closed position. The gates and the stem are held in this position due to the action of the actuator spring pushing upwards. Therefore, when the stem is protruding out the top of the actuator the valve is in the Closed position.

To open the valve, Hydraulic pressure is transmitted from a wellhead control panel to the top of the hydraulic actuator on the valve.

This hydraulic pressure pushes down on the actuator piston, overcomes the actuator spring AND the well flowing pressure to force the valve stem and gates ‘DOWN’ into the Open position. Maintaining the applied hydraulic pressure will ensure the valve remains open.

Loss of the applied hydraulic pressure, from the control panel and actuator, will allow the actuator spring and the well flowing pressure to rapidly return the stem and gates to the ‘UP’ Closed position.

Figure (3)

III. Injection skid

Consist of special horizontal vessel and high-pressure reciprocating pump,

Pump Details: -

- Pump Motor: Class 1 Div 1 explosion proof
- Gemini Controller: Class 1 Div 2
- Pump Type: Positive Displacement Offset Cam – Comet
- Pump Material: Stainless steel

- Maximum Output Pressure: 4,350 PSI (30 MPa) Model dependent
- Maximum Flow Rate: 2,113 Q/day (2,000 L/day continuous)
- Minimum Flow Rate: < 2.0 Q/day (< 2.0 L/day) continuous, < 0.25 Q/day (< 0.25L/day)
  Intermittent
- Seal Material: Teflon
- Motor: 230 VAC 3PH
- Operating Temperature: -40ºF/ ºC to +50ºC (122ºF)

Applications include: inject several chemical to well and pipeline to protect well, pipes and process equipment from corrosion, chock and failure.

- Methanol injection at wells or pipelines
- Injection of de-emulsifiers, corrosion inhibitor, desalting agents, soap, and other additives to

  oil and gas wells
- Glycol Circulation (low volume)
- Solvent Pumping
- Bearing Lubrication
- Water Treatment
- Asphaltene solvent/inhibitor

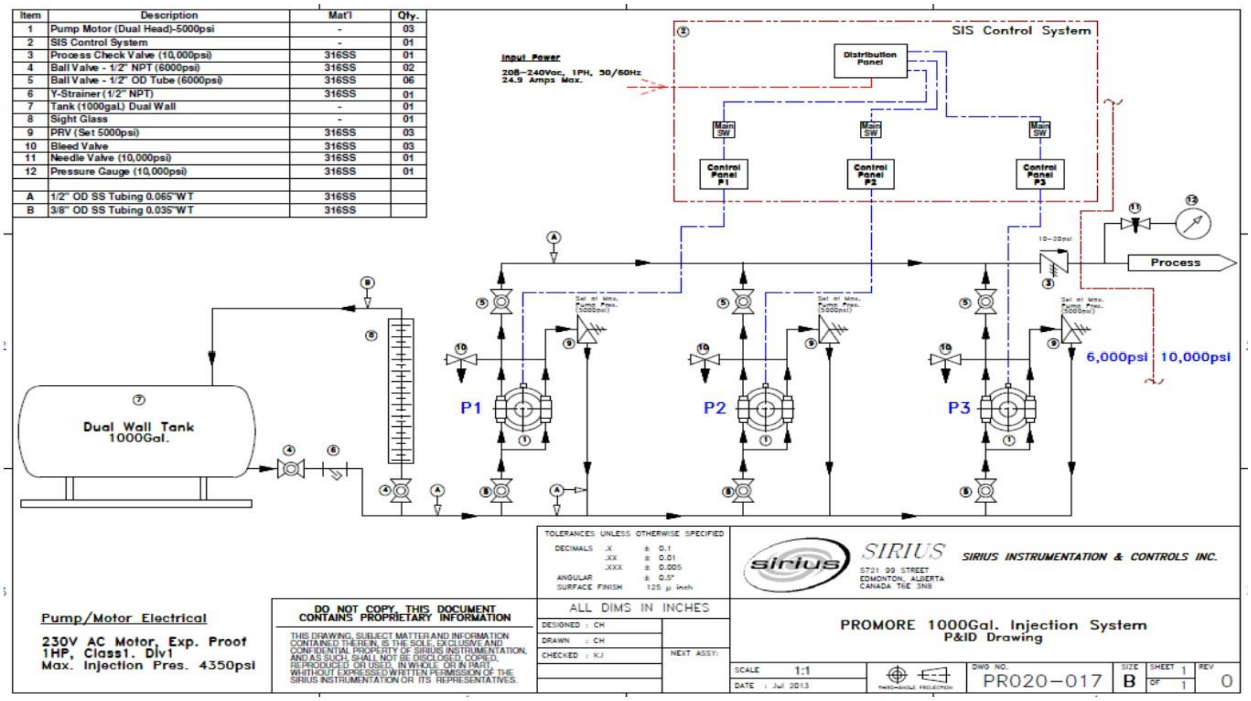


Figure (4)

IV. WHCP (Wellhead Control Pannel)

The schematic below is a simple graphic showing the operation of a typical Wellhead Hydraulic Control

Panel. The main components are:

- Oil Reservoir
- Pneumatic/Hydraulic Pump
- 3-way Block and Bleed Valve
- Remote Pressure Pilots (both HI and Lo)
- Remote Emergency Shut Down (ESD) Buttons (not shown)

When the well is opened for production, two (2) pressure switches Hi pilot & Lo Pilot **(Remote pilots)**

calibrated with both high and Low set pressures, are activated. Should the flow line pressure exceed

the set high or low pressures, the affected pilot will trip and vent the loop pressure from the line. This

will release the pneumatic pressure from the **3-way block and bleed** valve which will cause the **3-way**

valve to block any hydraulic pressure reaching the safety valves and vent the hydraulic pressure from

the **SCSSSV** and **SSV** Actuator – causing both valves to close.

The speed of closure can be enhanced by installing a 'Quick Release Exhaust valve' on the SSV

Hydraulic actuator. Also 'Fusible caps' can be fitted to the instrument loop. These fusible caps are

designed to MELT, in the case of a fire, and release the loop pressure shutting in the well.

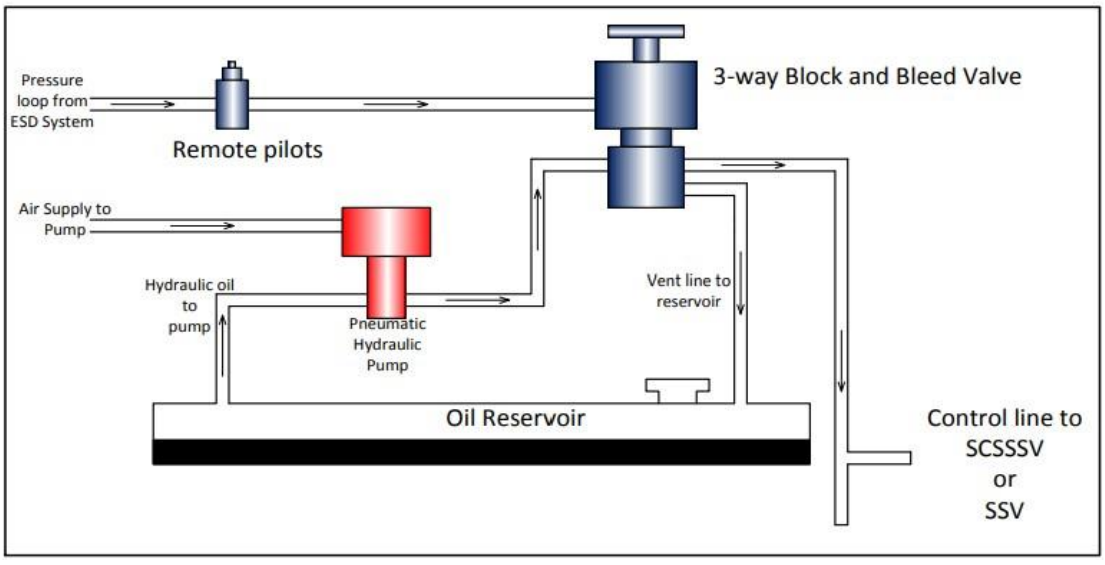


Figure (5)

V. Sand filter


coatesoffshore

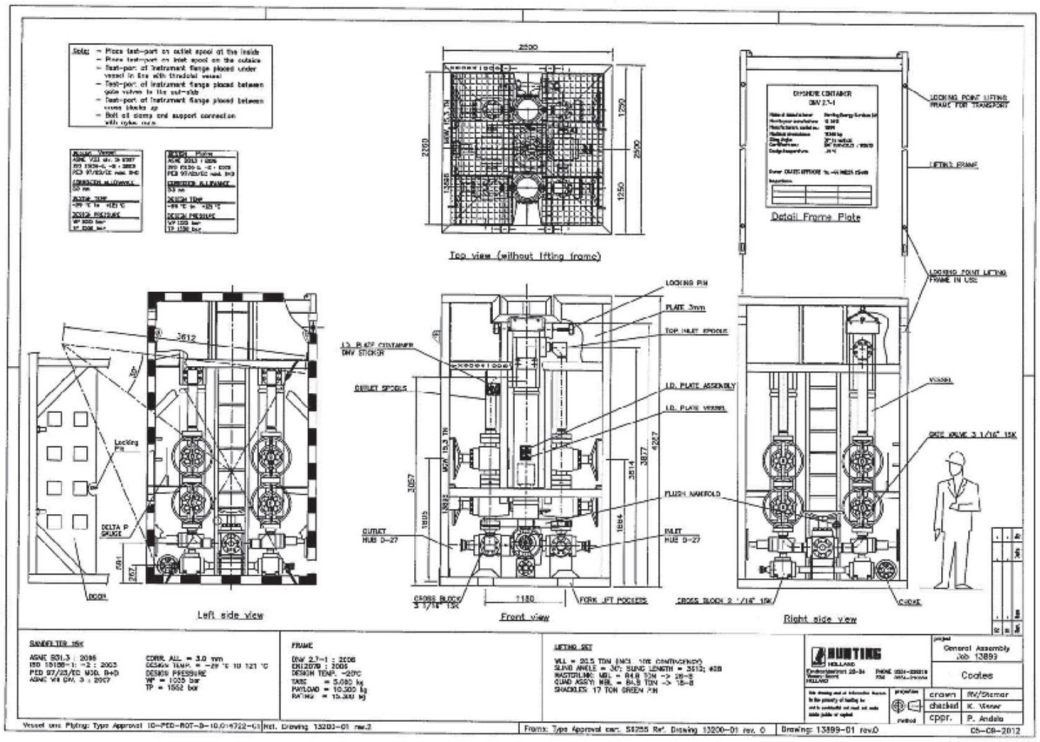

Top view (without lifting frame)
Detail Frame Plate
Left side view
Front view
Right side view
LOCKING PIN
PLATE 3mm
TOP INLET SPOOLE
I.D. PLATE ASSEMBLY
I.D. PLATE VESSEL
FLUSH MANIFOLD
OUTLET
INLET
VESSEL
CHOKE
FORK LIFT POCKETS
HUNTING
General Assembly
Job 13899
Coates

Figure (6)

As the name implies, Sand Filters were designed to remove sand from the fluids produced from and oil or gas well. Filters have undergone many design modifications, from vertical units, mesh wire screens to wire wrapped screens – double units etc.

The Sand Filter has the following features:

- Double barrier facility with dual gate valves on both the inlet and outlet
- Delta P system
- Bleed-off system
- Filter screen between 200 and 800 microns

VI. Choke valve

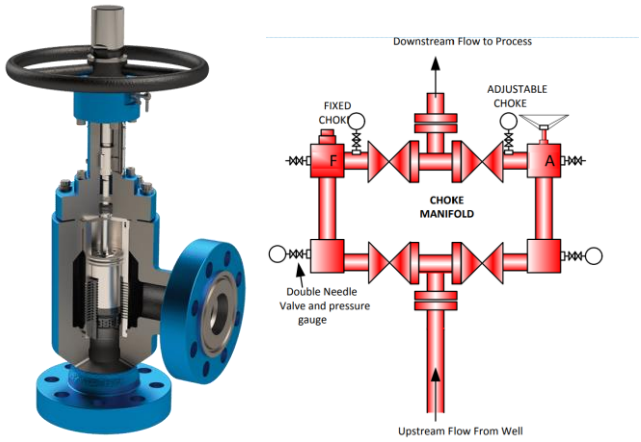


Figure (7)

Wellhead choke valve used to limit production rates for regulations, protect following equipment, and control flow rate to avoid water or gas coning.

VII. ACHE

Air-cooled heat exchanger (ACHE) is a type of heat exchanger that uses ambient air as the cooling medium to remove heat from a process fluid. It is designed to transfer heat between a fluid (such as a gas or liquid) and the surrounding air without the need for water or other external

cooling fluids. These heat exchangers are also known as Air Fin Fan Coolers or Air Fin Coolers or Air Coolers or Fin-tube heat exchangers.

In oil and gas production facilities, as well as in situations where gas cannot be recovered, the use of ACHE as a condenser for condensing process fluids becomes necessary. This is particularly relevant in cases where oil and gas wells produce three-phase fluids consisting of gas, oil, and water. The primary objective is to minimize the amount of gas released to the flare, and ACHE plays a crucial role in achieving this goal by converting the gas phase into a liquid phase. Consequently, the implementation of ACHE leads to an increase in oil production. In this study, we present experimental evidence demonstrating the impact of installing ACHE on the crude oil well pipeline downstream of the choke before the separators process. Our findings reveal a notable increase in the oil rate by 3.5%, achieved through condensate recovery. Additionally, we observed a significant decrease in gas by 5% this study applied for two oil wells with total oil producing 22000 bbl./d and gas production 42 MMscf.

Air-cooled heat exchangers and performance improvement tools including pre-cooling systems are typically needed during hot weather, when the temperature difference between ambient air and process fluid is close to each other, necessitating maximum capacity operation. In winter, capacity can be reduced by adjusting fan speed, bypassing improvement tools, or even stopping the motor completely, depending on process requirements. In some cases, excessive cooling may have negative effects, so it should be carefully controlled.

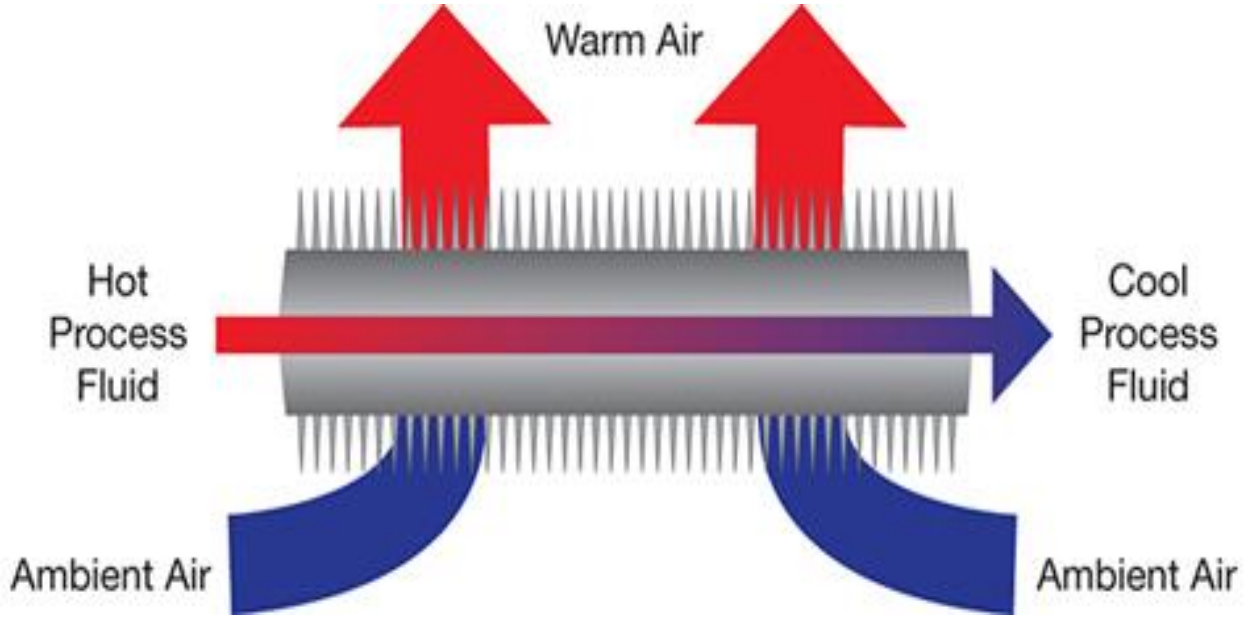


Figure (8)

An air-cooled heat exchanger (ACHE) transfers heat from a fluid to the atmosphere through convection and radiation. The heat transfer area of an ACHE is increased by attaching fins to the tubes that circulate fluid through them. An ACHE consists of a bundle of tubes through which a fluid flow. Ambient air is forced over the fins and tubes by fans or natural convection, and heat is transferred from the fluid to the air (Figure). ACHEs are

commonly used in applications where water is scarce, or the use of water for cooling is not desirable, such as in remote locations, arid climates, or where water quality is poor.

VIII. PSV valve

Pressure safety valves (PSV) are used extensively in oil and gas applications to protect vessels, pipes, and other equipment against overpressure. More commonly, the PSV discharge is sent to a flare via a flare header which collects several relief sources through a flare network of headers and sub-headers.

Commonly two types of PSVs are using in oil and gas industries, the conventional spring-operated PSV, and the balanced bellows spring-operated PSV.

In our plant PSV on production line is provided for final safeguarding element in case of line overpressure due to any process upsets. On production line The PSVs discharge line is connected to Blow Down Vessel.

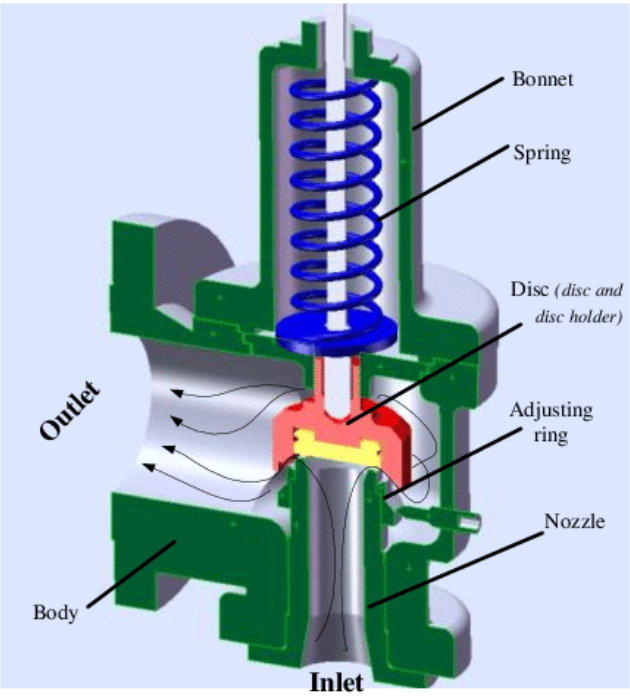


Figure (9)

IX. Manifold

Well head Fluids from the field wells are collected and passed further by the inlet manifold area. The manifolds allow operations to select various wells to flow to production separation or to run on test using manually operated valves.

The manifold can feed the main separation battery or the Test Battery

A multiphase mass flow meter 231-MPFM-001 is installed in between Test and Group Manifold for the necessary individual well flow measurement with suitable valve arrangement which will again mix the individual well fluid with bulk production fluid.

The inlet manifold also includes pig receiver section for individual wells which is provided with necessary monitoring instrumentation. No control of any of the operating parameters is provided.

The flows from the test manifold and group manifolds are equipped with ESD valves which will close if there are process upsets

the ESD valve can be reset and reopened from local panel.

Pressure transmitter and Local PG’s are mounted on the pig receiver in manifold area for measurement and monitoring.

No specific safeguarding is implemented to the manifold.

Figure (10)

X. Separator

Separator Function is the most crucial role in crude oil product improvement.

Separators are describing as a mechanical device used to primary separation, which separate gas and two liquids of different densities mostly oil and water.

Principle of Separation

Gravity Separation:

Droplets of liquid mist will settle out from gas, provided that, the gas remains in the separator long enough for mist to drop out.

The velocity of the gas through the separator is slow enough that no turbulence occurs. Gas bubbles in the liquid will break out in most oil field applications in 30 to 60 seconds.

Therefore, separators are designed where the liquid remains in the vessel for 30 to 60 seconds. The length of time that the liquid remains in the vessel is called residence time or retention time.

There are three types of Separators: -

- **Horizontal Separator**

The horizontal separator is designed for processing well stream with large volume of gas.

- **Vertical Separator**

These types are capable of handling large slugs of liquid without carryover to the gas outlet and is best suited for well streams with high liquid content and low gas volume.

- **Spherical Separator**

Spherical separators are compact vessels and provide good gas separation.

The most common used is Horizontal separator.

Horizontal three phase Separator internal components: -

- Liquid Level Controller
- Pressure Control Valve
- Pressure Relief Valve
- Mist Extractor
    1. Wire mesh mist extractor
    2. Vane mist extractor
    3. Centrifugal mist extractor
- inlet diverter
- Wave braker
- Defoaming plates
- Vortex braker
- Sand Jets and Drains
- Stilling Well

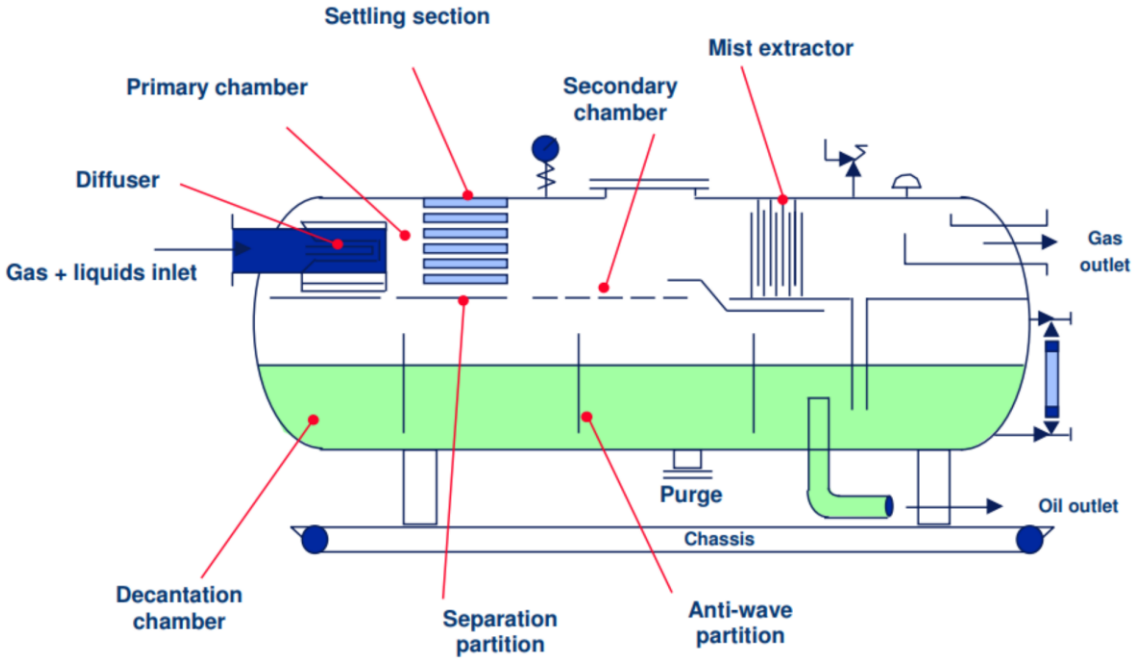


Figure (11)

Separator will divide stream to three components (Oil, Water and gas), oil will sent to oil treatment facility, water will enter water treatment or inject back to disposal well, and gas will send to power plant to produce power or simply flare it.

XI. Gas boot

Gas boot vessel is the third stage of separator after HP separator and LP separator,

Is use to remove maximum volatile gas in crude to provide safe storage.

Oil from LP separators passed through a Gas-boot for further oil and gas separation.

No control is specified for the Gas-boot since the fluid is passing through this vessel to storage tanks.

The gas leaving the Gas-boot flows to the separate LP flare gas header (alternatively known as Gas-boot flare) and oil flows to the storage tanks. Local TG /PG and LG's are mounted on the Gas-boot for monitoring.

Since the Gas-boot is an open vessel connecting separator to storage tank no PSV is installed on it. The gas separated from Gas-boot is passed on to LP flare header for the disposal. The Gas-boot can be bypassed using manual valves installed upstream and downstream the vessel.

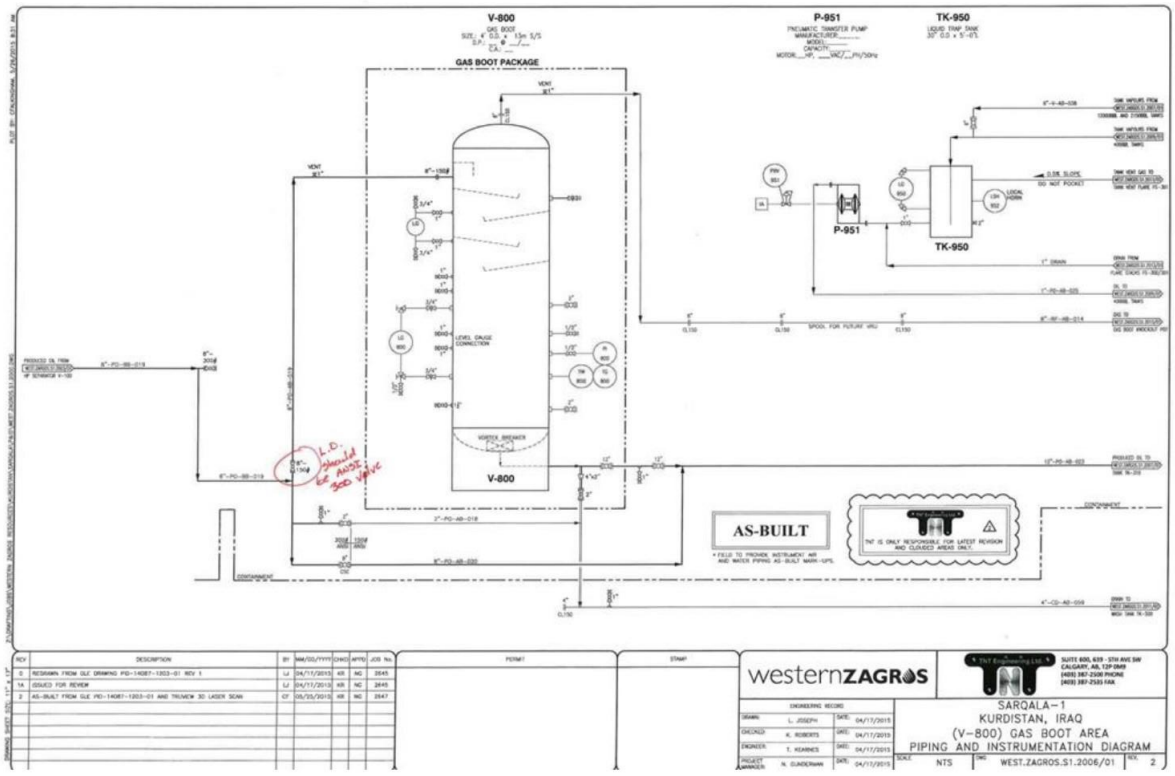


Figure (12)

XII. Flare system

Gas flaring involves the combustion of natural gas that is extracted along with oil. This practice has been ongoing since the inception of oil production more than 160 years ago. It occurs due to various factors, including market and economic limitations, inadequate regulation, and lack of political determination. Flaring and venting represent a squandering of a precious natural resource that could be utilized for beneficial activities like electricity generation or preserved. To illustrate, the volume of gas flared annually,

approximately 139 billion cubic meters, has the potential to supply power to the entire sub-Saharan Africa region.

Why gas flared?

Flaring continues to persist in the present time due to its relative safety, despite being an inefficient and environmentally harmful approach for disposing of the associated gas produced during oil extraction. The utilization of this associated gas often necessitates the presence of economically viable markets, which incentivize companies to invest in the infrastructure required for its capture, transportation, processing, and sale.

The HP flare system will be used continuously burn off all the HP gas produced at the facility. The remote flare ignition system includes two different ignition system; electrical electrode and fire ball. All the package provides the site PLC with various alarms and statuses. The HP Flare Knockout Drum is equipped to collect final condensate with a two-level transmitter to monitor and shutdown the process in case of system upsets.

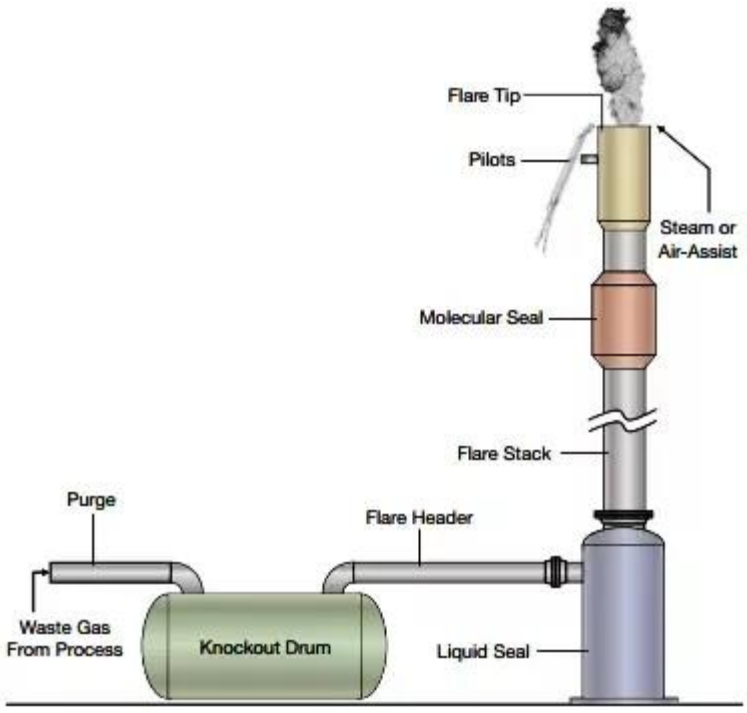


Figure (13)

XIII. Storage tanks

Crude oil tanks serve as storage facilities for unprocessed oil, enabling its transportation to various destinations or its conversion into refined goods.

The primary purpose of an oil storage tank is to serve as a storage facility for crude palm oil (CPO) during the palm oil processing. It ensures that the CPO is stored at a specific temperature and maintains a high level of sealing. Additionally, the oil storage tank proves to be beneficial for the temporary storage of crude palm oil.

At Tiny-tech Crude Oil Storage Tanks are manufactured as per International Standards. In the construction of crude oil storage tank, the most common standard in the world is API650, other standards have GB50341, BS2654, JIS B8501, etc.

CPF (central processing facility) Scheme

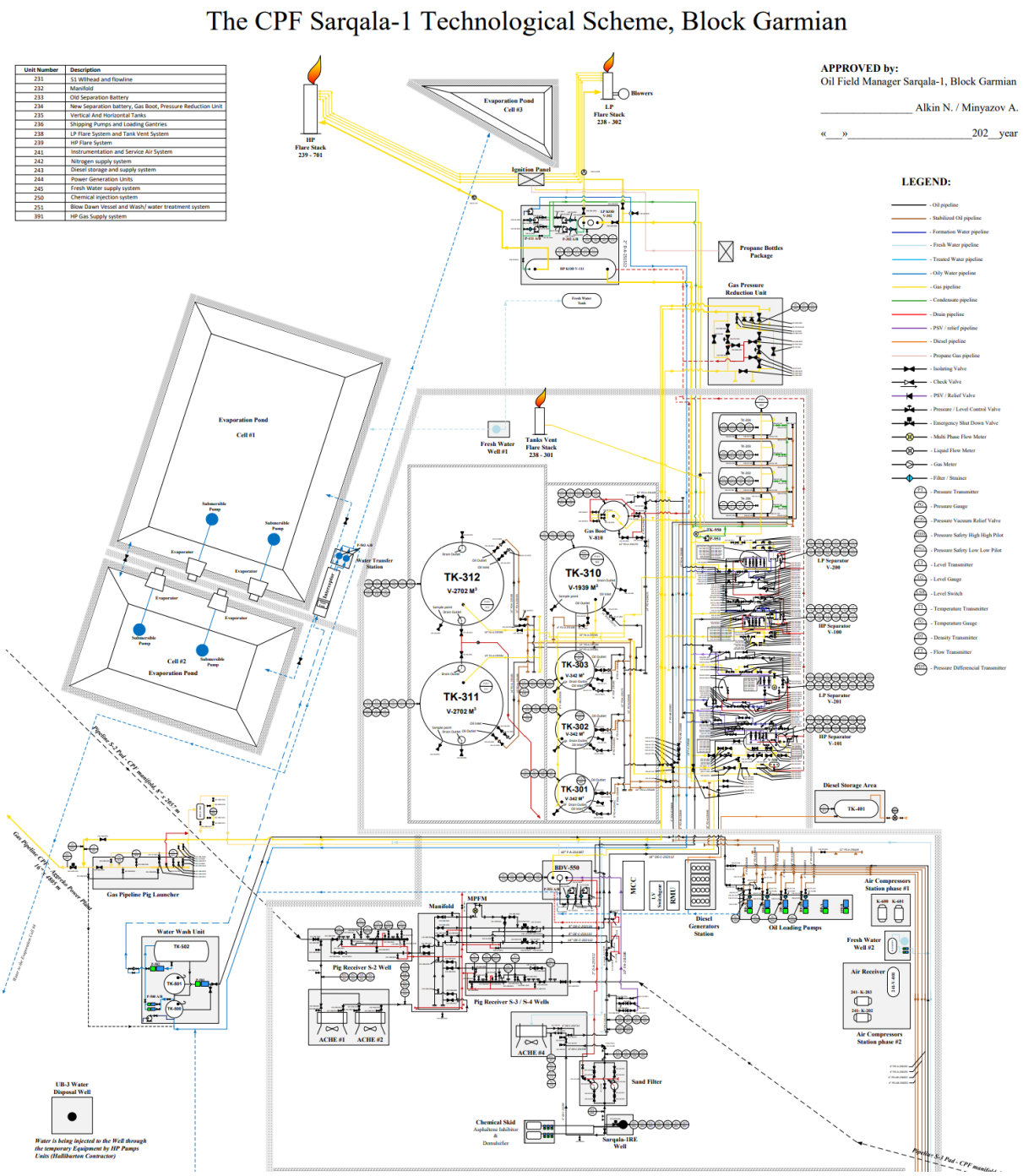


Figure (14)

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