WorleyParsons

resources & energy

EXXONMOBIL CANADA PROPERTIES (EMCP)

TRAINING MODULE 10

SEPARATION AND STABILIZATION SYSTEM

HEBRON PROJECT

DETAILED DESIGN - TOPSIDES

CAHE-WP-OMTRN-10-623-0010

28-OCT-2015

575 North Dairy Ashford
Houston, TX 77079
Telephone: +1 713 407 5000
www.worleyparsons.com

WorleyParsons
resources & energy

SYNOPSIS

This document presents the operations training module for the separation and stabilization system (623) on the Hebron topsides. This series of modules is used to train operations and maintenance personnel on the systems, equipment, and strategies to be employed in the safe, efficient, and effective operation of the facility.

> *Note: This module includes graphics, photos, drawings, and operational data based on design-phase facility information. Set points and operating parameters in this module are based on documentation generated during the design phase and are current as of the date of issue of the IFR version. EPC Contractor may not be able to include final operational data or "actual" field or facility photos, graphics, or as-built drawings in the Hebron IFU-version of this training document.*

DISCLAIMER

CAHE-WP-OMTRN-10-623-0010			SEPARATION AND STABILIZATION SYSTEM				
REV	DESCRIPTION	ORIGINATOR	REVIEW	APPROVAL	DATE	COMPANY REVIEW	DATE
D0	IFU	R. Gardina Developer	K. Lawrie Drilling Lead	M Gortarez OR Manager	28-OCT-15	R. Tobin CAS&R Lead	2 NOV 2015
A1	IFR	R. Gardina Developer	K. Lawrie Drilling Lead	M Gortarez OR Manager	30-SEP-15		

TABLE OF CONTENTS

WorleyParsons
resources & energy

TABLES

FIGURES

Module Introduction

INTRODUCTION

This module of instruction provides training in the configuration and operation of the separation and stabilization system. Each subsequent lesson in this module builds on the foundation of the previous lesson.

1. Introduction to the system
2. How the system works
3. How the equipment functions
4. How to control the system

Throughout the lessons and in the lesson feedback exercises, you may be asked to:

- Answer questions
- Describe equipment and processes
- Utilize drawings, diagrams, and photos to identify equipment and trace process flows

At the conclusion of the module, you will be given a test that encompasses information presented throughout the module.

Glossary

This glossary provides definitions of selected terms and explanations of acronyms used in this module. Familiarity with these terms will help you perform your job more effectively.

Table A. Glossary

Term	Definition
API	American Petroleum Institute
BS&W	Basic sediment and water
CEC	Compact electrostatic coalescer
Hydrodynamic	Relating to the force of liquid in motion. Affects the separation of oil from water in a plate pack coalescer.
KO	Knock out
Mist extractor	Remove small liquid particles from vapor that separated (flashed off) the well fluids.
MOV	Motor-operated valve
MSCFD	Million standard cubic feet per day
Oleophilic	Translates to “oil loving” to describe material with a strong affinity for oils rather than water. Oleophilic material is used in the separation process to attract oil droplets while not attracting water droplets or solids (fines).
Rag layer	A rag layer is the material that accumulates and persists at the oil/water interface. It consists of emulsified water and/or oil, clays, and solids. Under inefficient processing conditions (slow coalescence mechanics), rag layers may grow large enough to cause a process upset.
Separator	Vessel designed to separate production fluids into their constituent components of oil, gas, and water (three-phase) or liquids and gas (two-phase).
Surfactant	A substance capable of reducing the surface tension of a liquid in which it is dissolved.
TVP (True vapor pressure)	The vapor pressure of a substance is the pressure at which its gas phase is in equilibrium with its condensed phases (liquid or solid). It is a measure of the tendency of molecules and atoms to escape from a liquid or a solid. At a given temperature, a substance with higher vapor pressure vaporizes more readily than a substance with a lower vapor pressure. *True vapor pressure* is the pressure of the vapor in equilibrium with the liquid at 37.8 °C (100 °F).
VIEC-LW	Vertical internal electrostatic coalescer - low water; designed to remove the last traces of water in oil.
WAT	Wax appearance temperature

Lesson 1: About the System

LESSON INTRODUCTION

This lesson describes:

- Purpose of the system
- System design
- System components
- Any process hazards pertaining to this system
- Relationships between this system and other systems

At the completion of this lesson, you will be able to:

- Describe the purpose of the system
- Explain how this system functions to achieve the system purpose
- Name the primary equipment and major components in this system
- Describe any process hazards involved in this system and state the precautions to be taken

1. Separation and Stabilization System Overview

1.1 Purpose

Gas and water are separated from the oil in successive steps. Gas flow is routed to the gas compression systems for use as fuel gas, lift gas, and gas for reinjection. Produced water is sent to the water treatment system and then discharged overboard. Crude is routed to the storage cells in the GBS.

The production separation system consists of a four-stage separation system with associated heat exchangers and pumps.

1. HP separator
2. MP separator
3. LP separator
4. Oil/water Separator

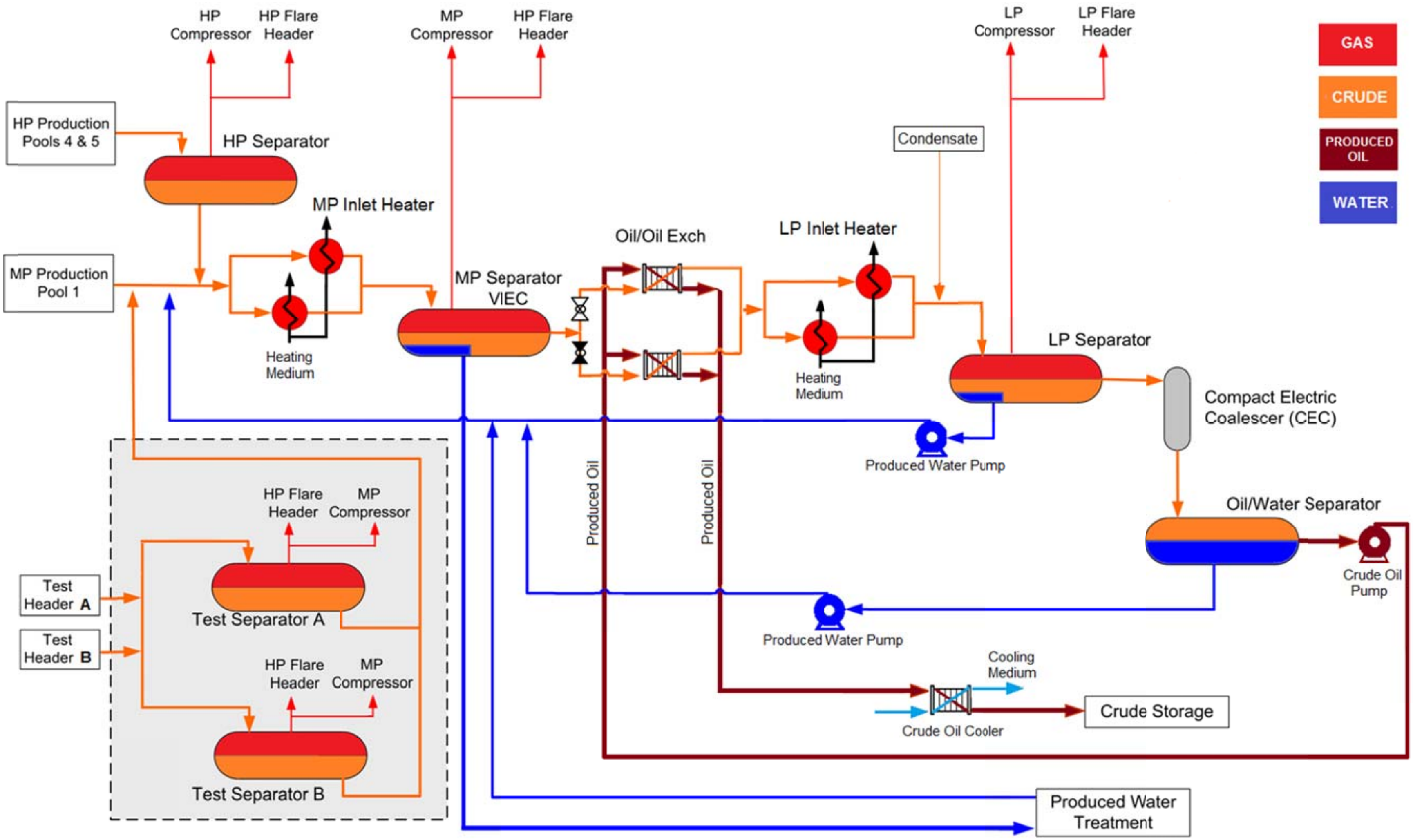
1.2 System Components

The separation and stabilization system (623) includes the following major components:

- Test separator A/B (MBD- 622201 / 221)
- Test separator mixing and sampling skid (V622202 / 222)
- HP separator (MBD-623201)
- MP inlet heaters (HBG-623205 / 215)
- MP Separator (MBD-623202)
- Oil/oil exchanger (HPL-623206 A/B)
- LP inlet heaters (HBG-623207 / 217)
- LP separator (MBD-623203)
- Compact electrostatic coalescer (MAD-624201)
- Oil/water separator (MBD-623204)
- Crude oil pumps (PBA-623208 A/B)
- Crude oil cooler (HPL-623209)

  Note: Equipment and major components will be described in detail in Lesson 3: About the Equipment. Controls will be described in Lesson 4: Controlling the System.

FIGURE 1. PRODUCTION AND TEST SEPARATION SIMPLIFIED FLOW DIAGRAM



1.3 System Design

The crude densities are 20 API (Pool 1) and 30 API (Pool 4, 5). Pool 1 constitutes 85% of the reserves and the remaining 15% comes from Pool 4 and 5. Well fluids from Pools 4 and 5 flow to the HP Separator, a two-phase separator operating at 2900 kPag. Liquid from the HP Separator is mixed with MP well fluid from Pool 1.

The separation unit is designed for a production rate of 150,000 barrels per day (BPD) of oil and total liquid rate of 314,000 BPD of oil and water. Total gas handling is 235 million standard cubic feet per day (MSCFD) (6.65 MSCMD). Production fluid is flashed and heated in several steps to meet the true vapor pressure (TVP) specification for the produced oil: 75.8 kPaa @ 45 °C. The crude is dehydrated to a specification of 0.5% volume basic sediment and water (BS&W).

Two test separators are used to analyze the stream from a selected individual well. The test separators are two-phase separators, separating gas from the liquids (oil and water). Each test separator has well allocation metering capable of meeting regulatory requirements.

All vessels, equipment, and piping is designed and constructed for sour service in the event the well stream contains H_2S gas.

1.4 References

The following references were used in developing this module. The references will be useful to you as you perform your assigned tasks.

Table B. Drawings

Drawing Number	Drawing Title
Process Flow Diagrams (PFD)	
CAHE-WP-PDPFD-21-622-0001	Test Separation
CAHE-WP-PDPFD-21-620-0001	HP and MP Production Separation
CAHE-WP-PDPFD-21-620-0002	LP Inlet Heater and Crude Oil Exchangers
CAHE-WP-PDPFD-21-620-0003	LP and Oil/water Separation
Process Shutdowns (PSD)	
CAHE-WP-PDZZZ-21-000-0002	Test Separation
CAHE-WP-PDZZZ-21-000-0003	HP and MP Production Separation
CAHE-WP-PDZZZ-21-000-0004	LP and Oil/water Separation
CAHE-WP-PDZZZ-21-000-0005	LP Gas Compression
CAHE-WP-PDZZZ-21-000-0006	MP and HP Compressor
Process and Instrument Diagrams (P&ID)	

Drawing Number	Drawing Title
CAHE-WP-PDPID-21-562-0007	Flow Lines from Headers
CAHE-WP-PDPID-21-622-0001,0002	Test Separator A and B
CAHE-WP-PDPID-21-623-0002	HP Test Separator
CAHE-WP-PDPID-21-623-0003	MP Separator Inlet Header
CAHE-WP-PDPID-21-623-0004-001	MP Inlet Heater
CAHE-WP-PDPID-21-623-0004-002	MP Inlet Heater
CAHE-WP-PDPID-21-623-0005	Oil/Oil Exchanger
CAHE-WP-PDPID-21-623-0006	LP Inlet Heater
CAHE-WP-PDPID-21-623-0007	LP Separator Inlet Header
CAHE-WP-PDPID-21-623-0008	LP Separator
CAHE-WP-PDPID-21-623-0009	LP Separator Produced Water Pumps
CAHE-WP-PDPID-21-623-0010	Oil Water Separator
CAHE-WP-PDPID-21-623-0011	Crude Oil Pump
CAHE-WP-PDPID-21-623-0012	Oil Water Separator Produced Water Pump
CAHE-WP-PDPID-21-623-0013	Crude Oil Cooler
CAHE-WP-PDPID-21-624-0001	Electrostatic Coalescer

Table C. References

Document Number	Document Name
CAHE-WP-PBDES-21-620-0001	System Description: Production and Test Separation
CAHE-ER-PRZZZ-10-641-0003	Hebron Scaling & Produced Water Reinjection Initial Assessment
CAHE-WP-RBPDB-10-000-0001	Material Design Basis Memorandum
CAHE-WP-PRZZZ-21-627-0001	Removal of Sand Jetting System
CAHE-WP-PBDES-22-671-0001	Methanol Injection System Description
CAHE-WP-PBDES-22-670-0001	Chemical Handling System Description

Document Number	Document Name
CAHE-WP-PRSIM-21-000-0003	Acid Gas Content for Years 2027,2033,2034,2035,2040,2042 and 2045
CAHE-WP-PDPFD-21-000-0001-001 thru CAHE-WP-PDPFD-21-000-0007-005	Heat & Material Balance

1.5 System-specific Process Hazards

The process hazards pertaining to this system include the following.

BIOCIDE

WARNING

BIOCIDE CAN BE TOXIC AND FLAMMABLE

The active ingredient in biocide can be toxic, flammable, and highly chemically reactive.

Biocide is batch injected into the inlet piping of the LP separator and oil/water separator to mitigate the generation of H_2S at the oil-water interface in the crude storage cells. Sampling is prohibited in lines that may contain biocide for one hour after completion of the biocide injection procedure. Refer to the P&IDs for specific sampling points.

SPILL TO SEA

WARNING

PROCESS TRAIN IS CONNECETED TO AN OUTLET TO THE SEA VIA THE PRODUCED WATER TREATMENT SYSTEM

O/W interface control is essential to prevent spills to sea. Low level of the O/W interface can cause off-specification water to enter the produced water treatment system.

If the amount of the oil released from upstream vessels to the produced water treatment system is so large that it completely overwhelms the system and free oil is discharged - an oil spill to sea has occurred.

POTENTIAL HEBRON PROCESS HAZARDS

Compliance with all SSH&E procedures regarding Hebron process hazards is mandatory.

- H_2S Exposure
- Hydrocarbon release
- NORM
- Pyrophoric Scale
- Sampling
- Corrosion

1.6 Process Chemistry

Demulsifier injection in the process must be carefully monitored to ensure off specification water is not directed to the produced water treatment system. Deviations from the optimum injection rate can significantly affect the ability of the produced water to system to operate properly resulting in excursions and/or spills to sea

- None

FEEDBACK EXERCISE

Directions: Complete the following exercises. Use this module and specified drawings and supplementary material as references. Circle the correct answer.

1.) The production separation system consists of a _____ -stage separation system with associated heat exchangers and pumps. (Circle all that apply.)

A. One

B. Two

C. Three

D. Four

2.) The produced oil from the LP separator meets the water content specification of ___% basic sediment and water (BS&W). (Circle all that apply.)

E. 0.3

F. 0.4

G. 0.5

H. 0.6

3.) Test separators A and B can be operated at up to ______ kPag. (Circle all that apply.)

I. 1950

J. 2360

K. 2900

L. 3100

4.) Production fluid is flashed and heated in several steps to meet the TVP specification for the produced oil of ____ kPaa at 45° C. (Circle all that apply.)

M. 65.2

N. 75.8

O. 77.6

P. 81.9

5.) ________ is very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Q. Biocide

R. H_2S

S. Pyrophoric scale

T. Crude oil

Lesson 2: How the System Works

LESSON INTRODUCTION

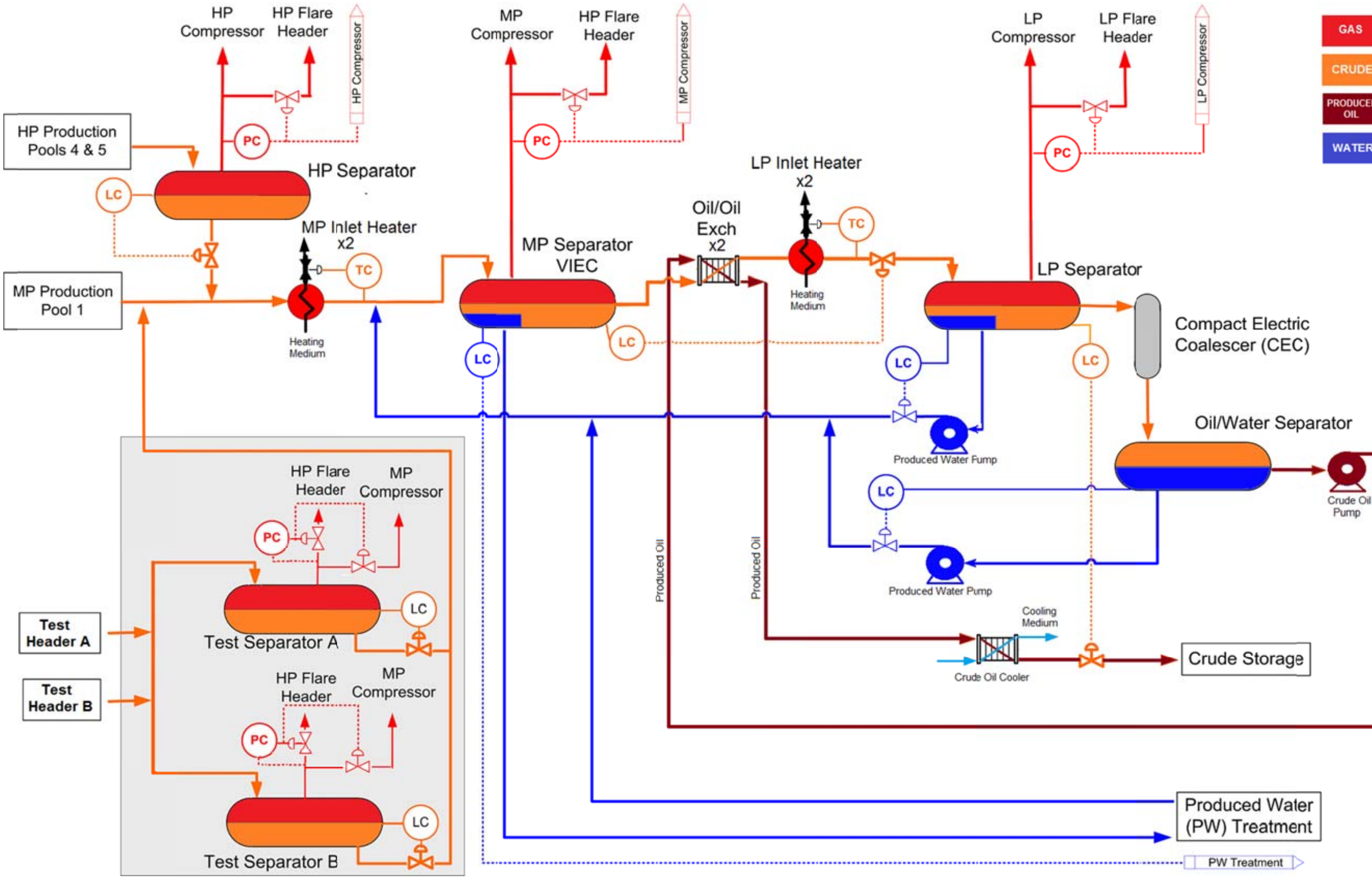
In this lesson, you will trace the separation and stabilization stream as it moves through the system.

At the completion of this lesson, you will be able to:

- Trace and explain the simplified flow path
  - Identify system boundaries and interfacing systems.
  - Identify major processing equipment in the system.
- Given the appropriate P&IDs, identify each system that provides input to this system and each system that is the destination of an output from this system.
  - Describe the input and output stream(s).
- Describe the changes of state or composition of the process flow(s), including any chemical, thermal, pressure, volume, and flow rate changes.
- Identify utilities supplying the system.

WorleyParsons
resources & energy

FIGURE 2. SEPARATION AND STABILIZATION PROCESS FLOW DIAGRAM



2. Separation and Stabilization System Process Flow

2.1 Test Separators A/B

All production wells are tested monthly for production reporting and reservoir management. The test separators separate vapor (gas) from the total liquid (oil and water), so the amount of produced oil, water, and gas from an individual well can be measured.

The production from each HP and MP well ties directly into one of the test headers (GAY-562205 / 225) through which the well fluid is routed to test separator A or B (MBD-622201 / 221). A crossover line with a motor operated valve installed can be used to test any MP or HP well at either test separator.

The test mode switch (HS-622201 / 221-01) must be set to either an HP or MP well test; logic then will select the test-appropriate set point on the split-range pressure controller (PC-622201 / 221-01).

The well fluid flows to a test separator by automatic valve alignment:

- Opening of the flow line MOV to the test header

Closure of the flow line MOV to the production header During well testing, only one well flows to the test separator. Interlocks in the PCS prevent lining up more than one well to a given test separator or lining up a well to a test separator that is shut-in.

However, reservoir data forecasts lower individual well flows - some as low as 340 kg/per day (Nov 2026). Should this scenario occur, the expectation is that operations will elect to test two wells simultaneously. One well will have a known flow rate (e.g., recently tested) so the flow rate of the second well can be determined as the difference between known production from one well and the total production of the two wells.

Inlet cyclones facilitate separation and reduce the tendency for foaming. The separator contains a full-width perforated distribution baffle that reduces turbulence and a full-width vane pack mist eliminator at the gas outlet. The drain pipe extends down to the low-low liquid level to where it drains liquids from the vane pack mist eliminator. Refer to Inlet Cyclones, Perforated Baffles, and Vane Mist Eliminator: Principle of Operation (topics below).

Table D. Test Separator: Operating Conditions

Operating Parameter	Max Liquid Case 2022	Max Gas Case 2023	Turndown: One HP Well; 2023
Temperature	45 °C	45 °C	52 °C
Pressure	1312 kPag	1312 kPag	2899 kPag
Flow: Vapor	3 m^3/h	18 m^3/h	26 m^3/h
Flow: Oil	31 m^3/h	39 m^3/h	21 m^3/h
Flow: Water	173 m^3/h	47 m^3/h	4 m^3/h

Refer to Lesson 4: Controlling the System for details on the alarms and shutdowns referenced in this lesson.

2.1.1 Liquid

The liquid (oil and water) that settles on the bottom of the test separator flows through the MP inlet heater before entering the MP separator. The minimum residence time for the production fluid is three minutes.

The liquid outlet from the test separator enters a loop with symmetrical piping in both halves of the loop. The halves of the loop rejoin to form the liquid discharge line to the MP inlet heater.

Each half of the loop is fitted with a Coriolis flow meter (FIT-622201 / 221-01/03) that measures liquid flow rate and determines the water content of the oil by online density measurement. Symmetrical piping ensures equal flow to each meter.

Both flow meters signal the flow controller (FC-622202 / 222-01) in the sampling cabinet associated with the test separator. Refer to Test Separator Mixing and Sampling System (topic below).

Level controllers (LC-622201 / 221-01) maintain the overall liquid level in the test separators A and B. The level control valves are installed downstream of the sampling system and the flow meters on the liquid outlet of the test separator. Refer to Test Separator Mixing and Sampling System (topic below).

The process is protected by shutdowns for safety high and safety low levels (LI-622201 / 221-02).

2.1.2 Vapor

Pressure in the test separator is maintained at the set point by a split-range pressure controller (PC-623201 / 221-01) modulating pressure valve (PV-622201 / 221-01A) on the gas outlet line to the MP compressor trains. This controller maintains a higher pressure (up to 1312 kPag) in the test separator in comparison with the MP separator (900 kPag) so the liquids in the test separator can flow into the MP separator.

Test separators A and B can be operated at up to 2900 kPag to accommodate HP well production. When high pressure is detected, the controller opens the pressure valve (PV-622201 / 221-01B) to send the vapor to the high pressure (HP) flare. A pressure safety valve (PSV-622201 / 221-02) relieves vapor to the HP flare header at 3900.0 kPag.

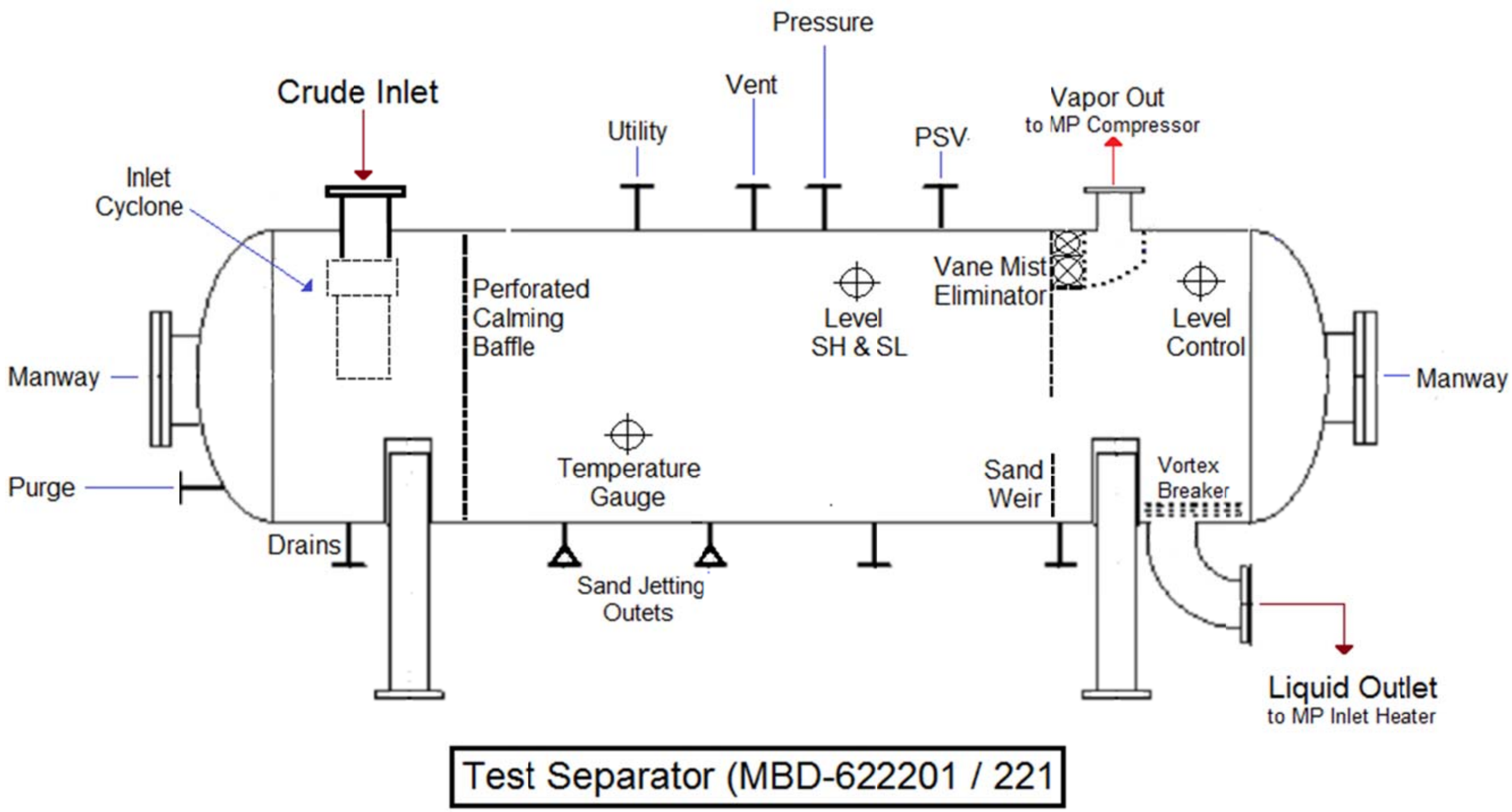
The process is protected by shutdowns for safety high and safety low pressures (PI-622201 / 221).

The vapor combines with the gas from the MP separator and flows to the MP compressors.

Redundant dual orifice flow meters measure vapor flow to the MP compressor. A manual sampling connection upstream of the overhead vapor flow meters is provided.

During well cleanup operations, the test separator can be operated at a lower pressure with vapor going to flare and liquids going to LP separator.

FIGURE 3. TEST SEPARATOR (ELEVATION VIEW)



2.2 Specialized Separation Components

2.2.1 Inlet Cyclone: Principle of Operation

An inlet cyclone has multiple effects on the incoming production stream to produce an even flow distribution.

The initial stage of the separation process takes place when the inlet cyclone disengages gas from the liquid. The inlet stream entering through the inlet nozzle is introduced tangentially into a vertical cyclone tube to create a centrifugal gas/liquid separation effect. The rapid change in direction and change of velocity causes the gas to break out of the liquid. The spiral design accelerates the incoming stream to a high gravity force, which particularly helps foam to break down into separate liquid and gas phases. The liquid stream strikes the cyclone walls and falls, entering the bulk fluid phase via a cross baffle to absorb the momentum. Gas forms a central vortex and exits the cyclone via a top exit.

This step reduces mist - liquid droplets in the gas - because excess mist can overwhelm the mist eliminator and allow too much liquid carryover in the vapor stream (see below).

The inlet cyclone also absorbs the momentum of the incoming stream. Otherwise, liquid entering the separator chamber can “shatter” when the feed stream's liquid smashes into a deflector and is broken up in extremely small droplets. This can create smaller droplets than were present in the feed stream, making the separation in the rest of the separator even harder.

An inlet cyclone enhances the homogenous distribution of the gas and liquid phases entering the vessel separation compartment, in order to optimize the separation efficiency. Maldistribution of liquid can lead to a large spread in residence times, decreasing the separation efficiency.

The inlet cyclone provides a large surface area over which the fluid mixture passes. The forces generated on the fluid mixture convert the energy in the flowing mixture and prevent the energy from shearing vapor bubbles in the mixture and forming additional foam which retards the separation of gas from the mixture.

2.2.2 Perforated Baffle: Principle of Operation

Flow enters the separator through inlet cyclones which break up the velocity of the inlet flow. After the energy and velocity of the inlet flow has been reduced, the flow then passes through the perforated calming baffle (flow distribution plate).

The baffle has two main functions: calm the liquid flow and distribute the fluid evenly across the vessel.

- The calming effect is a reduction turbulence and re-circulation within the liquid section to make separation by gravity more effective. The baffle also helps minimize the disruption caused by slugs and surges.
    - Turbulence can lead to re-entrainment of gas within the liquid.
    - Turbulence can thicken the interface level.

- A perforated baffle is referred to as a “flow straightener.” The baffle occupies the entire cross-sectional area of the vessel. As the stream approaches the baffle surface, the flow is forced to change direction and spread along the baffle surface. As a result, small streams of homogenous fluid enter the separation zone simultaneously. These homogenous layers (laminar flow) enhance the efficiency of gravity separation.

  Inefficient separation leads to large amounts of wet oil (emulsion) spilling over the weir into the oil outlet.

FIGURE 4. PERFORATED DISTRIBUTION BAFFLE

An even spread across the separation zone also is very important when an electrostatic coalescer is installed to coalesce small droplets into larger droplets. Electrostatic coalescence is most efficient when all electrostatic plates are exposed equally to homogenous flow.

> Note: The operating principles of an electrostatic coalescer and a plate pack are described in more detail in Lesson 2.

The perforated plate also acts as an additional impingement demister and foam breaker.

2.2.3 Vortex Breaker: Principle of Operation

A vortex breaker stops the formation of a vortex when a fluid (liquid or gas) is drained from a vapor-liquid separator. The formation of vortices can entrain vapor in the liquid stream, leading to poor separation and causing cavitation of downstream pumps. Vortices can also re-entrain liquid particles previously separated from the gas stream.

The grate-type design in Hebron separators uses a system of grating similar to the metal floor of a catwalk.

2.2.4 Vane Mist Eliminator: Principle of Operation

In every process involving contact between liquid and flowing gas, tiny mist droplets (liquid) are carried away with the gas. This phenomenon is called entrainment.

Very small droplets such as fog or mist cannot be separated practically by gravity. However, they can be coalesced to form larger droplets that will separate out.

A mist eliminator in a separator provides a large surface area within the relatively small volume vessel to collect liquid without substantially impeding gas flow. Unlike filters, which hold particles indefinitely, mist eliminators coalesce (merge) fine droplets and allow the liquid to drain through a pipe to the liquid in the bottom of the separator.

Of the three types of mist eliminators, the vane pack-type mist eliminator was preferred for Hebron because it is more efficient than a other-types when the production fluid is highly viscous and contains foaming liquids.

Vane mist eliminators consist of closely spaced corrugated plates that force mist-laden gas to follow serpentine paths. Vanes bend the path of mist-laden gas into relatively tight curves. As the gas changes direction, inertia or momentum keeps mist droplets moving in straighter paths, with some strike adjacent vanes. There, they are held by surface forces and coalesce (merge) with other droplets. The larger drops trickle to the bottom of the vanes until the droplets are large enough to fall through rising gas.

The oil droplets flow to a drain pipe which extends down to the low-low liquid level. The oil droplets are not exposed to the upward flowing gas so re-entrainment is impossible. The depth of the drain pipe also prevents splashing which would create eddies that slow the separation process.

The mist eliminator is boxed in to prevent gas bypass flow at the vapor outlet nozzle.

FIGURE 5. VANE PACK MIST ELIMINATOR

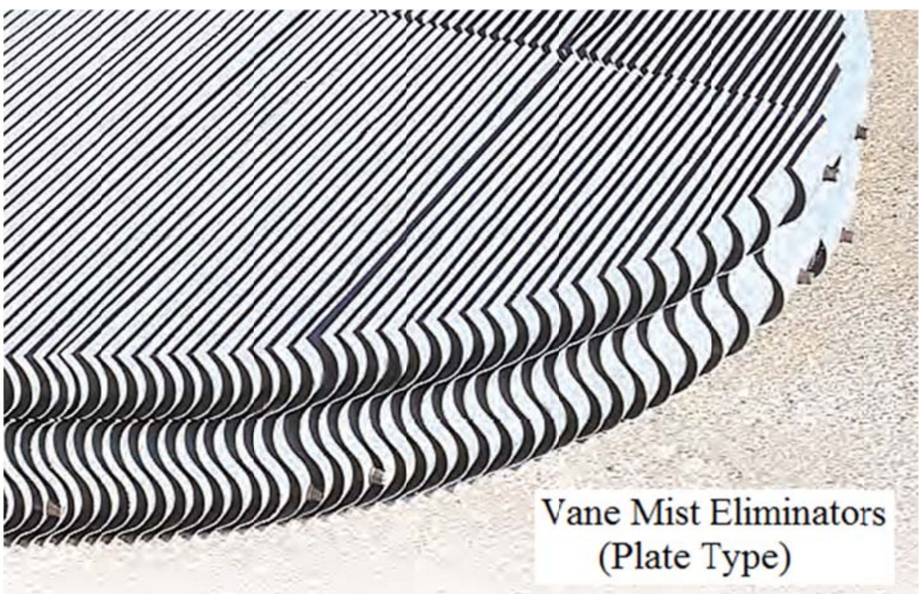


FIGURE 6. VANE PACK MIST ELIMINATOR WITH DRAIN PIPE

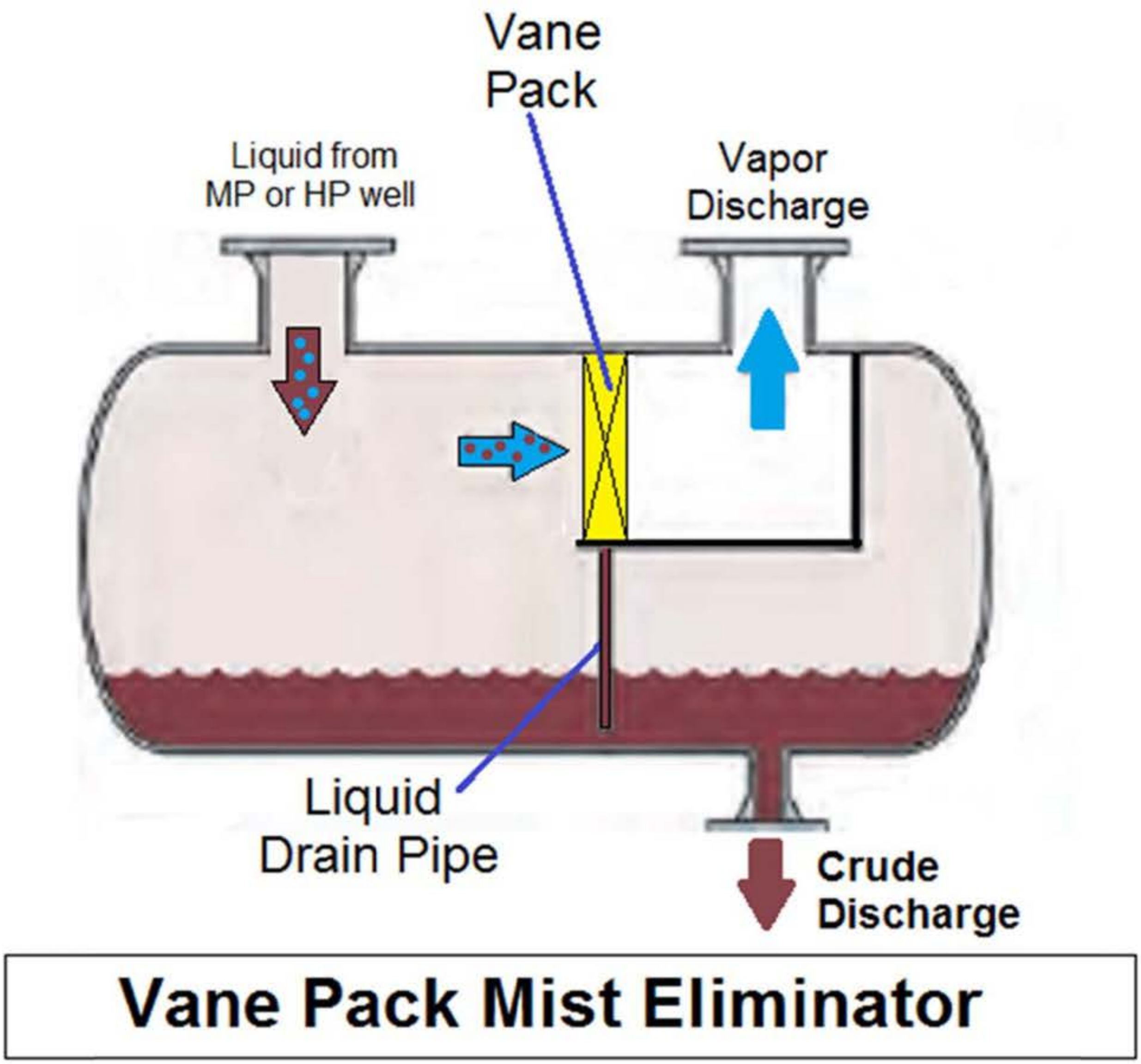
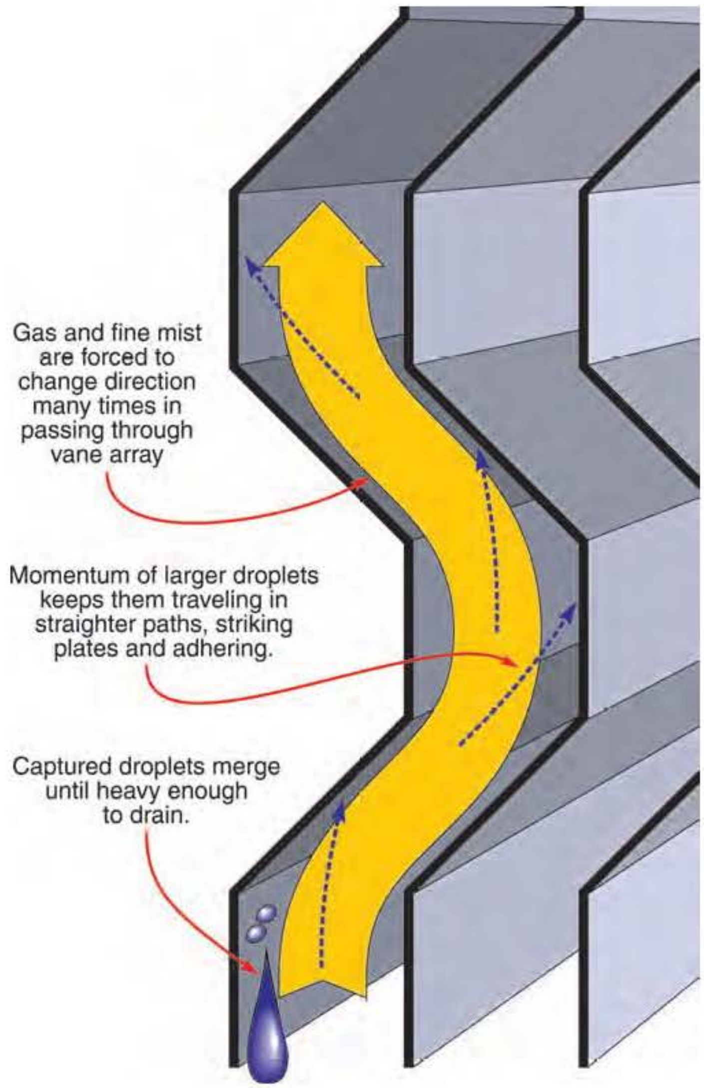


FIGURE 7. VANE-TYPE MIST ELIMINATOR: LIQUID COALESCING PROCESS



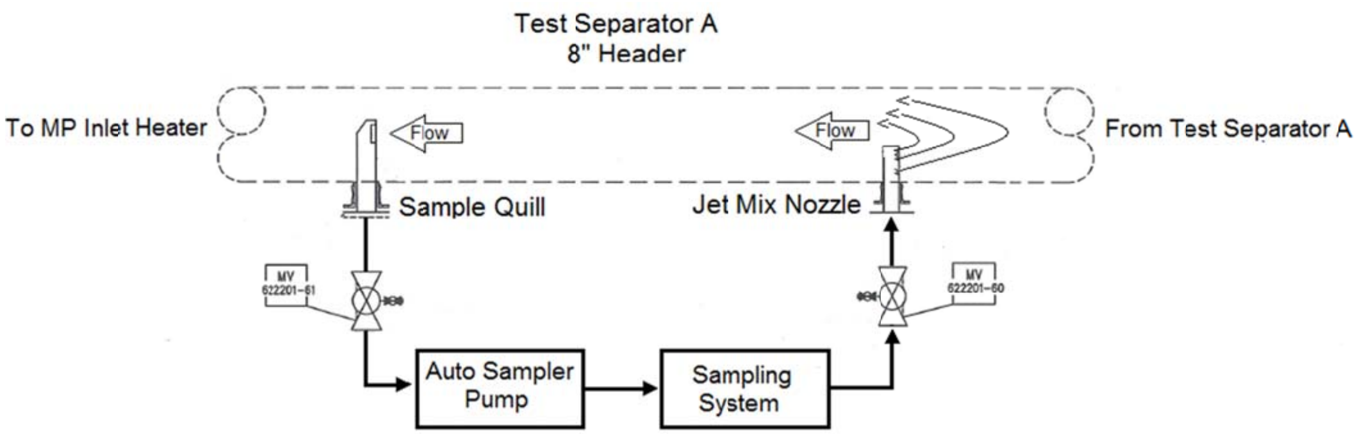
Capture of mist droplets in a vane array with vertical flow

2.3 Test Separator Mixing and Sampling System

Crude oil is sampled to establish the composition, quality, density, and water content.

An automatic mixing and sampling system upstream of the flow meters automatically measures, collects, and preserves liquid samples for lab analysis.

The liquid outlet from each test separator is fitted with a sample take-off quill and a sample return mixing nozzle. The mixing nozzle injects the discharge from the sampling enclosure into the crude flow 6' upstream of the take-off quill to create a consistently blended mixture at the intake of the quill.

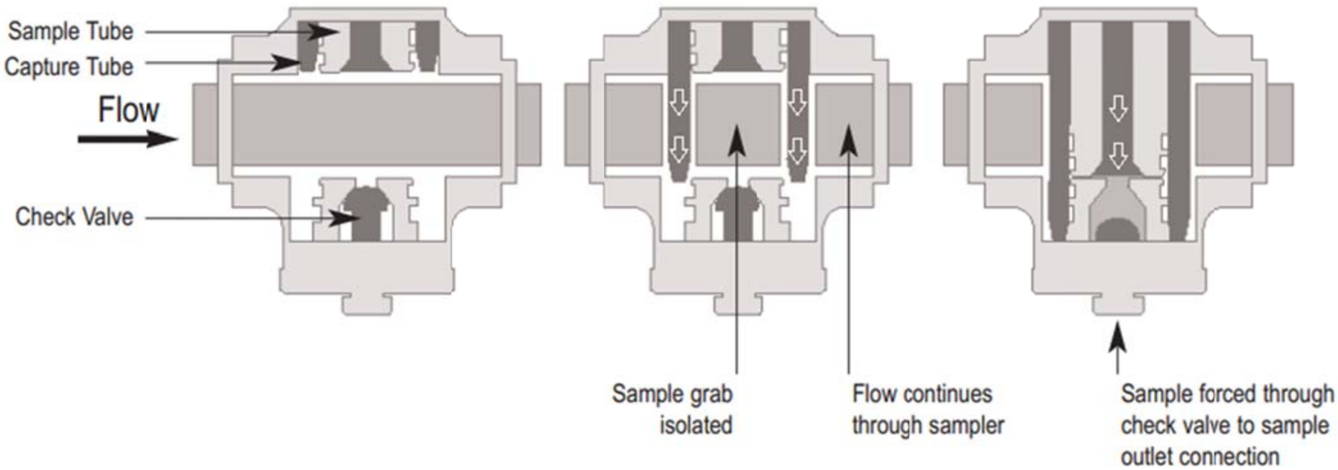


Flow from the auto sampler pump to the sampling enclosure is measured by a flow meter (FE-622204 / 224-01). The flow meter includes a flow-conditioning orifice plate which reduces turbulence in the flow prior to measuring the flow rate.

The auto sampler pump delivers the sample to the cell sampler inside the sampling system cabinet. As the fluid stream passes through the cell sampler, the device isolates and captures a 1 mL (1 cc) sample of the fluid then directs the sample through a three-way solenoid valve to one of two 4000 mL sample receivers.

The action of the cell sampler is controlled by an external flow control valve (FC-622202 / 222-01) which receives signals from the flow totalizer (FQI-622201 / 222-01/03) on the test separator liquid outlet, downstream of the sampling system take-off quill.

FIGURE 8. THREE-STAGE SAMPLE CAPTURE

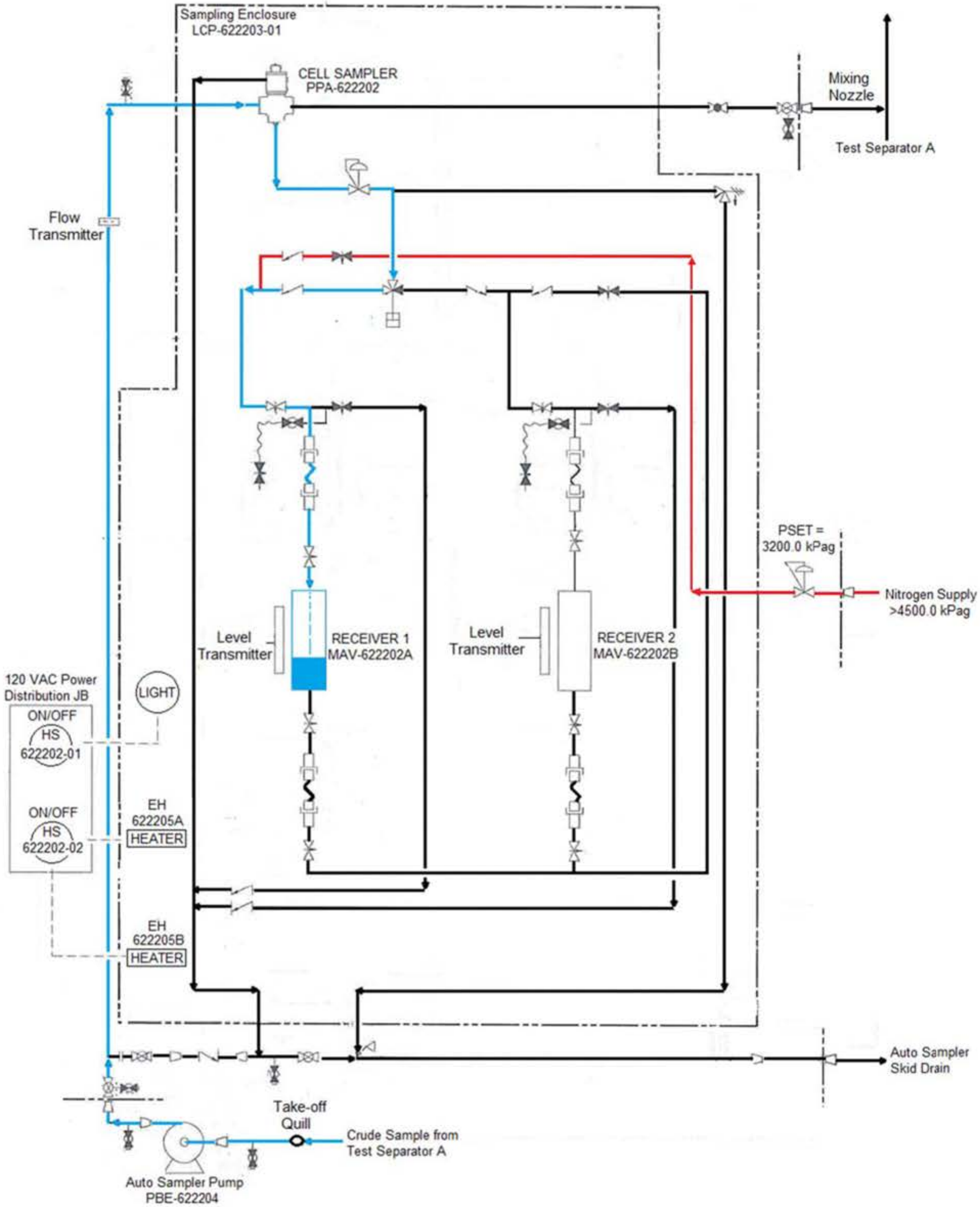


Nitrogen provided by N_2 bottles maintains pressure on the crude sample in the receiver to prevent separation of the constituent parts of the crude; thus, the analysis of the crude from the test separator can be performed on a sample that accurately represents the crude under operating conditions.

The level in each receiver is monitored by a level indicating transmitter (LIT-622202 / 222 A/B-01). The high level set point is 3600 mL. A minimum level of 200 mL is a start permissive.

The operator must isolate then remove the sample receiver and transport the container to the lab for analysis of the crude.

FIGURE 9. CRUDE SAMPLE FLOW TO SAMPLE RECEIVER



2.4 HP Separator

Production from 10 high pressure wells in pools 4 and 5 flows to the HP separator (MBD-623201), a horizontal, two-phase separator.

Vapor flashes and separates from the liquid at 2900 kPag and 52 °C.

- Vapor flows to the HP compressor
- Liquid (oil + water) flows through the MP inlet heater to the MP separator.

The vessel internals consist of inlet cyclones to facilitate separation and reduce the foaming. The fluid then passes through an inlet calming baffle that reduces turbulence. The full-diameter, perforated plate allows the gas/liquid to flow more uniformly after leaving the inlet cyclones. The plate also acts as a demister and foam breaker.

The liquid outlet is equipped with grating-type vortex breakers.

2.4.1 Vapor

Vapor flows to the HP compressor suction cooler. A flow indicator (FI-6232201) reports the vapor flow rate. A pressure controller (PC-623201-01) maintains the pressure in the line to the HP compressor at the set point and vents vapor to the HP flare when high pressure is detected. The pressure controller signals the Mark VI controller for the MP / HP / LG compressor trains.

The process is protected by shutdowns for safety high pressure and safety low pressure (PI-623201-02). Two pressure safety valves (PSV-623201-01/02) are installed, with one in service at a time, which relieves vapor to the HP flare header at 3900.0 kPag.

A vane pack mist eliminator at the gas outlet enhances droplet coalescence to make removal of liquid droplets from the vapor more effective.

2.4.2 Liquid

The minimum residence time for oil is three minutes.

The HP separator liquid (oil + water) flows on level control (LC-623201-01) to the MP inlet heater before entering the MP separator.

The process is protected by shutdowns for safety high liquid and safety low liquid level (LI-623201-02). A shutdown valve (SDV-623201-02) on the liquid outlet closes in the event of a process shutdown (PSD).

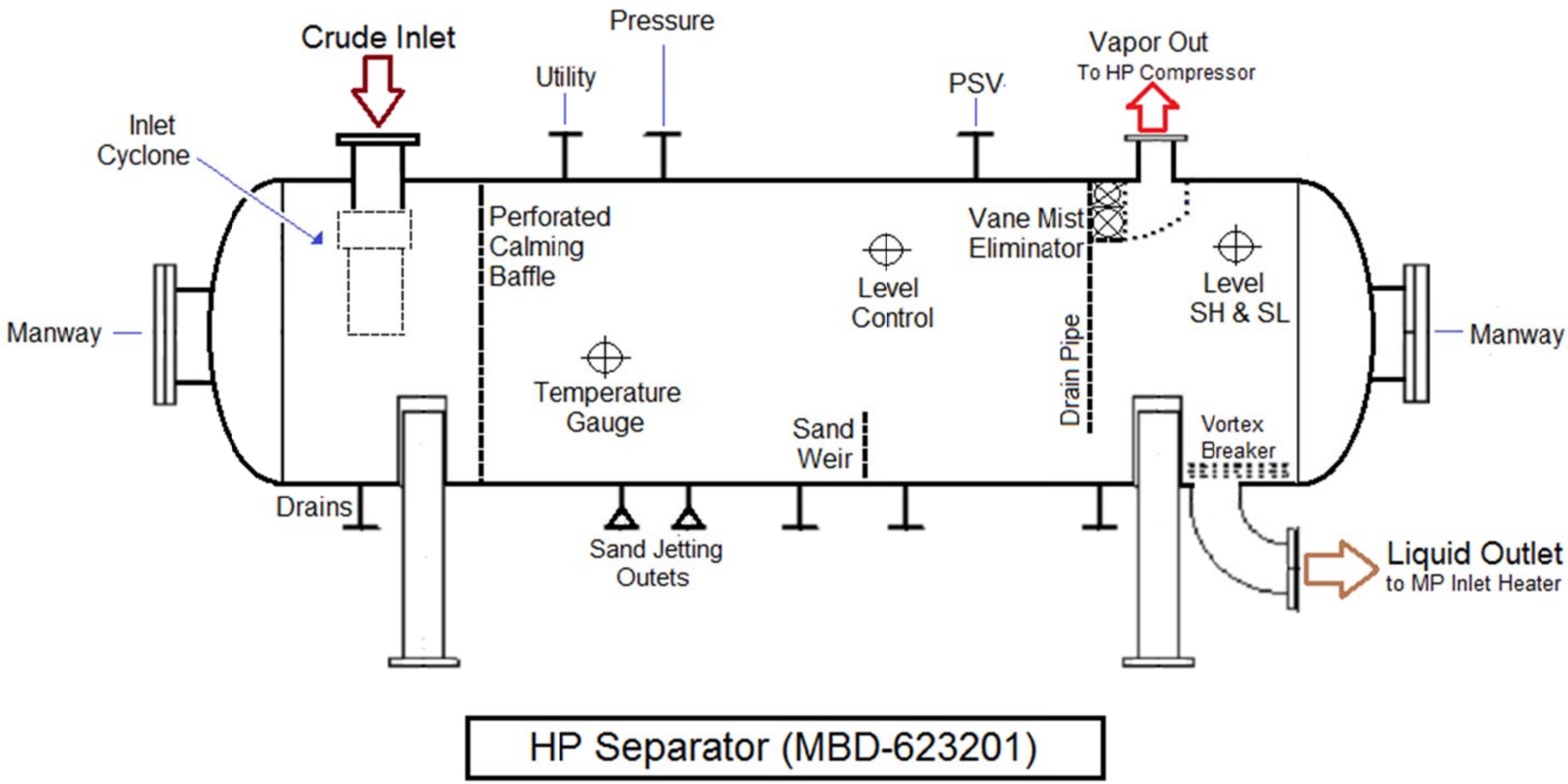
2.4.3 Chemical Injection

The separator is equipped with an injection quill at the inlet piping for injection of scale inhibitor, if required. There is an injection quill installed in the crude outlet piping for injection of water clarifier.

2.4.4 Future Modifications

Sand weirs and nozzles for future sand jetting equipment are provided to facilitate removal of sand and sludge.

FIGURE 10. HP SEPARATOR (ELEVATION VIEW)



2.5 MP Inlet Header

Flow to the shell and tube exchangers MP inlet heater (HBG-623205 / 215) is comprised of:

- MP production well flow from the 22 pool 1 wells
- Liquid from the test separators
- Liquid from the HP separator
- Produced water from the LP separator and OIW Sep via the LP Separator Produced Water Pumps
- Reject oil from the produced water system
- Condensate from the HP/LG/GI compressor suction scrubbers

These fluids collect in the MP separator inlet header, upstream of the MP inlet heater.

A pressure safety transmitter (PST-623205-07) activates a PSD trip if the header is over- or under-pressured. Five PSVs relieve to the HP flare header.

> Note: The HP separator will be isolated at startup. An isolation valve (MV-623201-30) on the discharge line from the HP separator will remain closed until the HP separator is brought on line, anticipated to occur in 2017.

2.6 MP Inlet Heaters

The 2 x 50% tube-and-bundle exchangers operate in parallel to heat the production fluid to 64-70 °C before it flows into the MP separator. After the water cut eventually rises above 50%, the required minimum temperature will drop but will remain above 61 °C throughout field life.

The heating medium is dilute TEG, a solution of 48% wt TEG + 52% wt water.

Dilute TEG heating medium enters the shell at 170 °C and exits at 98 °C. During initial production, crude will enter the tube at 49 °C and exit at 70 °C. After production ramps up, the crude will exit the exchanger at 64 °C. At low oil production rates the heating medium temperature will be operated lower to minimize the differential temperature between the heating medium and the crude oil while maintaining desired heater outlet temperature to prevent scale formation on heater.

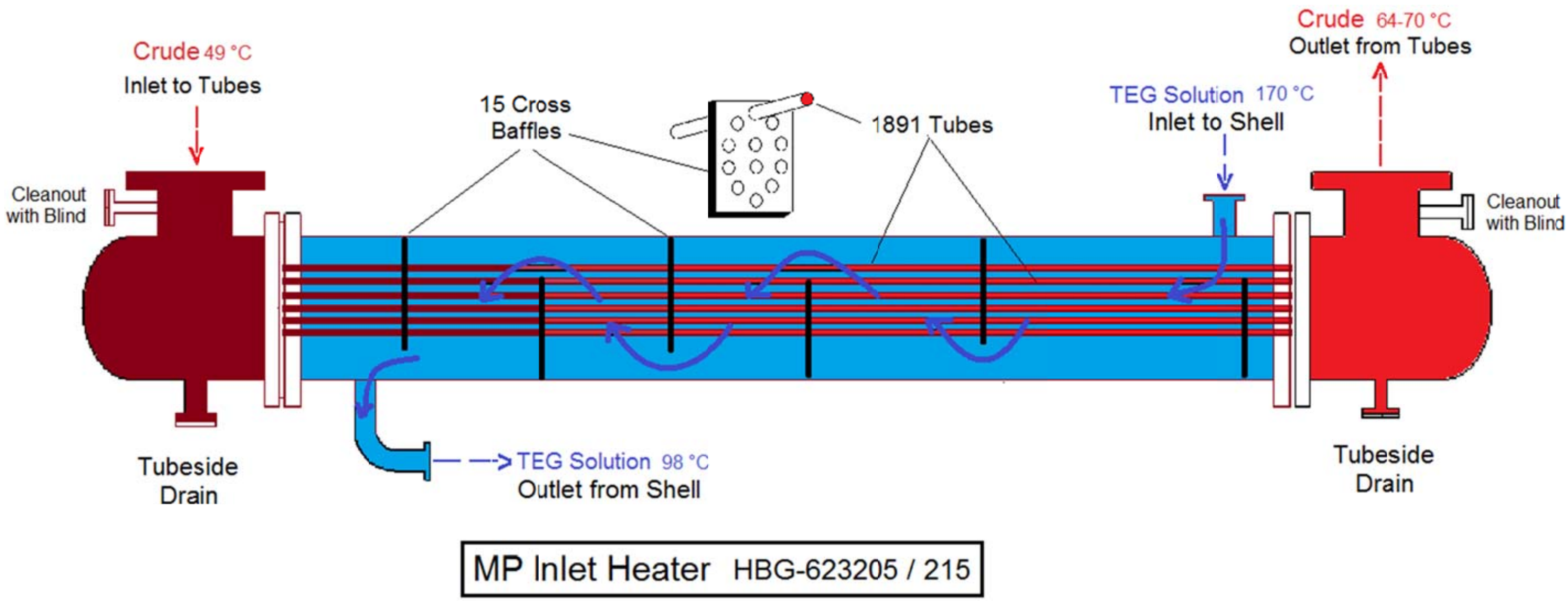
A temperature controller (TC-623205 / 215-01) receives a signal from a temperature indicating transmitter (TIT-623205 / 215-01) on the crude outlet line from each heater. The temperature controller maintains the temperature of the crude within the specified range by throttling the flow of heating medium via a temperature control valve (TV-623205 / 215-01) on the heating medium outlet from the exchanger.

Injection points for demulsifier, defoamer, asphaltenes inhibitor, and scale inhibitor are located on the collection header to the heaters.

Table E. MP Inlet Heater Operating Conditions (Year 2021)

Parameter	Tube Side Crude		Shell Side Dilute TEG	
	Inlet	Outlet	Inlet	Outlet
Temperature	49 °C	70 °C	170 °C	98 °C
Flow	1,905.31 m^3/h	1,899.15 m^3/h	511.27 m^3/h	
Pressure	1112.0 kPag		1200.0 kPag	

FIGURE 11. MP INLET HEATER: CRUDE WARMING PROCESS



2.7 MP Separator

The MP separator (MBD-623202) is a three-phase separator operating at 900 kPag.

The internals consist of inlet cyclones to facilitate vapor/liquid separation and reduce foaming before the liquid passes through inlet calming baffles to the vessel internal electrostatic coalescer - low water (VIEC-LW).

The vessel includes a vane pack mist eliminator at the gas outlet. The oil and water outlets are equipped with grating-type vortex breakers.

Production fluid at 64-70 °C from the MP inlet heater flows into the MP separator where the fluid is separated into vapor (gas), crude, and water. MP separator Inlet temperature should be maintained above 60 °C because separation performance could decrease significantly. The MP separator should not be operated for prolonged periods above 70 °C because service life of VIEC plates will be reduced.

- Vapor flows to the MP compressor suction cooler (HPL659204).
- Produced water flows to the produced water hydrocyclones (MHC-681202).
- Crude flows to the oil/oil exchanger (HPL-623206).

Table F. MP Separator: Operating Conditions (Year 2021)

Operating Parameter	Operating Value
Temperature	70 °C
Pressure	900 kPag
Flow: Vapor	149 m^3/h
Flow: Oil	926 m^3/h
Flow: Water	972 m^3/h

2.7.1 Electrostatic Coalescence

The MP separator includes a vessel internal electrostatic coalescer - low water (VIEC-LW) system. Gravity separates “free” water from the incoming fluid but the VIEC - LW is required to remove water emulsified in the oil phase; otherwise, excess water can carry over into the oil outlet.

Inside the vessel are two VIEC-LW cross-section walls containing electrodes; one wall is energized at 210 V and the other wall at 140 V. The VIEC is normally controlled from the process control system (PCS) but it also is possible to monitor and run the VIEC in local mode.

When the oil-water emulsion is subjected to the electric field, the phenomenon known as electrostatic coalescence occurs: small water droplets in the emulsion coalesce (join together) to form larger, heavier droplets that settle to the bottom of the separator. The water is routed to the produced water treatment system while the crude oil flows through the oil/oil exchanger en route to the LP separator.

Refer to the Electrical Coalescer - Principle of Operation topic (below).

Calculated residence time through the VIEC-LW installation is an 11-second exposure time followed by a settling time of five minutes in the space between the VIEC-LW wall and the water outlet nozzle.

The VIEC-LW power connections through the top of the vessel are monitored by a hydrocarbon leak detector.

The water in oil leaving the MP separator is reduced to less than 10% BS&W.

Note: Water production is anticipated to commence in the third year of production, but will ramp up quickly.

2.7.2 Oil

The oil level is maintained by a level controller (LC-623202-01) which controls the discharge of crude from the MP separator by adjusting a level control valve (LV-623202-01) located downstream of the LP inlet heater.

The process is protected by a level indicator (LI-623202-02) that triggers a PSD at safety high or safety low oil level.

2.7.3 Water

The water level is maintained by the oil-water interface level controller (LC-623202-03) which adjusts the level control valve (LV-623202-03) located downstream of the produced water cyclones. The level controller can be operator-selected for either gap (on/off) control or continuous level control. Gap control will be selected during periods of low produced water rates and during the post start-up period until the flow of produced water rises to the hydrocyclone minimum flow rate. Continuous level control will be selected when produced water flow is consistently above this minimum flow rate.

Produced water flow from the MP separator to the produced water hydrocyclones is measured by a flow-conditioning orifice flow meter (FE-623202-03). A flow totalizer (FQI-623202-03) records the cumulative produced water flow from the MP separator. The associated flow indicator (FI-623202-03) signals a flow controller (FC-681210/211/212-01) at the inlet of each compact flotation unit (CFU). These flow controllers adjust the flow of fuel gas that is added to the produced water to create the flotation effect in each CFU.

Refer to Produced Water Treatment System, Training Module 14, CAHE-WP-OMTRN-10-681-0014.

2.7.4 Interface

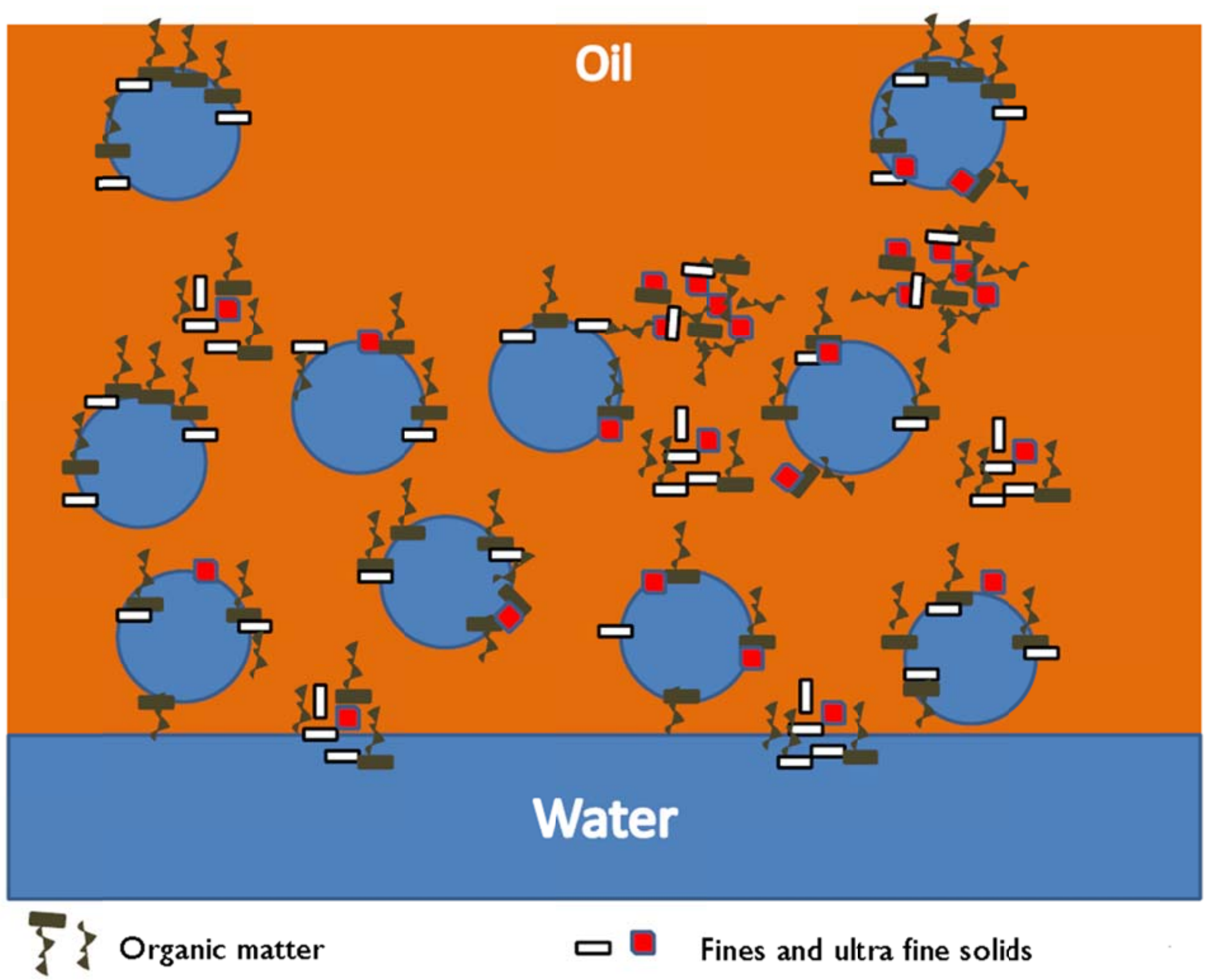
A level safety transmitter (LST-623202-05) monitors the interface level and signals the nucleonic level profiler (UCP-623202-05). Refer to Nucleonic Level Profiler: Principle of Operation (below).

The process is protected by an interface level safety low that trips on two-out-of-two voting (2oo2) from two level indicators (LI-623202-05 A/B). The trip closes the produced water outlet valve to prevent a further lowering of the interface. A trip also turns off both VIEC units.

The interface "rag layer" is manually drained through one of three skimming nozzles (MV-623202-19/20/21) located at different elevations. The oil/water emulsion is pumped by the skim oil pump (PBA-623212) to the crude outlet manifold to be exported via the crude export pumps. Skimmed oil also can be directed to the closed drain.

The rag layer is composed of small water droplets and large flocs dispersed in a continuous oil phase. Water content and rag layer density increase towards the water interface.

FIGURE 12. RAG LAYER



2.7.5 Vapor

MP separator vapor flows to the MP compressor suction coolers. A flow-conditioning orifice flow meter (FE-623202-02) measures gas flow. A flow totalizer (FQI-623202-02) records the cumulative gas flow from the MP separator.

The operating pressure of the MP separator is controlled at 900 kPag. A pressure indicating controller (PIT-623202-02) signals a split-range pressure controller (PC-623202-01) which sends a signal to the MP compressor controller to modulate the compressor spillback control valves (FV-659202-01 A/B) for each compressor train. If high pressure occurs at the MP separator, the pressure controller opens a pressure control valve (PV-623202-01) to send gas to the HP flare.

A parallel 8" control valve (PV-623202-01B) is installed on a new 6"/8" line bypassing the main control valve (PV-623202-01). During early life, prior to start-up of the compression system, the main line should be isolated and the 8" valve should be in operation to control the separator pressure by releasing gas to HP flare. After the 2nd well is brought on line and Lift Gas operation is started, gas flow will increase and the main line can be put in operation. Net gas production will be used for Fuel Gas or re-injected. During later restarts the valve (PV-623202-01B) can be used until the first wells have stabilized with sufficient gas to restart the compression system. Starting high GOR wells first will minimize the time with gas flaring. Transition between the 2 valves will require manual operator intervention.

The MP compressors are protected from safety high gas pressure by a pressure indicator (PI-623202-02) on the gas discharge from the MP separator. A PSD trip shuts in the MP wells and shuts off the gas supply to both MP compressor suction coolers by closing the shutdown valves on the gas supply (SDV-659202 / 222-05) and on the gas supply bypass (SDV-659202 / 222-06).

A blowdown valve (BDV-623202-04) and orifice (RO-623202-02) are installed for depressurizing the MP separator to the HP flare. The blowdown valve can be actuated locally or from the control room. A PSV will relieve to the HP flare header when vapor pressure reaches 1930.0 kPag.

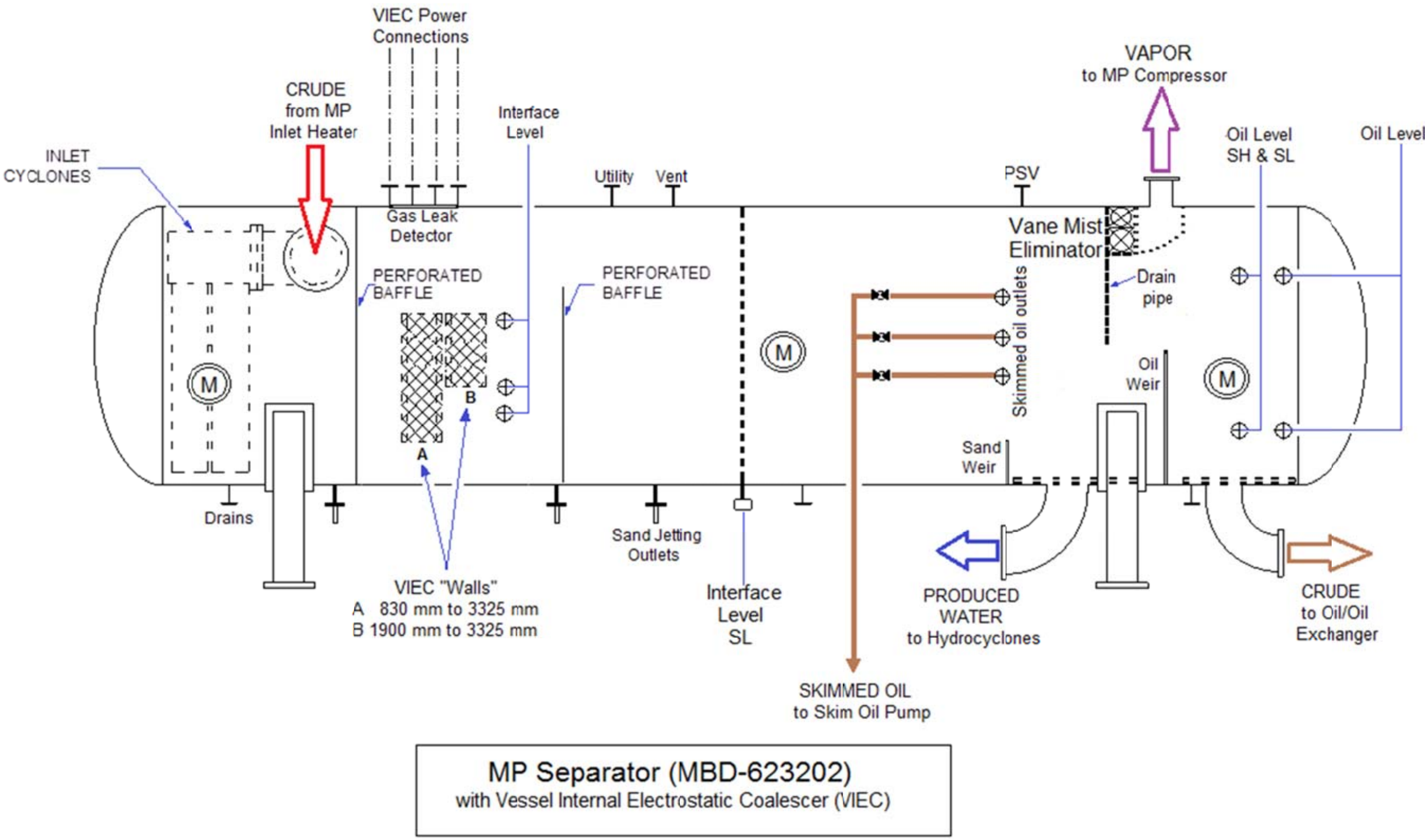
The wet pilot gas supply ties into the MP separator vapor line upstream of the pressure control valves. Wet pilot gas will be used during initial facility startup until there is sufficient gas to start the fuel gas system. Wet pilot gas also is used for a short duration when starting up after a full shutdown. There is a low flow alarm to indicate loss of pilot gas.

2.7.6 Chemical Injection

An injection quill is installed in the MP separator crude outlet piping to provide for demulsifier injection, if required, and a second injection quill in the MP header upstream of the heaters is provided for asphaltene inhibitor injection.

WorleyParsons
resources & energy

FIGURE 13. MP SEPARATOR (ELEVATION VIEW)



2.8 Electrical Coalescer - Principle of Operation

Gravity-based separators remove only the free water and have only a limited effect on water emulsified into the oil phase. Emulsion layers in the separators are difficult to monitor and hence difficult to control, which can result in carryover of excess water into the oil outlet.

The vessel internal electrostatic coalescer - low water (VIEC-LW) enhances the speed and efficiency of the separation process by using an electric charge to force small water droplets to merge and form larger water droplets. The larger the droplet, the faster it separates from the oil and the more quickly it will descend to the bottom of the tank.

In 1845, an English mathematician named George Stokes first described the physical relationship that governs the settling solid particles in a liquid. Stoke's law also can be used to calculate the settling rate of a heavier component like water in an oil/water emulsion. According to Stokes' law, the settling velocity will increase by the square of the droplet size; simply put, the larger the water droplet, the more rapidly the water settles to the bottom layer in the separator.

The MP separator contains two VIEC-LW walls. Electrodes form each cross-sectional wall which allows the fluid to pass the electrodes and be exposed to the electrical field which sets up attractive forces between the water droplets. Applying an external electrostatic field on the emulsion leads to more frequent and stronger collisions between the water droplets.

This phenomenon is called electrostatic coalescence. The oil-water emulsion in the separator consists of a polar liquid (water) dispersed in a non-conductive liquid (crude). When an uncharged droplet is subjected to an AC electric field, the field polarizes the droplet. As a result, the droplet has one positive side and one negative side, known as a dipole. Molecules that contain dipoles are called polar molecules. Polar molecules align so that the positive end of one molecule interacts with the negative end of another molecule.

When two water droplets with induced dipoles get close to each other, they will experience an attractive force pulling the droplets closer until they coalesce to form a larger droplet.

FIGURE 14. DIPOLE-DIPOLE INTERACTION

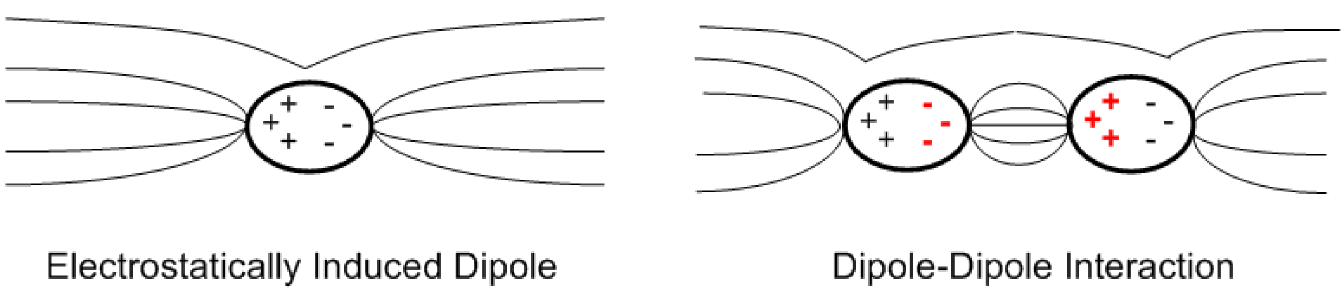
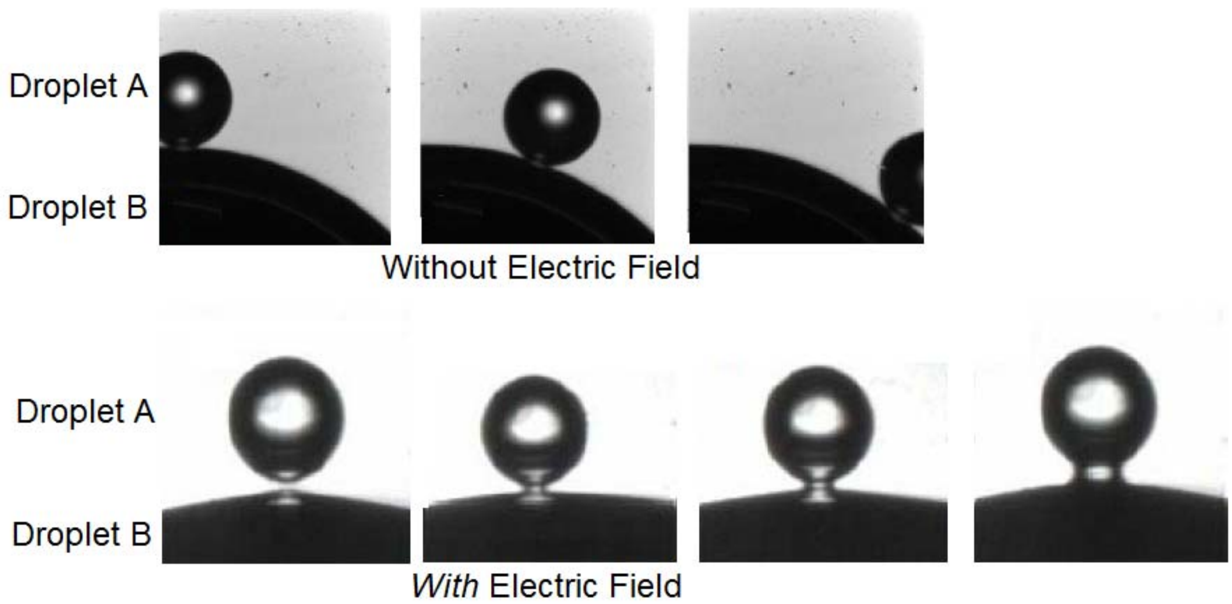


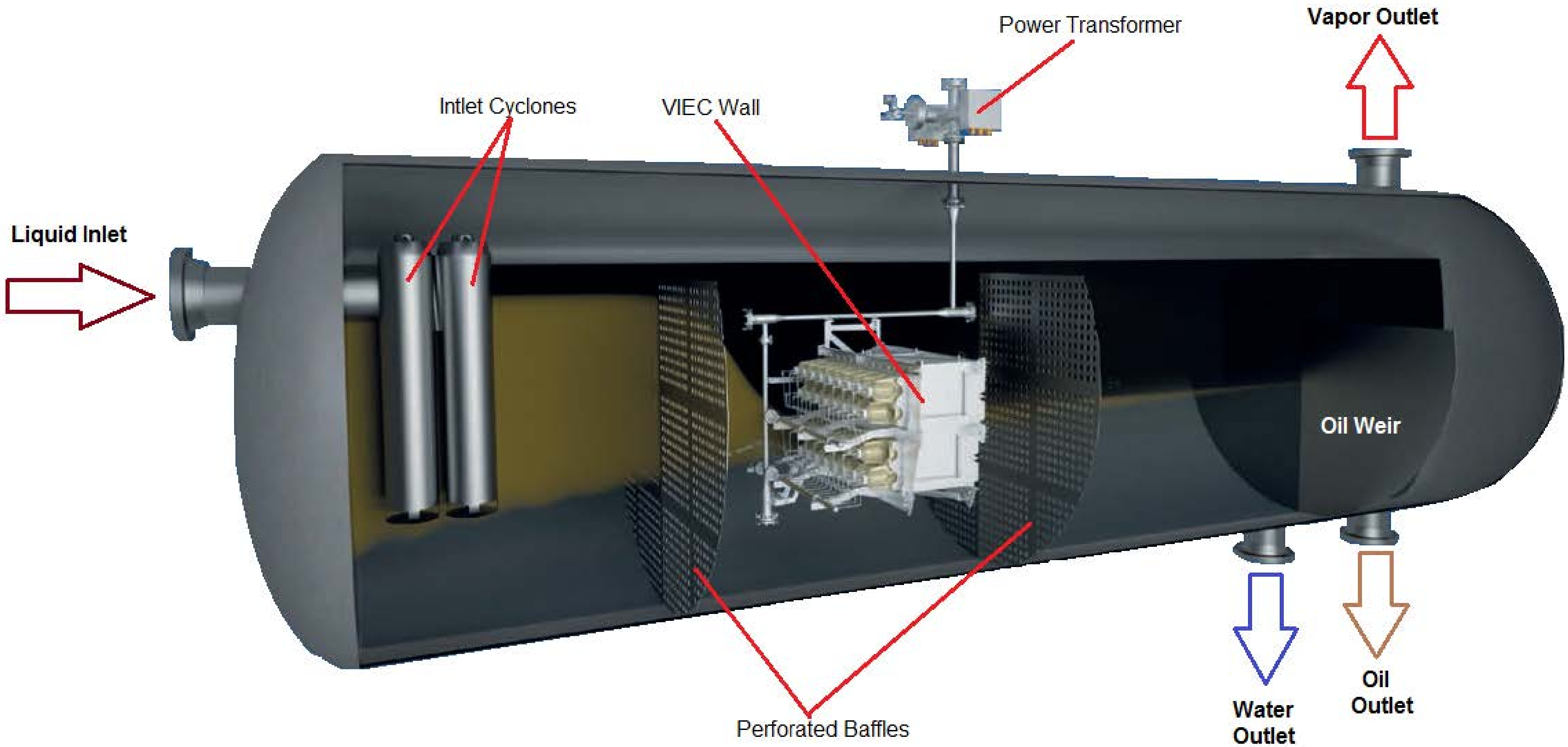
FIGURE 15. PHOTO WATER DROPLET COALESCENCE



The isolated electrodes make the VIEC operational in high water-content fluids without short-circuiting. The VIEC is powered by low voltage penetrators.

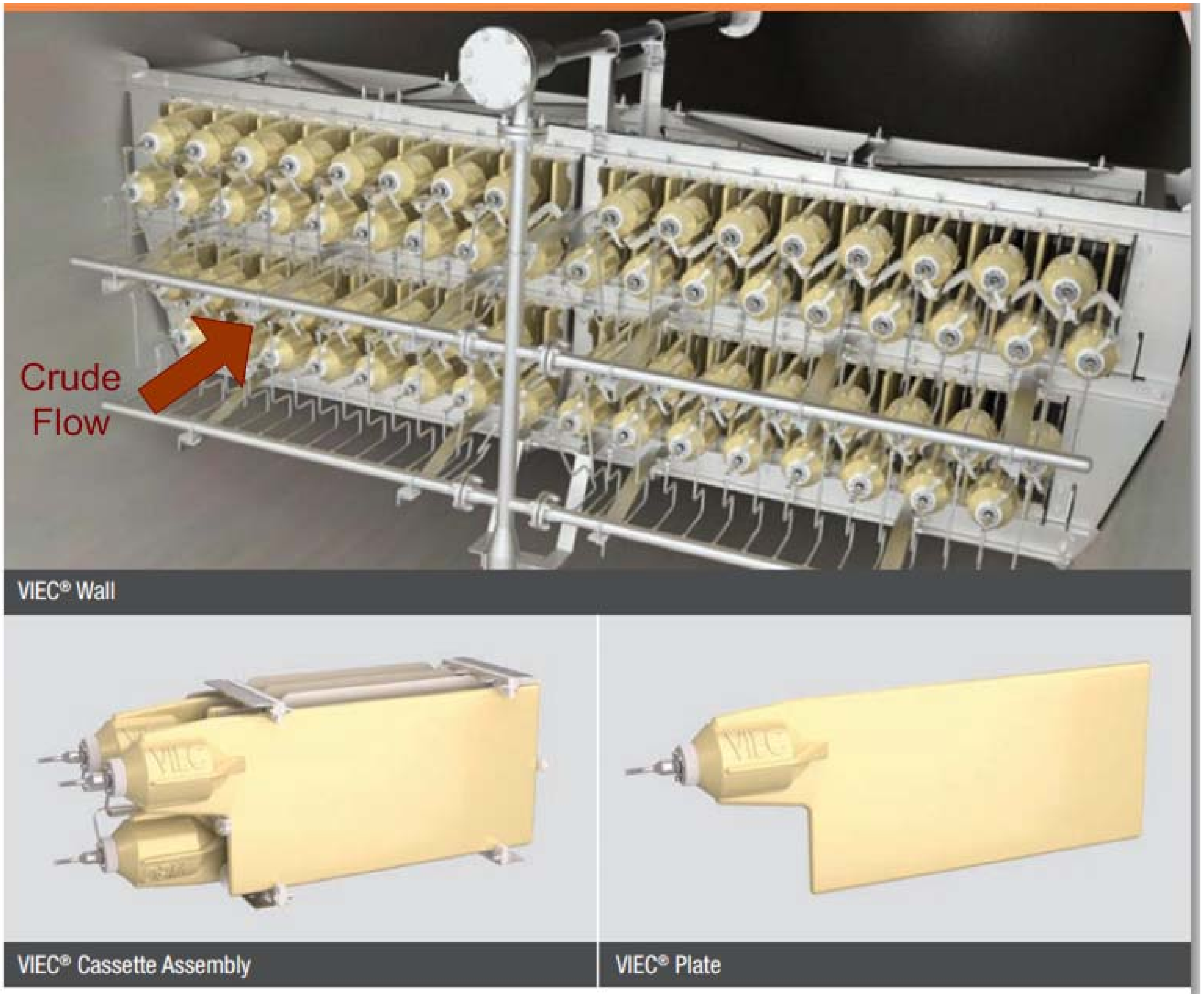
Note that dispersed oil droplets are non-conductive compared to the surrounding water.

FIGURE 16. VIEC WALLS INSTALLED IN A SEPARATOR



Separator with VIEC Wall (Typical)

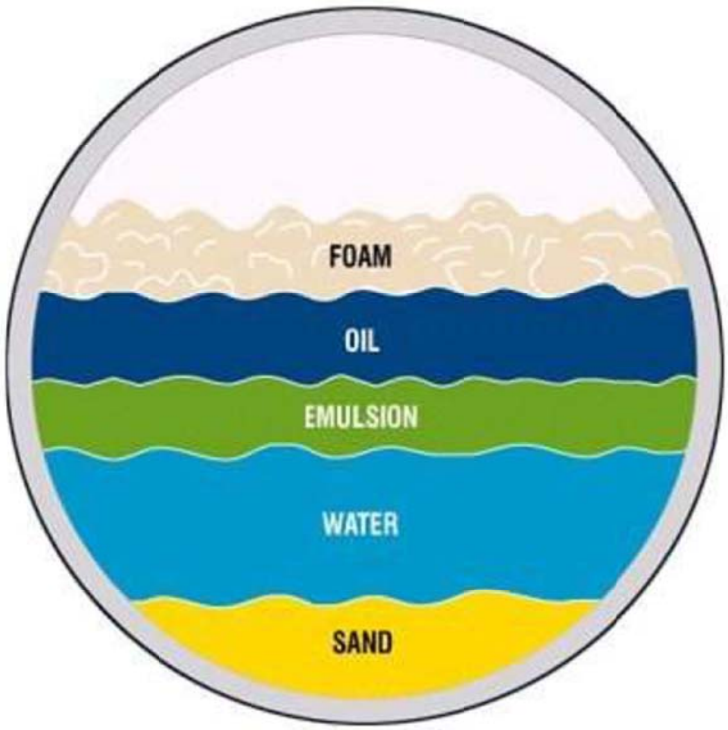
FIGURE 17. VIEC WALL COMPONENTS



2.9 Nucleonic Level Profiler: Principle of Operation

Separation vessels contain products such as gas, foam, oil, emulsion, water, and sand which naturally gravitate into different phases. Each phase has a different density.

FIGURE 18. SEPARATION OF LAYERS



The nucleonic profiler measures the vertical density of each layer by measuring the gamma absorption of the process material. This enables a meaningful and accurate measurement of the vertical density distribution within the MP separator. The device assesses both the interface quality and the level of the interfaces present within the vessel.

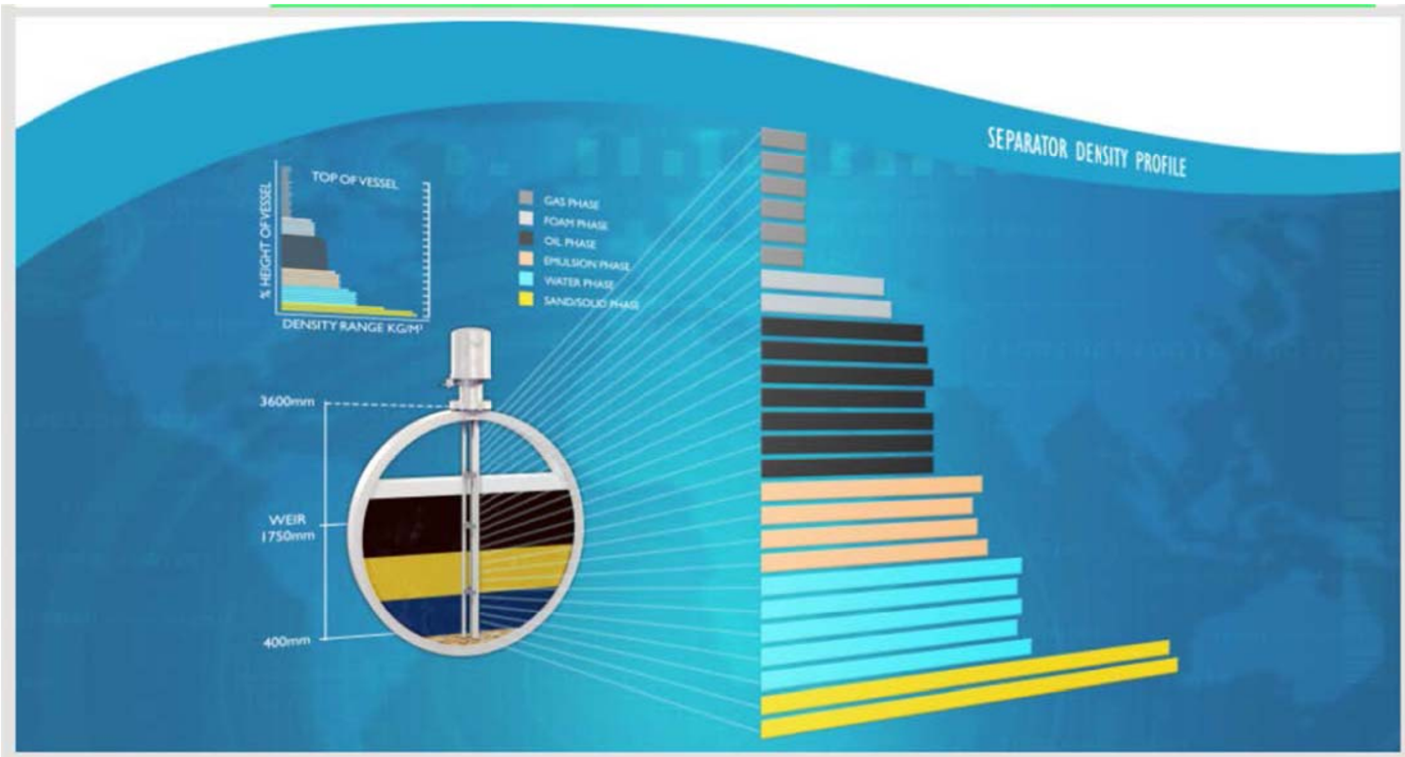
This information can be used to give outputs to control oil and water interface levels, and to control and monitor the effects of chemical additives.

Process material present between the source and detector will attenuate the radiation. The amount of attenuation measured by the Geiger Muller is then used to calculate the density of the intervening material.

Representative pulses from the GM tubes are counted in the signal processor unit(s) and made available for analysis to the PLC system. The PLC system collects information from each individual GM tube, and through a series of calculations determines the density of the material.

These calculations produce a density or interface profile within the vessel. Density bands are allocated for each of the phases. The top level of these phases can then be calculated with respect to instrument height. The measured interface levels can be used for control or shutdown purposes via hardwired outputs or communications via the PLC.

FIGURE 19. SIMULATED PROFILE



2.10 Oil/Oil Exchanger

MP separator oil flows through the oil/oil exchanger (HPL-623206 A/B), two 100% plate-and-frame heat exchangers (PHE) operating with one in service and one on standby.

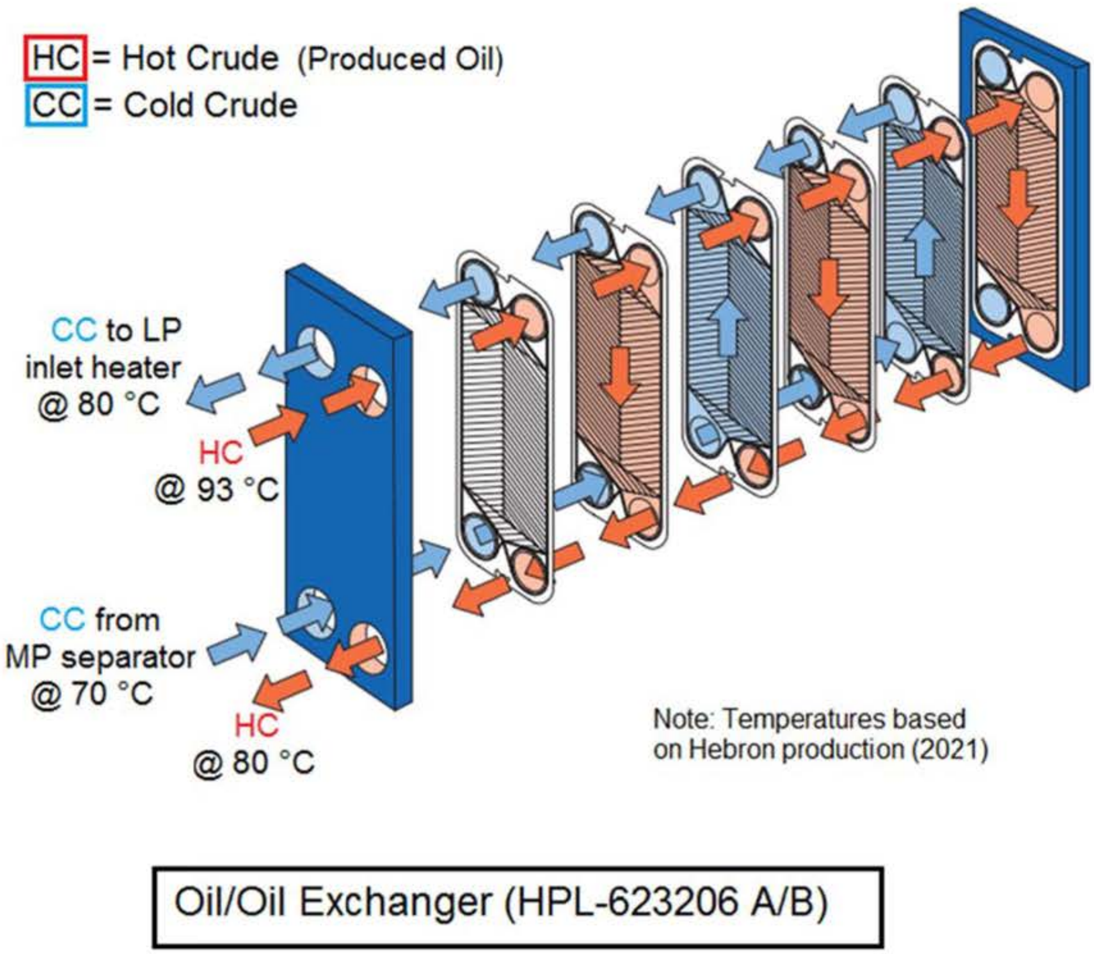
During initial production, produced oil from the downstream oil/water separator will enter the hot side of the exchanger at 93 °C and exit at 80 °C. The crude from the MP separator enters the cold side at 70 °C and exchanges heat with produced oil for storage to preheat the crude to 80 °C. After production ramps up, the crude will exit the exchanger at 75 °C.

Pressure differential indicators monitor the pressure differentials across the inlet strainers for each flow to an exchanger as well as the pressure differentials across each exchanger.

Table G. Oil/Oil Exchanger Operating Conditions (Year 2021)

Parameter	Hot Side Produced Oil		Cold Side Crude	
	Inlet	Outlet	Inlet	Outlet
Temperature	93 °C	80 °C	70 °C	80 °C
Flow: Liquid	925.3 m^3/h		1103.4 m^3/h	1102.7 m^3/h
Flow: Vapor	- - -		- - -	0.7 m^3/h
Flow: Total	925.3 m^3/h		1103.4 m^3/h	
Pressure: Inlet	660.0 kPag		900.0 kPag	

FIGURE 20. OIL/OIL EXCHANGER



2.11 LP Inlet Heaters

The LP inlet heaters (HBG-623207 / 217) are 2 x 50% shell and tube exchangers operating in parallel to heat the crude from the oil/oil exchanger to 91-95°C. Symmetrical piping ensures equal flow to both exchangers.

During initial production, dilute TEG heating medium enters the shell at 170 °C and exits at 92 °C while crude will enter the tube at 88 °C and exit at 92 °C. After production ramps up, the crude will exit the exchanger at 91-94 °C. At low oil production rates the heating medium temperature will be operated lower to minimize the differential temperature between the heating medium and the crude oil while maintaining desired heater outlet temperature to prevent scale formation on heater.

The hot crude mixes with compressor train condensate recycle which lowers the temperature to 88-93°C before entering the LP separator. Heating the crude facilitates oil-water separation by lowering the viscosity of the oil.

The temperature of the crude is controlled by a temperature controller (TC-623207 / 217-01) on the discharge from the associated LP inlet heater. Each temperature controller modulates a temperature control valve (TV-623207 / 217-01) on the heating medium discharge from the associated LP inlet heater. The flow of heating medium through each LP inlet heater is increased or decreased to keep the discharged crude within the specified temperature range.

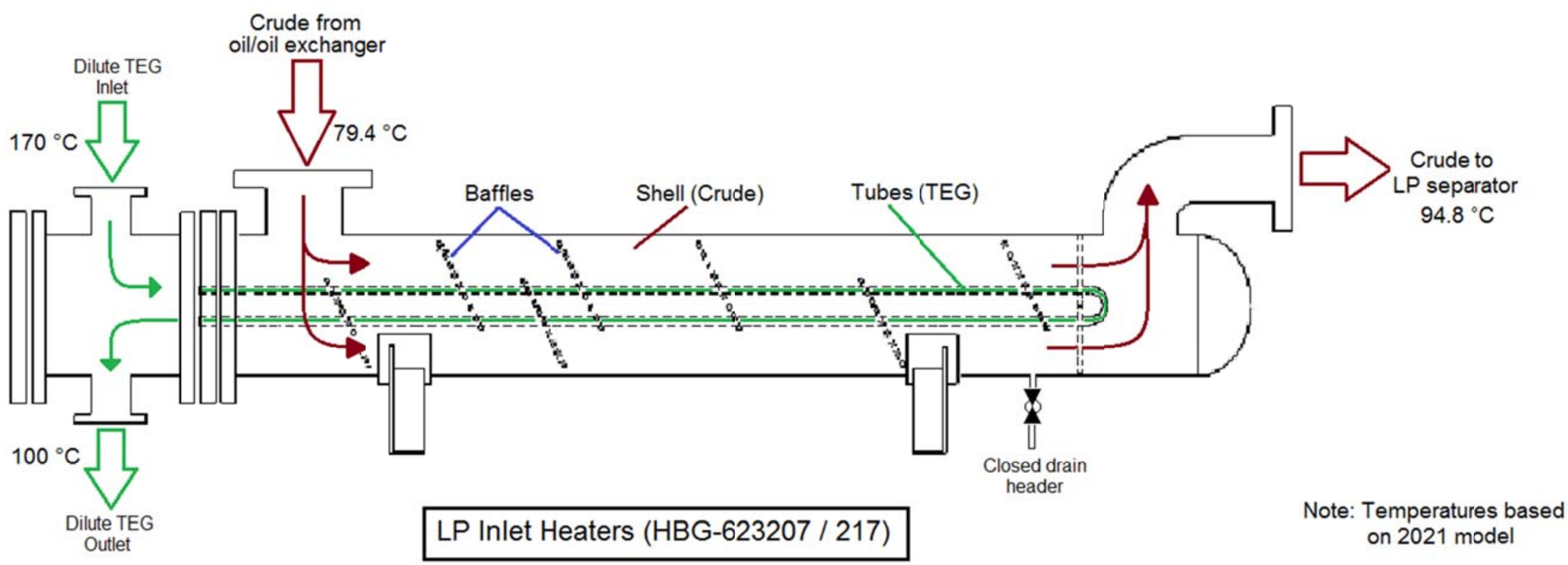
Note: The set point of the temperature controller (TC-623207 / 217-01) can be changed via a hand switch (HS-623203-06) at the inlet to the LP separator. The operator can change the set point when fluids from sources other than the LP inlet heater are directed to the LP separator.

Flow of crude through the LP inlet heater is maintained by an oil level controller (LC-623202-01) on the upstream MP separator. The level controller modulates a level control valve (LV-623202-01) on the crude outlet line from the LP inlet heater. As the oil level in the MP separator rises, the level valve opens to increase the flow rate of crude through the LP inlet heater. As the oil level in the MP separator drops, the level valve closes to slow the flow rate of crude through the LP inlet heater.

Table H. LP Inlet Heater Operating Conditions (Year 2021)

Parameter	**Tube Side Crude**		**Shell Side Dilute TEG**	
	Inlet	Outlet	Inlet	Outlet
Temperature	88 °C	94 °C	170 °C	92 °C
Flow: Liquid	1102.7 m^3/h	1101.7 m^3/h	166.4 m^3/h	
Flow: Vapor	0.7 m^3/h	1.6 m^3/h	- - -	
Flow: Total	1103.3 m^3/h		166.4 m^3/h	
Pressure	1200.0 kPag		650.0 kPag	

FIGURE 21. LP INLET HEATER FLOW



2.12 LP Separator

The LP separator (MBD-623203) is a three-phase separator operating at 59 kPag.

The primary flow to the LP separator is warm crude from the LP inlet heater (HPG-623207 / 217).

Additional liquid is supplied by:

- Condensate from the LP compressor suction scrubbers via the liquid recycle pumps (PBA-657207 A/B)
- Liquids from the flare KO drum
- Crude from test separators A/B (MBD-622201 / 221)
- Condensate from the MP compressor suction scrubbers
- Produced water recycled from the LP separator via the LP separator produced water pumps (PBA-623210 A/B).

The internals consist of inlet cyclones to facilitate vapor/liquid separation and reduce foaming before the liquid passes through two sequential inlet calming baffles to two plate packs that function as a liquid / liquid coalescer. Refer to Plate Packs: Principle of Operation (below).

The vessel includes a vane pack mist eliminator at the gas outlet. Oil droplets separated from the gas by the mist eliminator drain into the bottom of the vessel through a 2000 mm long drain pipe that extends 100 mm below the low-low liquid level (LLLL).

The oil and water outlets are equipped with grating-type vortex breakers.

Table I. LP Separator: Operating Conditions (Year 2021)

Operating Parameter	Operating Value
Temperature	92.5 °C
Pressure	59 kPag
Flow: Vapor	6 m^3/h
Flow: Oil	924 m^3/h
Flow: Water	180 m^3/h

The temperature of the crude flowing to the LP separator is controlled by a temperature controller (TC-623207 / 217-01) on the crude outlet from the LP inlet heater. The temperature controller modulates a temperature control valve (TV-623207 / 217-01) that adjusts the flow of heating medium through the LP inlet heater.

The set point of the temperature controller (TC-623207 / 217-01) can be changed via a hand switch (HS-623203-06) at the inlet to the LP separator. The operator can change the set point when fluids from sources other than the LP inlet heater are directed to the LP separator in order to meet the true vapor pressure (TVP) specification for the crude. To minimize scaling problems, the temperature must be kept as low as possible while still meeting the TVP specification.

Flow of the crude (oil/water emulsion) from the LP inlet heater into the LP separator is controlled by a level control valve (LV-623202-01) on signal from a level controller (LC-623202-01) on the MP separator.

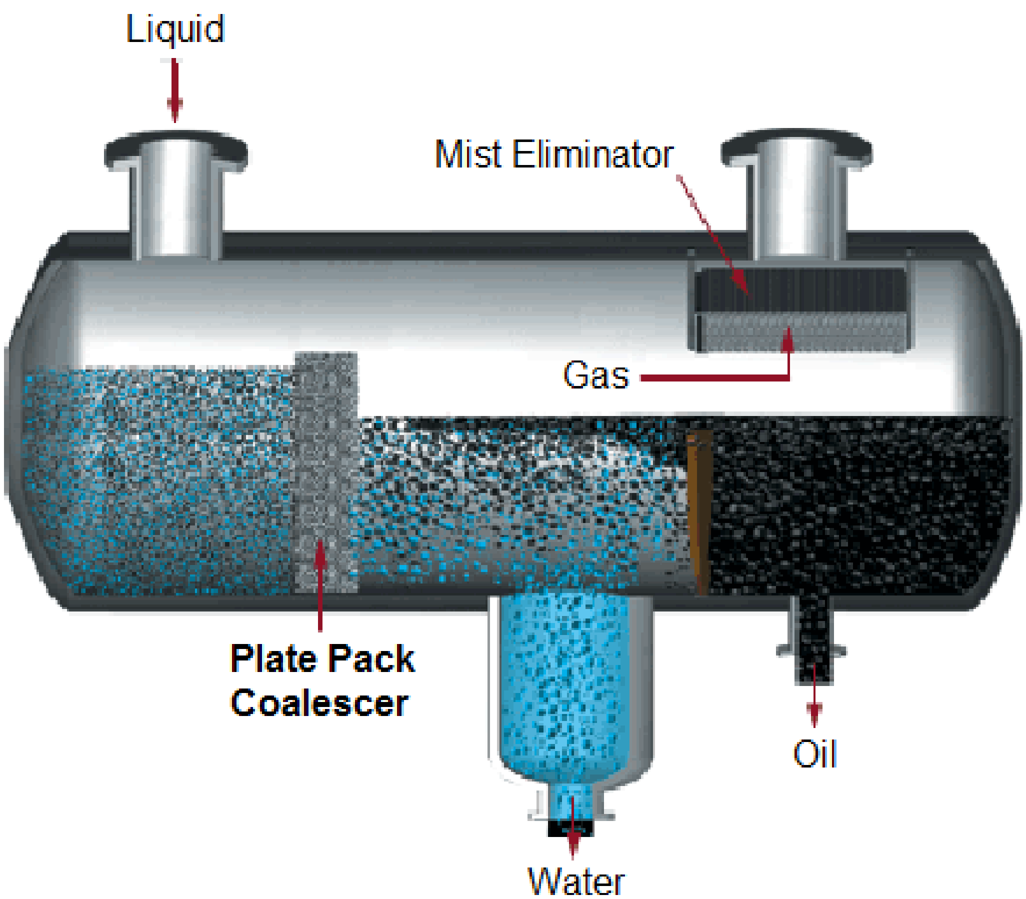
The level valve (LV-623202-01) and the inlet to the LP separator are located above the LP separator.

2.12.1 Oil

The oil/water emulsion enters the top of the LP separator by gravity flow in order to reduce turbulence that causes re-entrainment of gas and to eliminate the shearing effect of a pump which would create the smaller oil droplets that make the separation process less efficient. Inlet cyclones facilitate vapor/liquid separation and reduce foaming before the liquid passes through two sequential inlet calming baffles. The fluid spreads across the surface of the first baffle through which the flow is distributed equally into the separation zone.

A second, shorter baffle is placed in front of the plate packs to create the essential laminar flow across the stack of plates. Oil droplets coalesce on the plates and rise to the top layer while solids drop to the bottom of the vessel. Refer to Plate Packs: Principle of Operation (below).

FIGURE 22. PLATE PACK COALESCER EFFECT



The minimum residence time for the emulsion is five minutes.

Separated oil flows over the oil weir and is discharged through the vortex breaker to the compact electrostatic coalescer.

The oil level in the oil box, downstream of the overflow weir, is maintained by an oil level controller (LC-623203-01) which modulates a level control valve (LV-623203-01) controlling the flow of produced oil downstream of the crude oil cooler.

The process is protected by PSD in the event of either a safety low oil level or safety high oil level by a level indicator (LI-623203-02).

2.12.2 Interface

The level of the oil/water interface is maintained by a level controller (LC-623203-03) which adjusts a level control valve (LV-623203-03) on the discharge from LP produced water pumps (PBA623210A/B) downstream of the LP separator. The level controller can be operator-selected for either gap (on/off) control or continuous level control. Gap control will be selected during periods of low produced water rates and during the post start-up period until the flow of produced water rises to the hydrocyclone minimum flow rate. Continuous level control will be selected when produced water flow is consistently above this minimum flow rate.

The process is protected against an oil/water interface safety low level by a level indicator (LI-623203-04).

The interface “rag layer” is manually drained through one of three skimming nozzles (MV-623203-19/20/21) located at different elevations. Skimmed oil from the LP separator is combined with the skimmed oil from the oil/water separator then pumped by the skim oil pump (PBA-623212) to the crude outlet manifold to be exported via the crude export pumps. Skimmed oil also can be directed to the closed drain.

> Note: The skim oil pump will run intermittently as needed by operations to excavate skim oil. The maximum number of starts is not to exceed one start per day.

2.12.3 Water

Produced water is discharged through a vortex breaker to the LP separator produced water pump (PBA-623210 A/B) which recycles the MP inlet heater. The LP produced water warms the liquid flowing into the MP inlet heaters.

The process is protected against safety high pressure or safety low pressure on the produced water pump discharge. A pressure indicator (PI-623210 A/B-02) stops the pump in the event of a PSL or PSH.

2.12.4 Gas

Gas flows to the 1st stage LP compressor.

A split-range pressure controller (PC-623203-01) maintains the LP separator pressure at 59 kPag. The pressure controller sends a signal to the 1st stage LP compressor controller which modulates the compressor recycle valves (PV-657202-02 A/B) for each compressor train. If high pressure occurs at the LP separator, the pressure controller opens a pressure control valve (PV-623203-01) to send gas to the LP flare.

The gas flow is measured by a conditioning orifice (FE-623203-02) with the flow indicator (FI-623203-02) signaling the split-range pressure controller (PC-623203-01).

The process is protected from safety high or safety low pressure by a pressure indicator (PI-623203-02).

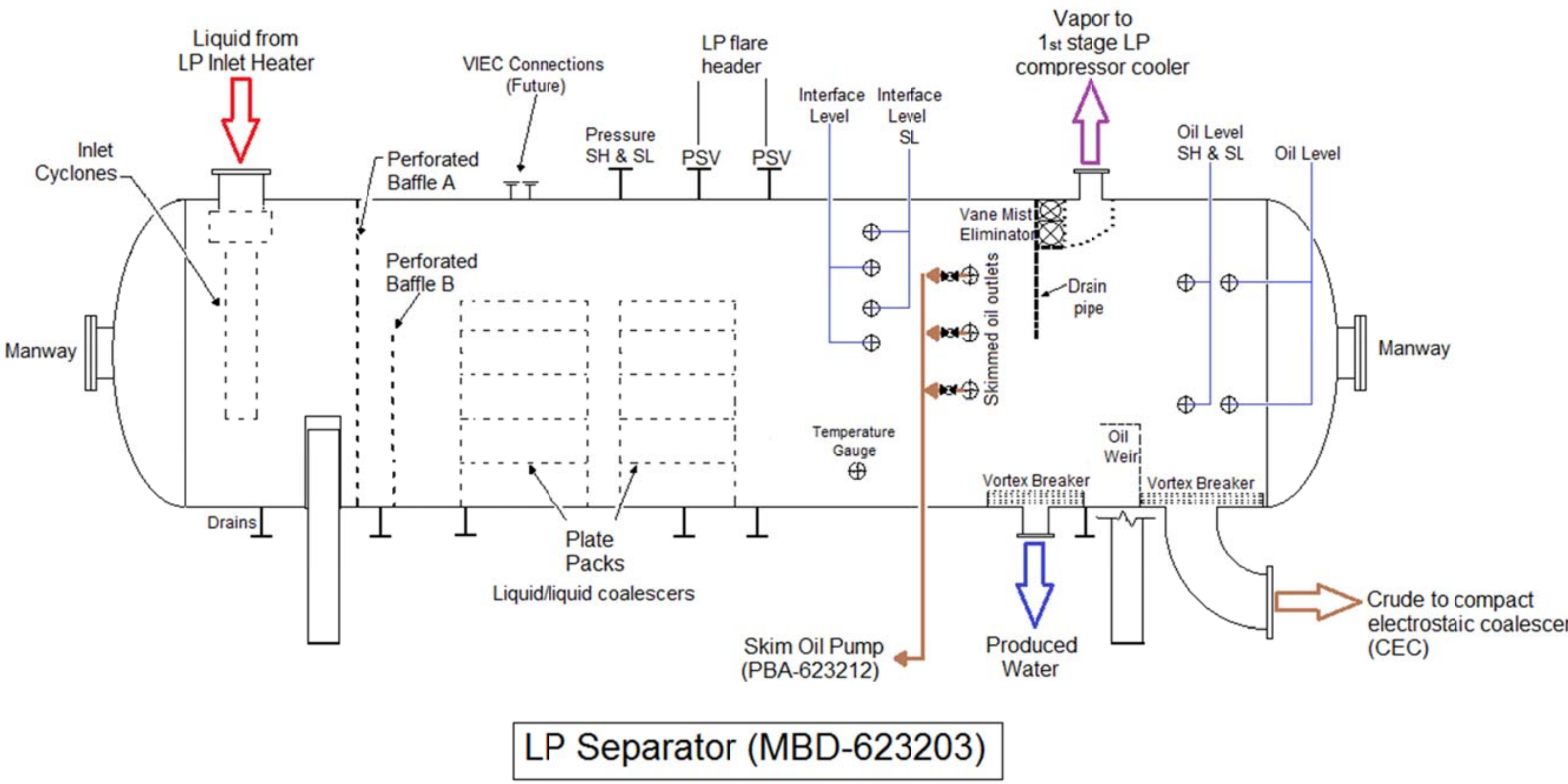
A blowdown valve (BDV-623203-04) and orifice are provided for depressurizing the LP separator to the LP flare. The blowdown valve is actuated from the control room or locally at the valve.

2.12.5 Chemical Injection

A connection with injection quill is provided for:

- Biocide injection at the LP separator inlet piping to mitigate the generation of H_2S at the oil water interface in the crude storage cells.
    - Temporary hose and tote tank are used
- Defoamer injection at the inlet piping, if required
- Demulsifier injection in the crude outlet piping, if required

FIGURE 23. LP SEPARATOR (ELEVATION VIEW)



2.12.6 Plate Packs: Principle of Operation

Electrostatic coalescence separates water from the oil/water emulsion whereas plate pack coalescence separates oil from the oil/water emulsion.

Gravitational settling becomes increasingly difficult as the droplet size of the dispersed phase decreases. The settling process can be enhanced considerably by passing the dispersion through a coalescer plate pack. The plate pack is a liquid / liquid coalescer which removes oil from the oil/water emulsion in the LP separator.

Stoke’s Law calculates the rate of oil droplet rise in the same way that it is used to calculate water settling as was described in Electrostatic Coalescer: Principle of Operation. The basic premise of efficient plate pack coalescence depends upon laminar flow and adherence to Stoke's Law. Laminar flow in this context means flowing gently, smoothly, and without turbulence.

The inlet calming baffles convert the turbulent inlet flow to the calmer, homogenous, laminar flow required for plate pack coalescence.

A plate pack is a stack of parallel plates tilted upward at a 45° angle. The spacing between the plates of 50 mm was calculated based on the characteristics of the emulsion.

FIGURE 24. PLATE PACKS IN THE HEBRON LP SEPARATOR

The plates are constructed of oleophilic material that attracts oil but not water or solids. Oil droplets rise up and meet the undersides of the plates where they are attracted to the oleophilic material. As the droplets move up the slope of the plate, small droplets merge (coalesce) into larger droplets. Rising oil droplets are captured by the next higher plate. The larger oil droplets, due to greater buoyancy than small droplets, migrate to the top of the plate pack and into a concentrated oil phase where it overflows the oil weir into the oil box.

FIGURE 25. RISE OF COALESCED OIL DROPLETS ON PLATES

2.13 Compact Electrostatic Coalescer

Oil flows from the LP separator at 88-93 °C to the compact electrostatic coalescer (CEC) (MAD-624201) which operates at 59 kPag, the same operating pressure as the LP separator.

The CEC is a vertical vessel that operates liquid full.

Crude flows vertically downwards through the CEC. Droplet coalescence is achieved by applying AC electric fields (50–60 Hz) to the water-in-oil emulsions under turbulent-flow conditions. The electrostatic field polarizes the water droplets and weakens the emulsion film. The turbulence increases the collision frequency between the water drops. The polarized water droplets coalesce into larger droplets which enhances oil water separation. The emulsion layer is reduced as the water droplets coalesce resulting in larger droplets entering the downstream gravity oil/water separator.

The electrodes are insulated to prevent short circuiting in case of high water content such as caused by a water slug.

The operator can adjust the voltage from the control room or at the local panel.

The process is protected against a safety low oil level in the CEC. A differential pressure level indicator (LI-624201-02) de-energizes the CEC transformer at the safety low level.

A bypass line around the CEC can deliver crude directly from the LP separator to the oil/water separator.

A vent valve is provided at the top of the CEC for manually venting of accumulated gas to the closed drain system.

Table J. CEC: Operating Conditions (Year 2021)

Operating Parameter	Operating Value
Temperature	92.5 °C
Pressure	59 kPag
Flow: Vapor	- - -
Flow: Oil	924 m^3/h
Flow: Water	110 m^3/h

FIGURE 26. FLOW THROUGH THE CEC

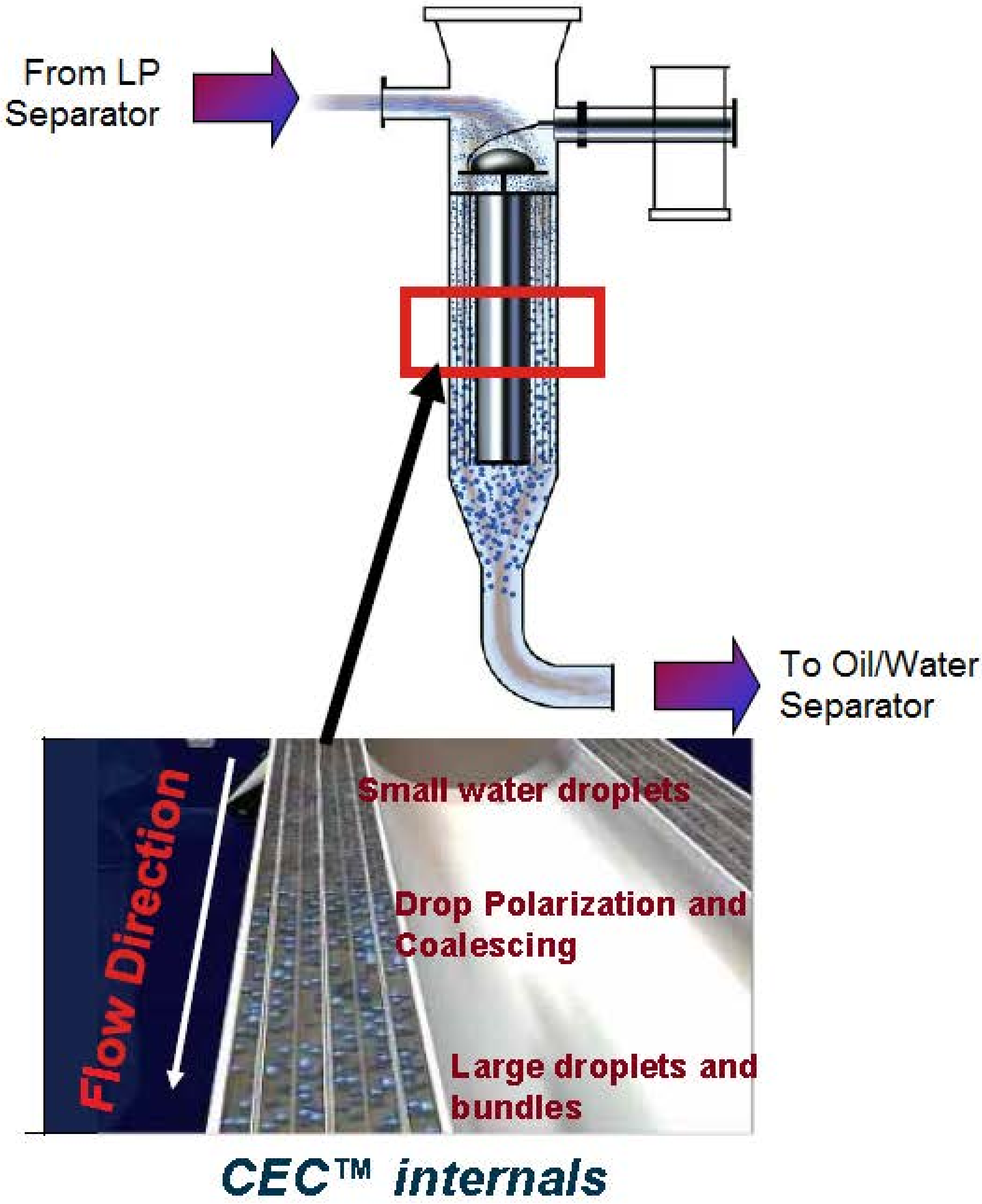
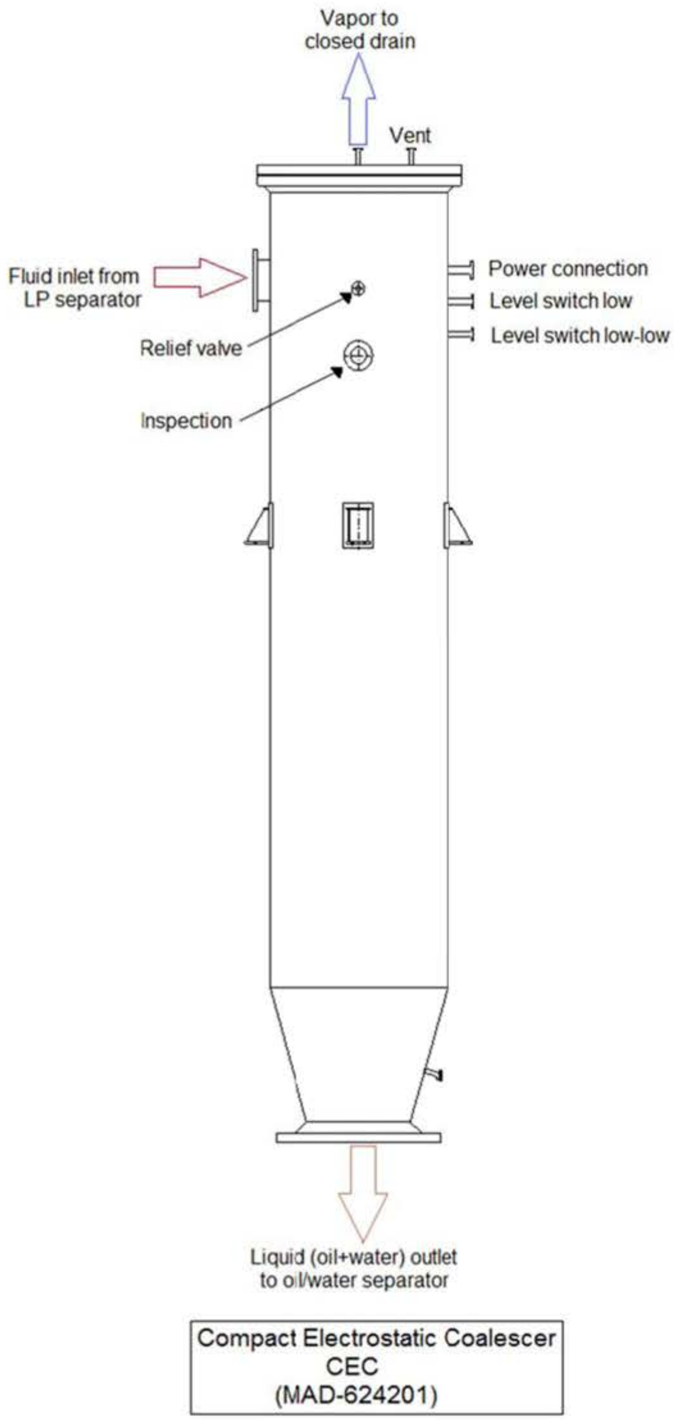


FIGURE 27. COMPACT ELECTROSTATIC COALESCER



WorleyParsons
resources & energy

2.14 Oil/Water Separator

The oil/water (O/W) separator (MBD-623204) is a two-phase horizontal coalescer-type separator that is the final step in separating oil from water. The oil/water emulsion was treated in the compact electrostatic coalescer (CEC) to enlarge water droplets which enhances the separation process in the O/W separator.

The oil/water separator operates liquid full.

Note: A bypass line around the CEC can deliver crude directly from the LP separator to the oil/water separator.

The O/W separator operates at a pressure higher than the LP separator operating pressure by the static head difference between the two vessels. There is a locked open pressure equalizing line from the top of the oil/water separator to the LP separator vapor outlet piping. Vapor has been efficiently removed from the production fluids by upstream separators so minimal vapor is released from the O/W separator.

Oil and water exit the CEC and enter the O/W separator where the liquid passes through four energized grids sandwiched between five diffusion baffles. The baffles create a non-turbulent flow of uniform velocity over the cross-sectional area and prevent thermal channeling.

The electrostatic coalescer is energized by a 50 kVA transformer. The electrostatic field created across each electrostatic grid accelerates the dehydration process by imparting electrical charges to water droplets that are present in the crude oil stream.

The first grid is energized with low voltage due to the higher water content in the oil and the second grid has a higher applied voltage due to very low water content remaining in the oil. Oil flows horizontally through the increasing voltage AC electric fields. Oil, which is non-conductive, is unaffected by the AC field. The emulsified water droplets suspended in the oil are highly conductive and move from the charge (grid) to the ground (baffle). This continual movement causes the droplets to collide and coalesce until a droplet is large enough that gravity pulls the droplet into the water phase of the O/W separator. Refer to Electrostatic Coalescence: Principle or Operation (above).

The oil water separation achieved in the oil/water separator is 0.5 BS&W or lower.

The produced water pump (PBA-632210 A/B) recycles water to the MP production header where the produced water preheats crude entering the MP inlet heater.

Table K. Oil/water Separator: Operating Conditions (Year 2021)

Operating Parameter	Operating Value
Temperature	92.5 °C
Pressure	59 kPag
Flow: Vapor	- - -
Flow: Oil	924 m^3/h
Flow: Water	110 m^3/h
Hydrocarbon liquids in water	≤ 1,000 ppm
Water in hydrocarbons	≤ 0.5% BS&W

Ten nozzles with valves are piped to a trough allowing the operator to locate the interfacial emulsion (rag) layer level by visually inspecting the discharge to the trough. The skim oil pump (PBA-623212) removes the rag layer in the oil water separator by pumping from one of three oil skimming nozzles installed at different elevations. The nozzles are connected to an internal perforated pipe. The oil/water emulsion is pumped by the skim oil pump to the crude outlet manifold to be exported via the crude export pumps. Skimmed oil can also be directed to the closed drain.

The process is protected by PSD shutdowns:

- Safety high pressure
- Safety high temperature
- Safety low oil level
- Safety high and low oil/water interface levels

Refer to Lesson 4: Controlling the System for details.

Table L. Produced Oil Specifications

Parameter	Specification
True vapor pressure	< 75.8 kPaa @ 45 °C
Water in oil	0.5% BS&W max.
Storage temperature	45 °C

FIGURE 28. OIL/WATER SEPARATOR (ELEVATION VIEW)

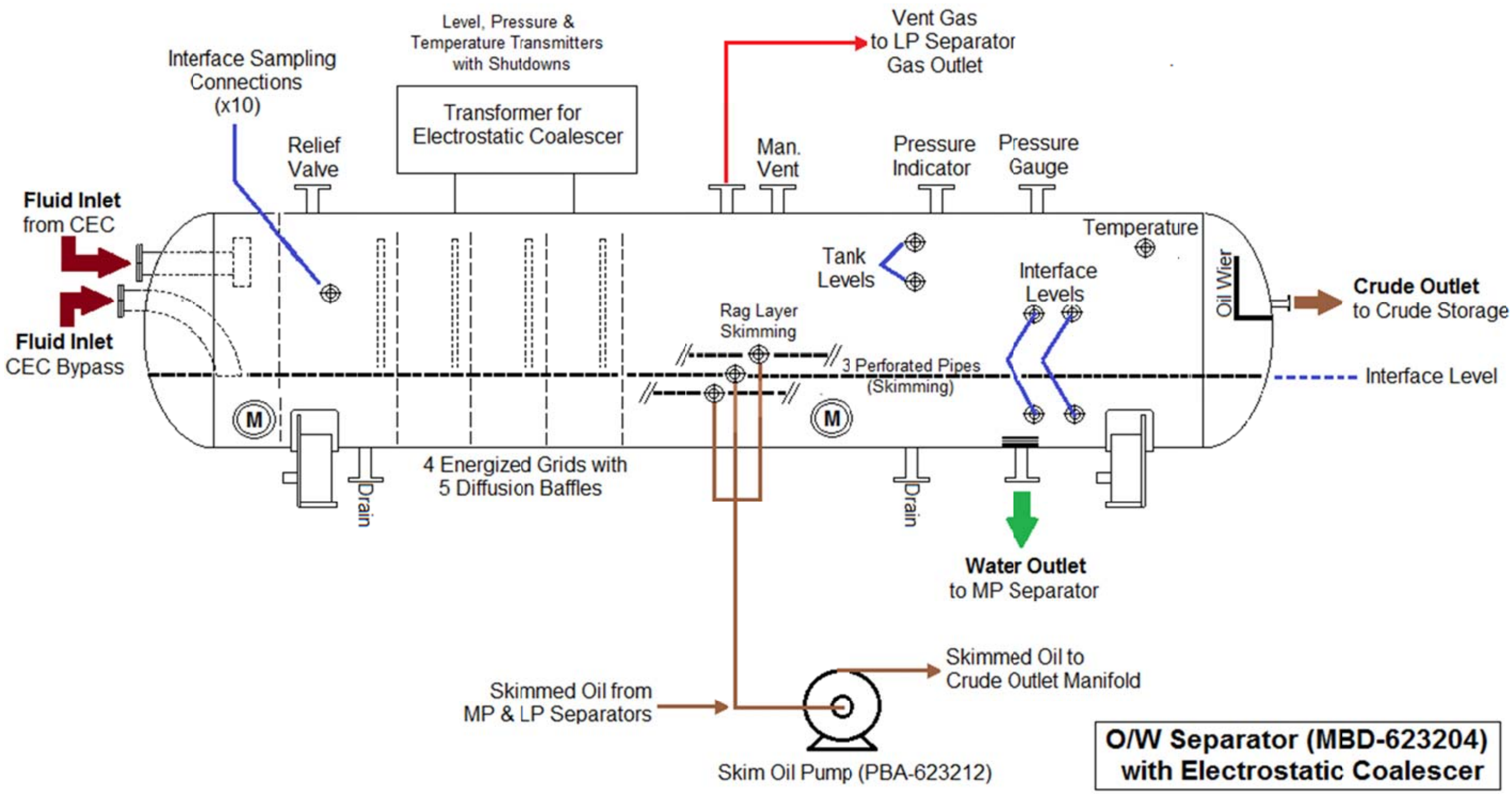
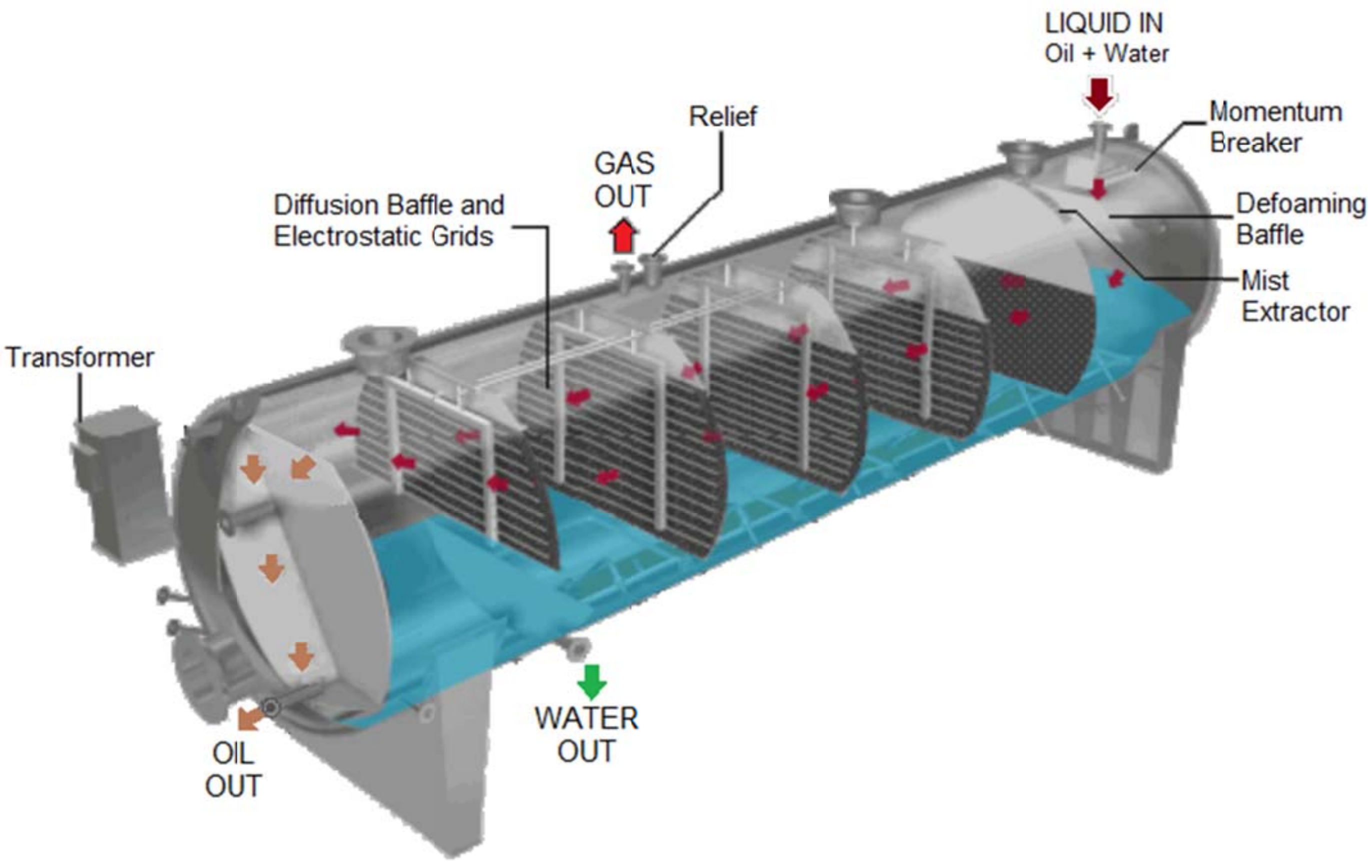


FIGURE 29. ELECTROSTATIC GRIDS IN AN O/W SEPARATOR



Typical Configuration of Electrostatic Grids and Baffles

2.15 Crude Oil Pumps

The 2 x 100% crude oil pumps (PBA-623208 A/B) transfer produced oil from the top of the oil/water separator through the oil/oil exchanger where the produced oil transfers heat to the crude before the crude enters the LP inlet heater. The produced oil then is routed through the crude oil cooler where the temperature of the produced oil is further reduced before entering the crude inlet manifold for storage in the GBS cells.

Pour point depressant (PPD) will be injected upstream of the crude oil pumps during the first well production. Subsequently, PPD will be injected on an “as needed” basis.

2.16 Crude Oil Cooler

In the final stage of the separation and stabilization process, the 1 x 100% crude oil cooler (HPL-623209) uses dilute TEG cooling medium to cool the crude for storage. Cooling medium is a solution of 48% wt TEG + 52% wt water.

Produced crude enters the exchanger at 80 °C and exits to the crude storage cell at 45 °C. The cooling medium enters the exchanger at 16 °C, flows countercurrent to the oil, then exits the cooler at 55 °C. These temperatures are based on the 2021 model; the temperature of the produced crude at the inlet is expected to drop to ~75 °C starting in 2022.

Temperature is controlled by a temperature controller (TC-623209-02) that controls a temperature control valve (TV-623209-02) on the cooling medium return line. The temperature controller receives a signal from a temperature valve (TV-623209-02) on the crude oil cooler discharge to produced oil storage. The temperature controller adjusts the flow of cooling medium through the crude oil cooler to maintain the temperature of the produced oil to storage within the desired temperature range.

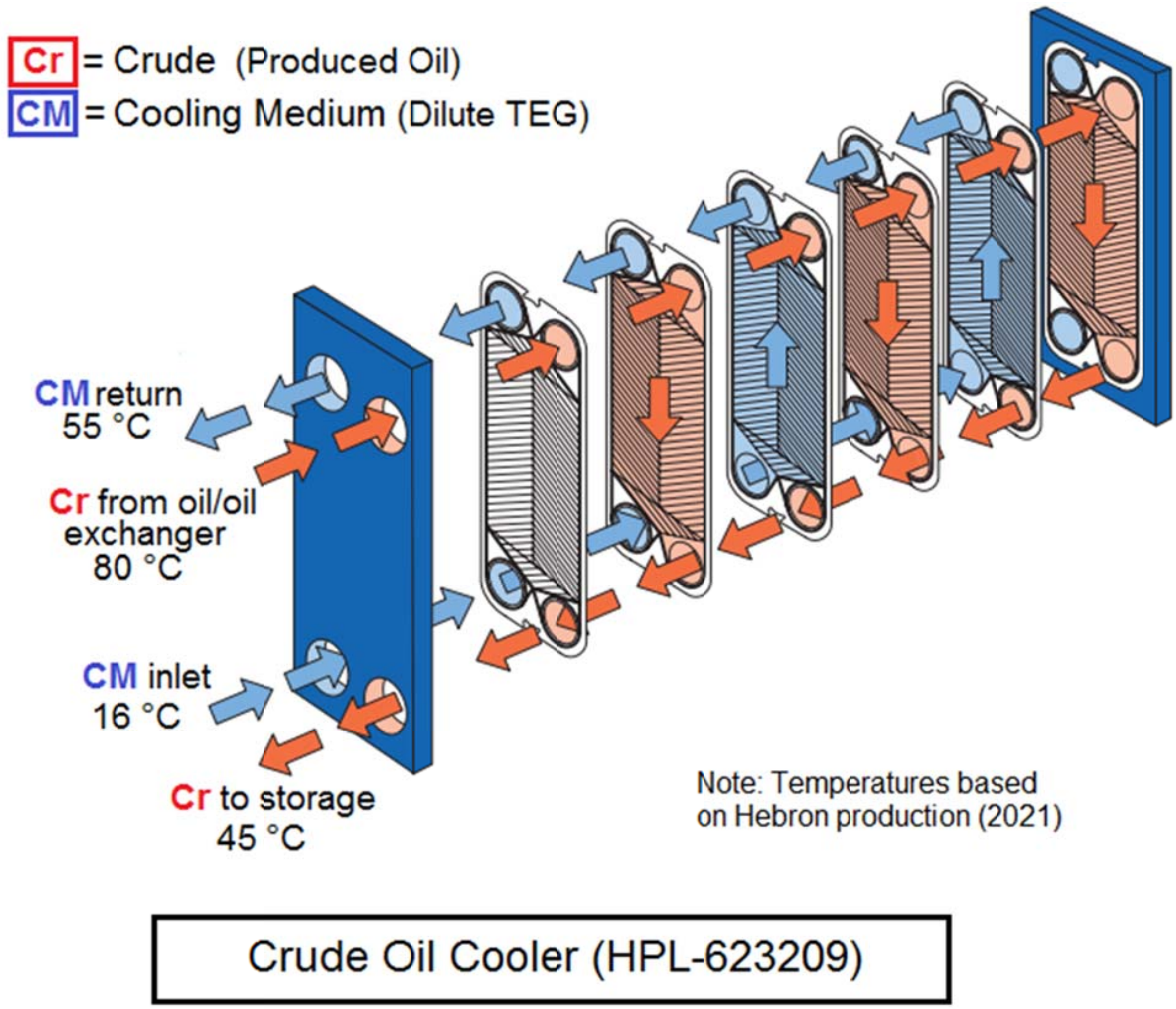
A safety high temperature (TSH-623209-03) at the produced oil outlet starts an eight-hour countdown timer that triggers a PSD if the produced oil temperature remains high when the timer expires. The countdown timer is displayed on the HMI. The SIS generates an alarm one hour before the timer expires.

Because the crude oil cooler operates at the wax appearance temperature (WAT), wax builds up along the tube walls. High differential pressure across the crude oil cooler indicates wax build up on the plates. To dissolve the wax, the operator temporarily raises the set point of the crude outlet temperature controller (TC-623209-02) to 65°C, the wax dissolution temperature. When the differential pressure drops back to normal, the temperature controller is set back to the normal operating set point. Limitations in the gravity based structure (GBS) crude storage cells prohibit this operation for more than eight hours at 60 °C.

Table M. Crude Oil Cooler Data Sheet (Year 2021)

Parameter	Hot Side Crude		Cold Side Dilute TEG	
	Inlet	Outlet	Inlet	Outlet
Temperature	80 °C	45 °C	16 °C	55 °C
Flow	925.3 m^3/h		513.3 m^3/h	
Pressure	370.0 kPag		680.0 kPag	

FIGURE 30. CRUDE OIL COOLER



FEEDBACK EXERCISES

Directions: Complete the following exercises. Use this module and specified drawings and supplementary material as references. Circle the correct answer.

1.) All production wells are tested _______ for production reporting and reservoir management. (Circle all that apply.)

A. Daily

B. Weekly

C. Monthly

D. Quarterly

2.) The initial stage of the separation process takes place when the __________ disengages gas from the liquid. (Circle all that apply.)

A. perforated calming baffle

B. inlet cyclone

C. vortex breaker

D. compact electrostatic coalescer

3.) Nitrogen maintains pressure on the test separator crude sample in the sample receiver to ___________. (Circle all that apply.)

A. verify the sample accurately represents the crude under operating conditions

B. prevent introduction environmental contaminants

C. prevent separation of the constituent parts of the crude

D. reduce the risk of explosion from leaking hydrocarbons

4.) Vapor flashes and separates from the liquid at 2900 kPag and 52 °C. Vapor flows to the ______. (Circle all that apply.)

A. HP compressor suction cooler

B. LP flare header

C. LG suction cooler

D. atmospheric vent

5.) The vessel internal electrostatic coalescer - low water (VIEC-LW) is installed in the ___________. (Circle all that apply.)

A. HP separator

B. MP separator

C. LP separator

D. Oil/water separator

6.) The water level in the MP separator is maintained by the oil-water interface level controller (LC-623202-03) which adjusts the level control valve (LV-623202-03) located downstream of the _________. (Circle all that apply.)

A. oil/water separator

B. produced water cyclones

C. LP separator

D. produced water pump

7.) The CEC operates _________. (Circle all that apply.)

A. on level control

B. at 50% level

C. liquid full

D. at low pressure

8.) Skimmed oil from the LP separator is combined with the skimmed oil from the oil/water separator, eventually to be _____________. (Circle all that apply.)

A. recycled through the oil/oil exchanger as the heating medium

B. pumped back to the inlet of the LP separator

C. recycled to the MP production header

D. exported via the crude export pumps

9.) ____________ separates oil from the oil/water emulsion. (Circle all that apply.)

A. electrostatic coalescence

B. plate pack coalescence

C. laminar flow

D. turbulence

10.) Droplet coalescence in the CEC is achieved by ___________ the water-in-oil emulsions under turbulent-flow conditions. (Circle all that apply.)

A. applying DC electric fields to

B. applying AC electric fields to

C. injecting an oleophilic chemical to

D. increasing the temperature of

11.) Crude oil pumps transfer produced oil from the top of the oil/water separator through the _________________ where the produced oil transfers heat to the crude. (Circle all that apply.)

A. MP inlet heater

B. LP inlet heater

C. oil/oil exchanger

D. crude storage

Lesson 3: About the Equipment

LESSON INTRODUCTION

This lesson describes the physical attributes and functioning of each primary piece of equipment

At the completion of this lesson, you will be able to:

- Identify specified equipment and major components on a system PFD / P&ID.
- Describe the design features of specified equipment and components.
- Explain how specified equipment and components affect the process.

3. Separation and Stabilization System Equipment and Components

The major equipment, components, auxiliary equipment, and support systems for the separation and stabilization system are described in this section.

The separation and stabilization system (623) includes the following major components:

- Test separators A/B (MBD-6225201 / 221)
- HP separator (MBD-623201)
- MP inlet heaters (HBG-623205 /215)
- MP separator (MBD-623202)
- Oil/oil exchanger (HPL-623206 A/B)
- LP inlet heaters (HBG-623207 / 217)
- LP separator (MBD-623203)
- Compact electrostatic coalescer (MAD-624201) and oil/water separator (MBD-623204)
- Crude oil pumps (PBA-623208 A/B)
- Crude oil cooler (HPL-623209)

Note: Refer to the vessel drawings in Lesson 2.

Note: The functions and / or actions of each alarm and shutdown identified in this lesson are described in Lesson 4: Controlling the System.

3.1 Test Separators A/B

The two-phase test separators (MBD-622201 / 221) separate vapor (gas) from the total liquid (oil and water), so the amount of oil, water, and gas produced by an individual well can be measured.

Inlet cyclones facilitate separation by reducing the occurrence of foaming. The separator inlet contains a full diameter calming baffle with 30 mm perforations to reduce turbulence.

The vapor passes through a full-width vane pack mist eliminator at the gas outlet. A drain pipe extends from the mist eliminator to the low-low liquid level (LLLL) to prevent re-entrainment of the liquid in the gas.

A grating-type vortex breaker at the liquid outlet prevents the formation of a vortex when the liquid is drained from the test separator. A vortex can entrain vapor in the liquid stream, leading to poor separation and, possibly, causing cavitation of the auto sampler pump.

A sand weir and nozzles for sand jetting (future) are provided to facilitate removal of sand and sludge. Only the nozzles are installed; sand jetting internals are not installed.

Table N. Test Separator Data Sheet

Equipment Description	
Length	6,500 mm
Internal Diameter	2,000 mm
Normal Operating Parameters	
Pressure (Min/Norm/Max)	1312 / - - - / 2899 kPag
Temperature (Min/Norm/Max)	44 / - - - / 76 °C

3.1.1 Auto Sampling System

Crude oil is sampled to establish the composition, quality, density, and water content. An automatic mixing and sampling automatically measures, collects, and preserves liquid samples for lab analysis.

The mixing and sampling system consists of two skids for each test separator:

- Auto sampler pump (V-622204 / 224)
- Auto sampler enclosure (V-622202 / 222)

AUTO SAMPLER PUMP SKID

The take-off quill installed in the outlet line from the test separator routes crude samples to the auto sampler pump (PBE-622204 / 224). The vertical, centrifugal pump pressurizes the crude sample to 3256.0 kPag for delivery to the auto sampler enclosure.

Table O. Auto Sampler Pump Data Sheet

Equipment Description	
Type	Vertical, centrifugal
Driver; Electric	11.2 kW
Rated Capacity	15.9 m^3/h @ 33 m
Redundancy (per test separator)	1 x 100%
Normal Operating Parameters	
Discharge Pressure	3256.0 kPag

AUTO SAMPLER ENCLOSURE SKID

Each auto sampler enclosure houses the equipment that “captures” and preserves the crude samples.

- Flow transmitter (FE-622204 / 224-01)
- 1 x Jiskoot 210C sample grab cell (PPA-622202 / 222)
- 2 x 4000 mL sample receivers (containers) (MAV-622202 / 222 A/B)
- Level transmitters (LIT-622202 / 222 A/B); one for each sample receiver
- Nitrogen supply

Nitrogen bottles supply nitrogen at a minimum pressure of 4,500 kPag. Nitrogen pressure in the sample receivers maintains the integrity of the crude sample.

Each enclosure is insulated and is equipped with two electric heaters (EH-622205 / 225 A/B) turned on and off by a hand switch (HS-622202 / 222).

FIGURE 31. CELL SAMPLER

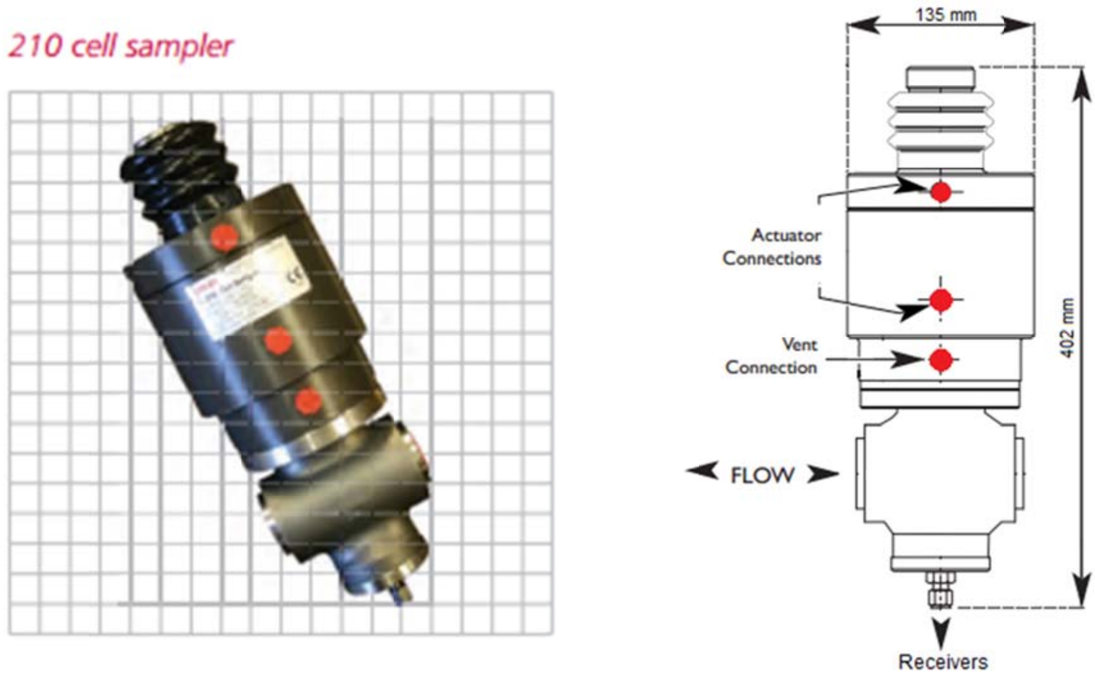
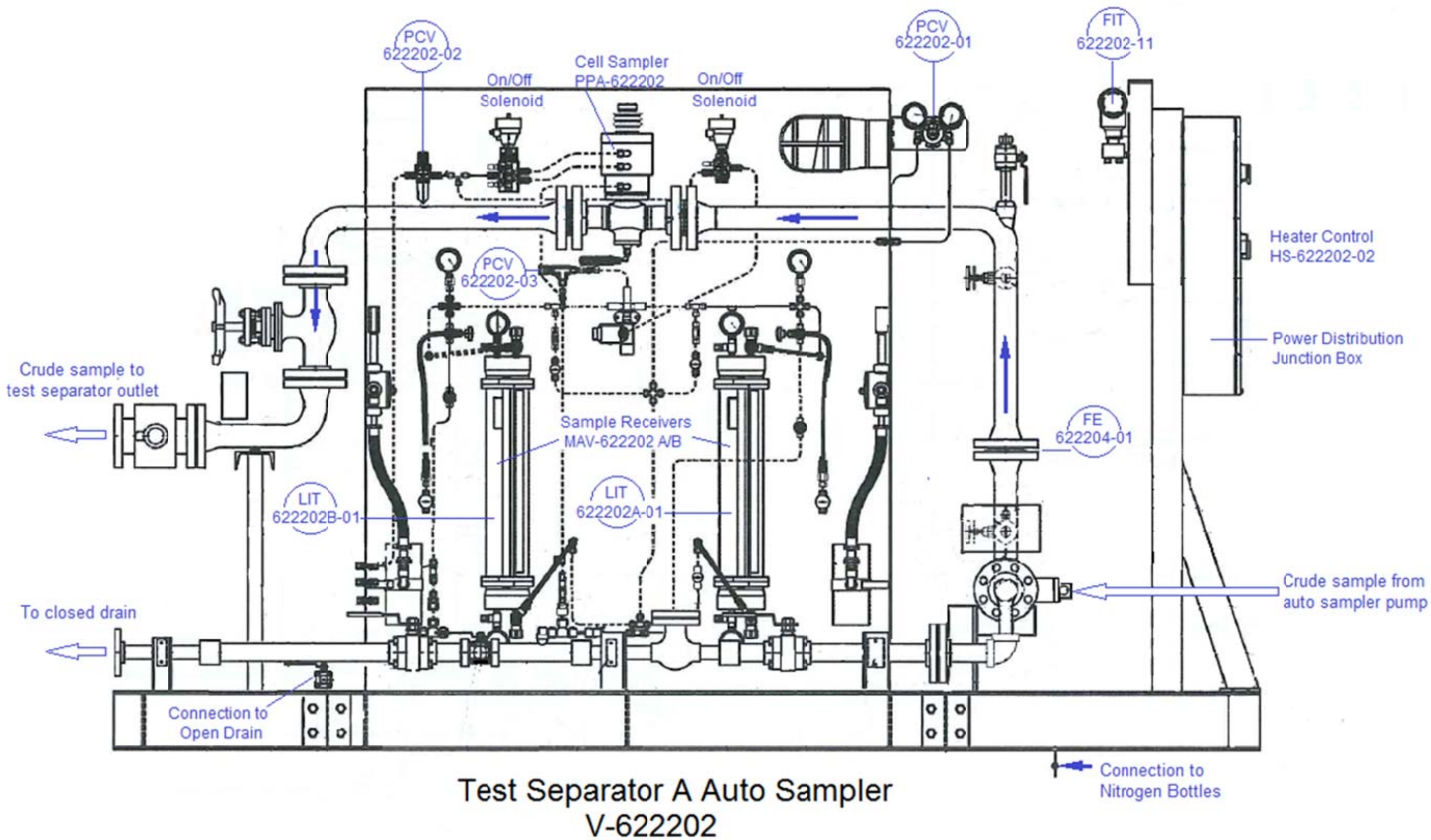


FIGURE 32. AUTO SAMPLER ENCLOSURE



WorleyParsons
resources & energy

3.2 HP Separator

The HP separator (MBD-623201) is a two-phase separator operating at 2899 kPag. The production stream from HP wells is separated into vapor (gas) and liquid (oil and water) phases.

Internal components that enhance the two-phase separation:

- Inlet cyclones
- Full diameter calming baffle
- Full-width vane pack mist eliminator at gas outlet with a drain pipe for liquids
- Sand weir
- Grating-type vortex breaker at the liquid outlet

Connections for the injection of demulsifier, defoamer, and scale inhibitor are located upstream of the HP separator.

Table P. HP Separator Data Sheet

Equipment Description	
Length	7,600 mm T/T
Internal Diameter	2,300 mm
Normal Operating Parameters	
Pressure (Norm)	2899 kPag
Temperature (Norm)	52 - 76 °C

3.3 MP Inlet Heaters

The MP inlet heaters (HBG-623205 / 215) are 2 x 50% shell and tube exchangers, utilizing a dilute TEG (glycol + water) heating medium.

The tube side is designed for wet H_2S service.

Table Q. MP Inlet Heater Data Sheet

Equipment Description	
Length	6,600 mm T/T
Diameter	1,520 mm
Number of Tubes	1891
Tube O.D.	25.40 mm
Tube Length	6.6 m

3.4 MP Separator

The MP separator (MBD-623202) is a three-phase separator operating at 900.0 kPag. Production fluids and produced water are separated into vapor (gas), water, and crude phases.

Internal components that enhance the three-phase separation:

- Inlet cyclones
- Two full diameter calming baffles
- Vessel internal electrostatic coalescer - low water (VIEC-LW)
- Full-width vane pack mist eliminator at gas outlet with a drain pipe for liquids
- Sand weir
- Oil weir
- Grating-type vortex breakers at the water and crude outlets

The MP separator contains two VIEC-LW walls situated between the two calming baffles. The first wall is downstream of the inlet device and spans the liquid layer from 830 mm to 3325 mm high. The second wall spans the liquid layer from 1900 mm to 3325 mm high.

The first wall is energized at 210 V and the second wall at 140 V. When the oil-water emulsion is subjected to the electric field generated by the VIEC-LW walls, electrostatic coalescence occurs: small water droplets in the emulsion are polarized so that when two water droplets collide they coalesce (join) to form a larger droplet. When a water droplet reaches sufficient mass, gravity pulls it to the bottom layer in the separator. Oil floats on top of the water layer.

The vessel includes three vertically aligned nozzles through which the operator can drain the rag layer to the skim oil pump for transfer to the crude outlet manifold.

Sand weirs and nozzles for future sand jetting equipment are provided to facilitate removal of sand and sludge.

An asphaltene inhibitor injection quill is installed upstream of the MP inlet heaters and a demulsifier injection quill is installed in the crude outlet piping of the MP separator.

Table R. MP Separator Data Sheet

Equipment Description	
Length	21,500 mm T/T
Internal Diameter	5,400 mm
Normal Operating Parameters	
Pressure	900 kPag
Temperature	64 °C

3.5 Oil/Oil Exchanger

The oil/oil exchangers (HPL-623206A/B) are 2 x 100% plate and frame exchangers operate on a duty / standby basis. Warm produced oil transfers heat to the crude from the MP separator.

Table S. Oil/Oil Exchanger Data Sheet (Year 2021)

Equipment Description	
Length	6911 mm
Width	1470 mm
Height	3121 mm
Normal Operating Parameters	
Cold Side: Crude	900 kPag @ 64 °C
Hot Side: Produced Oi	660.0 kPag @ 88 °C

3.6 LP Inlet Heaters

The LP inlet heaters (HBG-623207 / 217) are 2 x 50% “Helixchanger”-type shell and tube exchangers, using dilute TEG (glycol / water) heating medium. The crude is on the shell side, and the heating medium is in the tubes.

Table T. LP Inlet Heater Data Sheet

Equipment Description	
Length	7,315 mm
Diameter (I.D.)	940 mm
Number of U-Tubes	398
Tube O.D.	19.05 mm
Tube Length	7.3 m
Deck Level	Lower
Redundancy	2 x 50%
Normal Operating Parameters	
Shell	650.0 kPag @ 74.00 °C
Tubes	1200.0 kPag @ 170.00 °C

3.7 LP Separator

The LP separator (MBD-623203) is a three-phase separator operating at 59.0 kPag. Production fluids and produced water are separated into vapor (gas), water, and crude phases.

The primary flow to the LP separator is warm crude from the LP inlet heater (HPG-623207 / 217) with the capability of separating crude, condensate, and produced water from other sources.

Internal components that enhance the three-phase separation:

- Inlet cyclones
- Two full-diameter calming baffles
- Two liquid / liquid coalescer plate packs
- Full-width vane pack mist eliminator at gas outlet with a drain pipe for freed oil
- Oil weir
- Grating-type vortex breakers at the water and crude outlets

Table U. LP Separator Data Sheet

Equipment Description	
Length	14,000 mm T/T
Internal Diameter	3,700 mm
Normal Operating Parameters	
Pressure (Min/Norm/Max)	- - - / 59 / 1010 kPag
Temperature (Min/Norm/Max)	-29 / 87 / 120 °C

The plate pack coalescer separates oil from the oil/water emulsion. A plate pack is a stack of parallel plates tilted upward at a 45° angle. Oil droplets are attracted to the oleophilic material on the underside of each plate. Small droplets merge (coalesce) into larger droplets which migrate to the top of the plate pack and into a concentrated oil phase where it overflows the oil weir into the oil box. Refer to Plate Pack: Principle of Operation (above).

The vessel includes three vertically aligned nozzles through which the operator can drain the rag layer to the skim oil pump for transfer to the crude outlet manifold.

Sand weirs and nozzles for future sand jetting equipment are provided to facilitate removal of sand and sludge. Provision is included for future VIEC internals, if required.

Connections with injection quills are provided for injection of biocide, defoamer, and demulsifier.

3.7.1 LP Separator Produced Water Pump

The LP separator produced water pumps (PBA-623210 A/B) are electrically driven, vertical, centrifugal pumps operating on a 2 x 100% basis. The pumps transfer produced water from the LP separator to the MP inlet heaters.

Table V. LP Separator Produced Water Pump Data Sheet

Parameter	Specification
Capacity	73.0 m3/h
Suction Pressure	221 kPag
Discharge Pressure	1408 kPag
Discharge Temperature	93 °C

3.8 Compact Electrostatic Coalescer (CEC)

The compact electrostatic coalescer (CEC) (MAD 624201) operates at 59 kPag, the same operating pressure as the LP separator. The CEC is a vertical vessel that operates liquid full.

Crude flows vertically downwards through the CEC. Power is provided by a 10 kVA transformer. Droplet coalescence is achieved by applying AC electric fields (50–60 Hz) to the water-in-oil emulsions under turbulent-flow conditions. The emulsion layer is reduced as the water droplets coalesce resulting in larger droplets entering the downstream gravity oil/water separator.

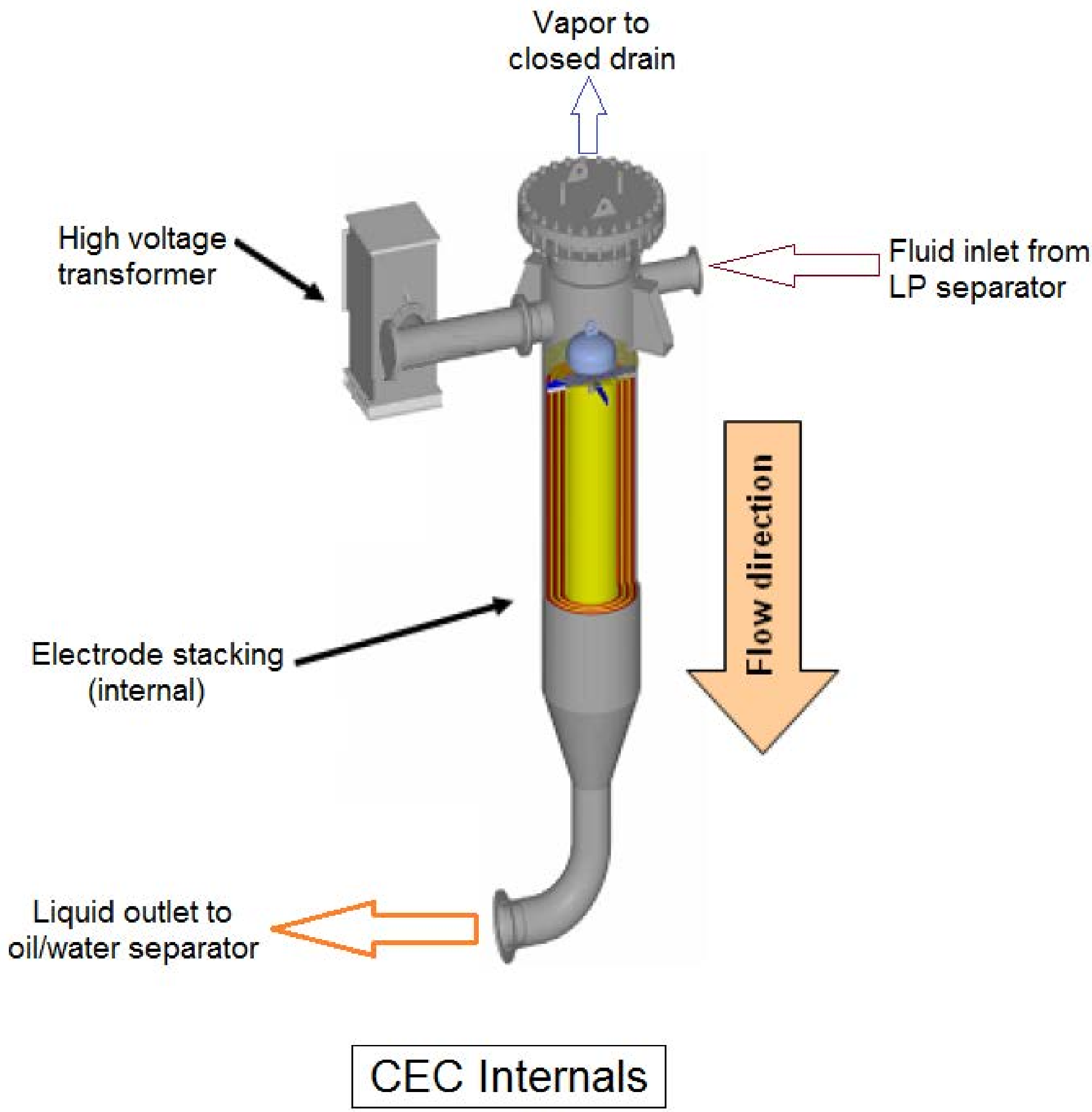
The electrodes are insulated to prevent short circuiting in case of high water content such as caused by a water slug.

The operator can adjust the voltage from the control room or at the local panel.

Table W. CEC Data Sheet

Equipment Description	
Height	6,000 mm T/T
Internal Diameter	1,220 mm
Normal Operating Parameters	
Pressure	59 kPag
Temperature	93 °C

FIGURE 33. COMPACT ELECTROSTATIC COALESCER CONFIGURATION



3.9 Oil/water Separator

The oil/water (O/W) separator (MBD-623204) is a two-phase, horizontal coalescer-type separator that is the final step in separating oil from water. The O/W separator is classified as two-phase because minimal vapor remains in the crude.

The O/W separator operates at a pressure higher than the LP separator operating pressure by the static head difference between the two vessels.

The oil/water separator operates liquid full.

Internal components that enhance the two-phase separation:

- Inlet distributor
- Four energized grids with five diffusion baffles
- 50 kVA transformer
- Oil weir
- Grating-type vortex breaker at the produced water outlet

The oil/water emulsion was treated in the compact electrostatic coalescer (CEC) to enlarge water droplets which enhances the separation process in the O/W separator.

Oil and water exit the CEC and enter the O/W separator where the liquid passes through four energized grids sandwiched between five diffusion baffles. The 50 kVA transformer creates an electrostatic field across each grid to accelerate the dehydration process by imparting electrical charges to water droplets that are present in the crude oil emulsion. The droplets to collide and coalesce until a droplet is large enough that gravity pulls the droplet into the water phase of the O/W separator. Refer to Electrostatic Coalescence: Principle or Operation (Lesson 2).

Voltage indication is provided at the panel and in the control room. The operator can select among five transformer voltage settings ranging from 12 to 25 kV to optimize separator performance.

The operator can determine the level of the interface through ten interface sampling ports aligned vertically. Three rag layer is drained through one of three oil skimming nozzles at different elevations then pumped to the crude outlet manifold by the skim oil pump (PBA-623212).

Table X. Oil/Water Separator Data Sheet

Equipment Description	
Length	16,460 mm T/T
Internal Diameter	14,572 mm
Volume	295.24 m^3
Normal Operating Parameters	
Pressure (Min/Norm/Max)	- - - / 176 / 1110 kPag
Temperature (Min/Norm/Max)	-29 / 87 / 120 °C

3.9.1 Skim Oil Pump

The skim oil pump (PBA-623212) is an electrically driven, centrifugal pump operating on a 1 x 100% basis. The pump transfers skimmed oil from the MP, LP, and oil/water separators to the crude outlet manifold.

Process fluid to be pumped is an oil/water emulsion with potential for abrasive sand and tar-like constituents. Viscosity will significantly increase with decreasing temperature.

The skim oil pump will be run intermittently as needed by operations to excavate skim oil. The maximum number of starts is not to exceed one start per day.

Table Y. Skim Oil Pump Data Sheet

Parameter	Specification
Capacity	15.0 m^3/h
Suction Pressure	196.5 kPag
Discharge Pressure	772 kPag

3.9.2 Oil/water Separator Produced Water Pump

The O/W separator produced water pumps (PBA-623211 A/B) are electrically driven, vertical, centrifugal pumps operating on a 2 x 100% basis. The pumps transfer produced water from the oil/water separator to the MP inlet heaters.

Table Z. O/W Separator Produced Water Pump Data Sheet

Parameter	Specification
Capacity	113.2 m^3/h
Suction Pressure	179 kPag
Discharge Pressure	1430.0 kPag
Discharge Temperature	91 °C

3.9.3 Crude Oil Pumps

The crude oil pumps (PBA-623208 A/B) are electrically driven, vertical, centrifugal pumps operating on a 2 x 100% basis. The pumps transfer produced oil from the oil/water separator through the oil/oil exchanger and the crude oil cooler to the crude inlet manifold for storage in the GBS cells.

Table AA. Crude Oil Pump Data Sheet

Parameter	Specification
Capacity	1035.0 m^3/h
Suction Pressure	173 kPag
Discharge Pressure	678.0 kPag
Discharge Temperature	91 °C

3.10 Crude Oil Cooler

Produced oil from the top of the oil/water separator is pumped by the 2 x 100% crude oil pumps (PBA-623208 A/B) through the oil/oil exchanger and then further cooled in the 1 x 100% crude oil cooler (HPL-623209) to 45-50°C before being routed to the storage cells.

The crude oil cooler is a single pass plate and frame exchanger utilizing dilute TEG cooling medium.

Parallel strainers (2 x 100%) are provided on the produced oil and cooling medium inlets to the crude oil cooler. Cleaning of the crude oil cooler itself requires a production shutdown.

Table BB. Crude Oil Cooler Data Sheet (Year 2021)

Equipment Description	
Size	5256 mm L x 1190 mm W x 3120mm H
Deck Level	Lower
Redundancy	1 x 100%
Normal Operating Parameters	
Hot Side (Crude)	370.0 kPag @ 74.00 °C
Cold Side (TEG)	680.0 kPag @ 16.00 °C

FEEDBACK EXERCISES

Directions: Complete the following exercises. Use this module and specified drawings and supplementary material as references.

1.) Internal components in the HP separator that enhance the two-phase separation include _______. (Circle all that apply.)

A. Inlet cyclones

B. Full diameter calming baffle

C. Full-width vane pack mist eliminator

D. Vessel internal electrostatic coalescer

2.) The operator can adjust the ____________ of the CEC from the control room or at the local panel. (Circle all that apply.)

A. flow

B. voltage

C. pressure

D. level

3.) Oil flows from the LP separator to the CEC where an electrostatic field increases the _________ for efficient separation in the oil/water separator. (Circle all that apply.)

A. oil viscosity

B. water droplet size

C. flow rate

D. oil density

4.) Warm produced oil flowing through the oil/oil exchangers transfers heat to the crude from the ___________. (Circle all that apply.)

A. HP separator

B. MP separator

C. LP separator

D. Oil/water separator

5.) The operating pressure of the MP separator is ___________. (Circle the answer.)

A. atmospheric

B. 59 kPag

C. 900 kPag

D. 2899 kPag

Lesson 4: Controlling the System

LESSON INTRODUCTION

This lesson introduces the key process variables controlled in this system and explains how they are controlled to maintain the process within allowable operating limits. You will learn the consequences to the system of deviating from these limits and the impact on personnel safety and the environment. You also will learn about the system's protective devices and the function of each end device.

At the completion of this lesson, you will be able to:

- Explain specified aspects of the system control philosophy.
- Describe the functions of specified controllers.
- Identify the normal control mode for all controllers.
- Identify process alarms and associated shutdown functions.
- Identify process interlocks and actions of interlocks.
- Describe the indicators of potential process upsets.
    - Describe the result of the process exceeding a specified set point on the operating parameters chart.
- Describe how to start / stop / throttle specified equipment.

WorleyParsons
resources & energy

4. Controlling the Separation and Stabilization System

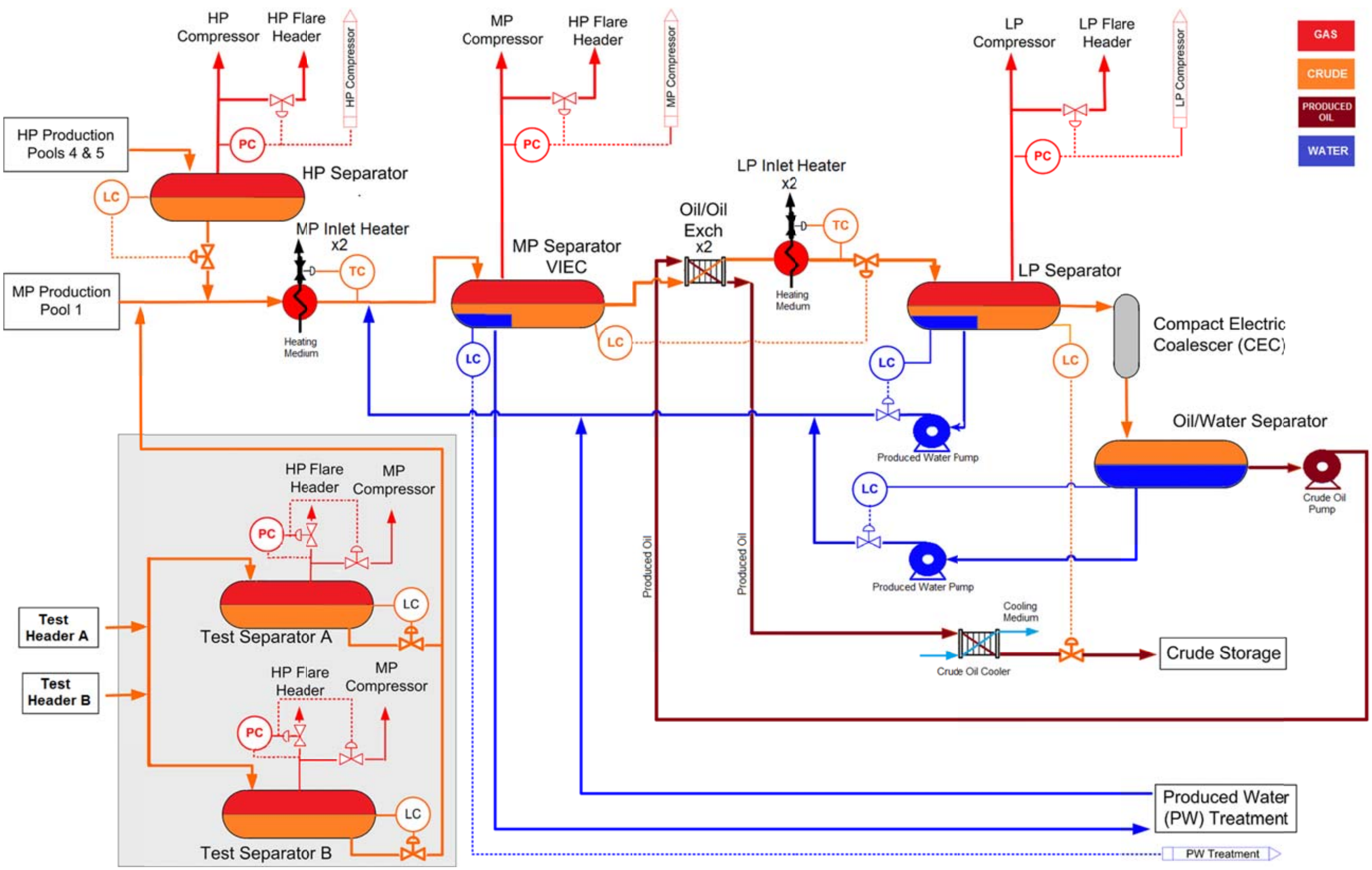
4.1 Normal Operating Parameters

Service	Parameter	Controller Tag No.	Normal	Remarks	Controller
Test separator A/B (MBD-622201 / 221 A/B)	Level	LC-622201 / 221-01	925 mm	Modulates LV-622201 / 221-01	PCS
	Pressure HP well test (Year 2025)	PC-622201 / 221-01	2900 kPag	Split-range pressure controller (op. selection)	PCS
	Pressure MP well test (Year 2022)	PC-622201 / 221-01	1312 kPag	Split-range pressure controller (op. selection)	PCS
HP separator (MBD-623201)	Level	LC-623201-01	1150 mm		PCS
	Pressure	PC-623201-01	2900 kPag		PCS
MP inlet heater (HBG-623205 / 215)	Temperature (crude out)	TC-623205 / 215-01	65 °C	Modulates heating medium flow (TV-623205 / 215-01)	PCS
MP separator (MBD-623202)	Pressure	PC-623202-01	900 kPag	Split-range pressure controller (signals MP compressors)	PCS
	Level (oil)	LC-623202-01	3325 mm		PCS
	Level (interface)	LC-623202-03	1900 mm	Gap or continuous control of LV-623203-03 (op. selection)	PCS

Service	Parameter	Controller Tag No.	Normal	Remarks	Controller
LP inlet heater (HPL-623207 / 217)	Temperature (crude out)	TC-623207 / 217-01	93 °C	Modulates heating medium flow (TV-623207 / 217-01) HS-623206-06 adjusts temperature set point to attain specified TVP when fluids to LP separator sourced from other than LP inlet heater	PCS
LP separator (MBD-623203)	Pressure	PC-623203-01	59 kPag	Split-range pressure controller (signals LP compressors)	PCS
	Level (oil)	LC-623203-01	2200 mm	Modulates LV-622203-01 on produced oil outlet of crude oil cooler	PCS
	Level (interface)	LC-623203-03	635 mm	Gap or continuous control of LV-623203-03A on discharge of produced water hydrocyclones (op. selection)	PCS
Oil/water separator (MBD-623204)	Level (interface)	LC-623204-01	762 mm	Gap or continuous control of LV-623204-01 on discharge of produced water pumps (PBA-623211 A/B) (op. selection)	PCS
Crude oil cooler (HPL-623209)	Temperature (produced oil)	TC-623209-02	50 °C	Controls TV-623209-02 on cooling medium out	PCS

Information on system response to abnormal readings is provided in Alarm and Shutdown / Interlock Functions table (below).

FIGURE 34. SEPARATION SYSTEM CONTROLLERS (SCHEMATIC)



Note: For the set points and actions associated with the devices described in this section, refer to Alarm and Shutdown / Interlock Functions table (below).

4.2 Test Separator Controls

The test separators separate vapor (gas) from the total liquid (oil and water), so the amount of produced oil, water, and gas from an individual well can be measured.

The test mode switch (HS-622201 / 221-01) must be set to either an HP or MP well test; logic then will select the test-appropriate set point on the split-range pressure controller (PC-622201 / 221-01).

LEVEL

Level controllers (LC-622201 / 221-01) maintain the overall liquid level in the test separators. The level controllers modulate level control valves (LV-622201 / 221-01), installed downstream of the sampling system and the flow meters on the liquid outlet of the test separator.

The process is protected by shutdowns for safety high and safety low levels (LI-622201 / 221-02).

PRESSURE

Pressure in the test separator is maintained at the set point by a split-range pressure controller (PC-623201 / 221-01) modulating pressure valve (PV-622201 / 221-01A) on the gas outlet line to the MP compressor trains. This controller maintains a higher pressure (up to 1312 kPag) in the test separator in comparison with the MP separator (900 kPag) so the liquids in the test separator can flow into the MP separator.

The process is protected by shutdowns for safety high and safety low pressures (PI-622201 / 221-02).

SAMPLER

The action of the cell sampler is controlled by an external flow control valve (FC-622202 / 222-01) which receives signals from the flow totalizer (FQI-622201 / 222-01/03) on the test separator liquid outlet, downstream of the sampling system take-off quill.

FIGURE 35. TEST SEPARATOR CONTROLS

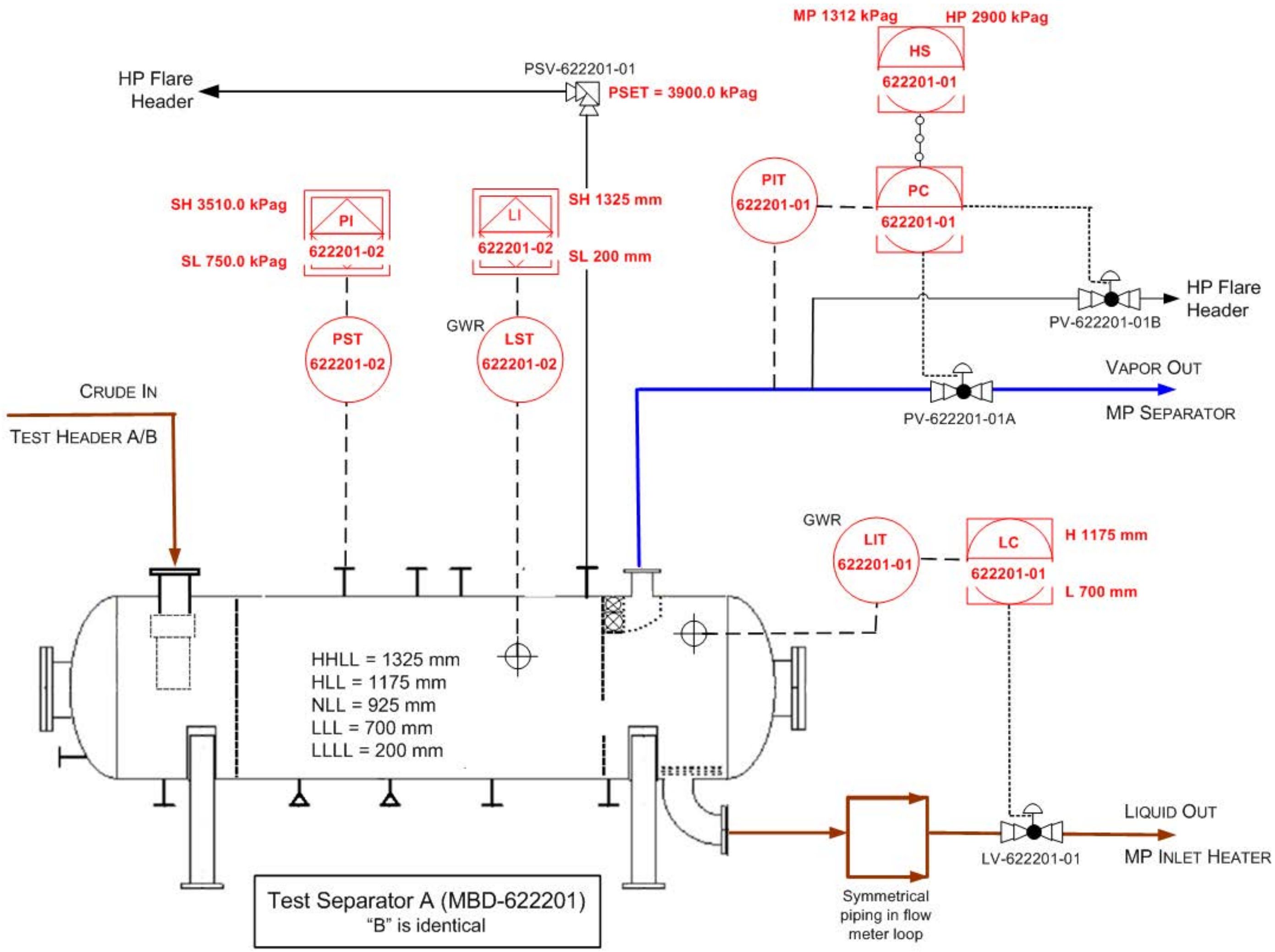
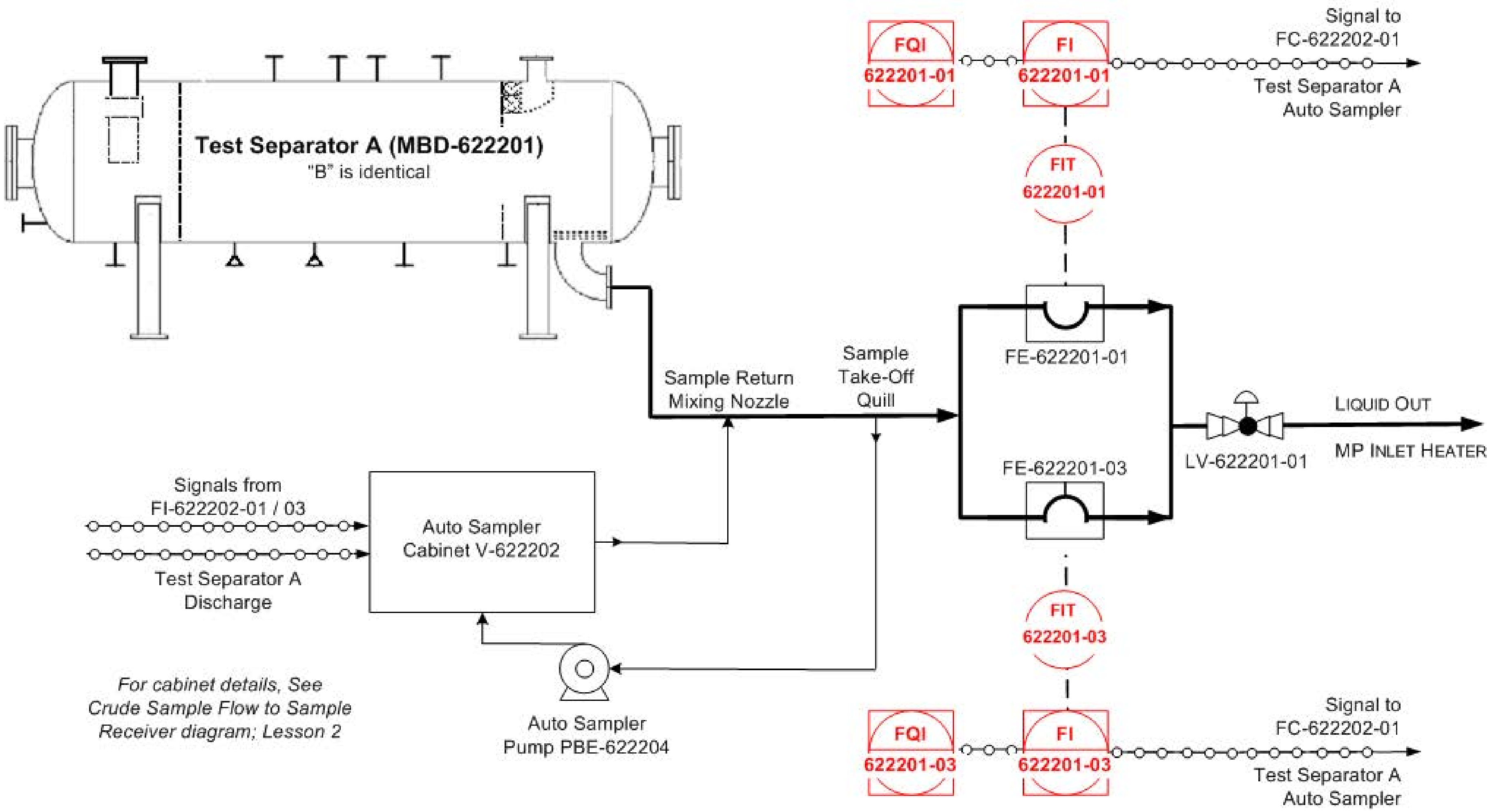


FIGURE 36. TEST SEPARATOR FLOW MEASUREMENT



4.3 HP Separator Controls

Production from 10 high pressure wells in pools 4 and 5 flows to the HP separator (MBD-623201), a horizontal, two-phase separator.

LEVEL

The HP separator liquid flows to the MP inlet heater on level control (LC-623201-01). The level controller modulates a level control valve (LV-623201-01).

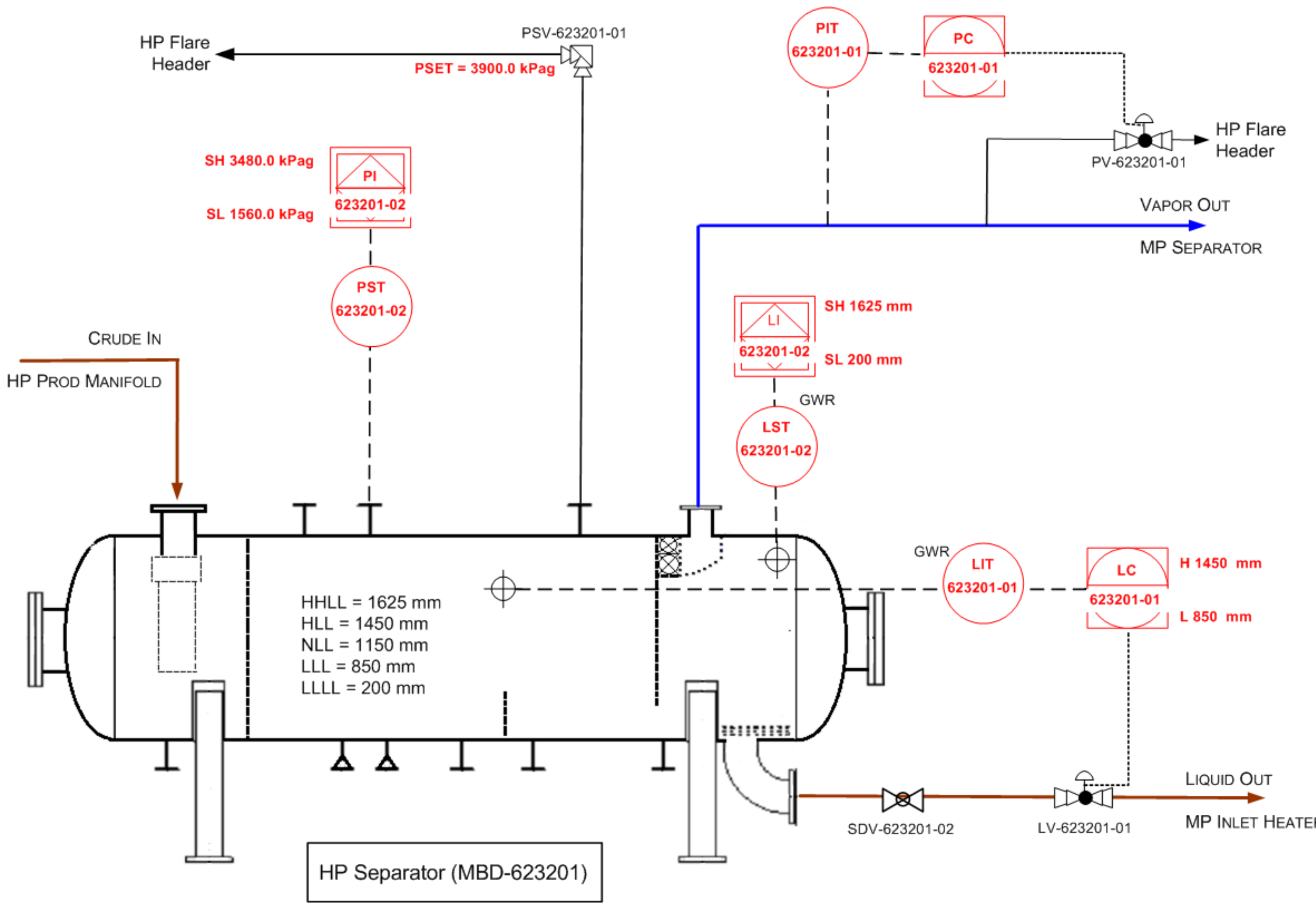
The process is protected by shutdowns for safety high liquid and safety low liquid level (LI-623201-02). A shutdown valve (SDV-623201-02) on the liquid outlet closes in the event of a process shutdown (PSD).

PRESSURE

A pressure controller (PC-623201-01) maintains the pressure in the line to the HP compressor at the set point and vents vapor to the HP flare when high pressure is detected. The pressure controller signals the central control panel for the MP / HP / LG compressor trains.

The process is protected by shutdowns for safety high pressure and safety low pressure (PI-623201-02). A pressure safety valve (PSV-623201-01) relieves vapor to the HP flare header at 3900.0 kPag.

FIGURE 37. HP SEPARATOR CONTROLS



4.4 MP Inlet Heater Controls

The 2 x 50% tube-and-bundle exchangers operate in parallel to heat the production fluid to 64 °C to 70 °C before it flows into the MP separator.

PRESSURE

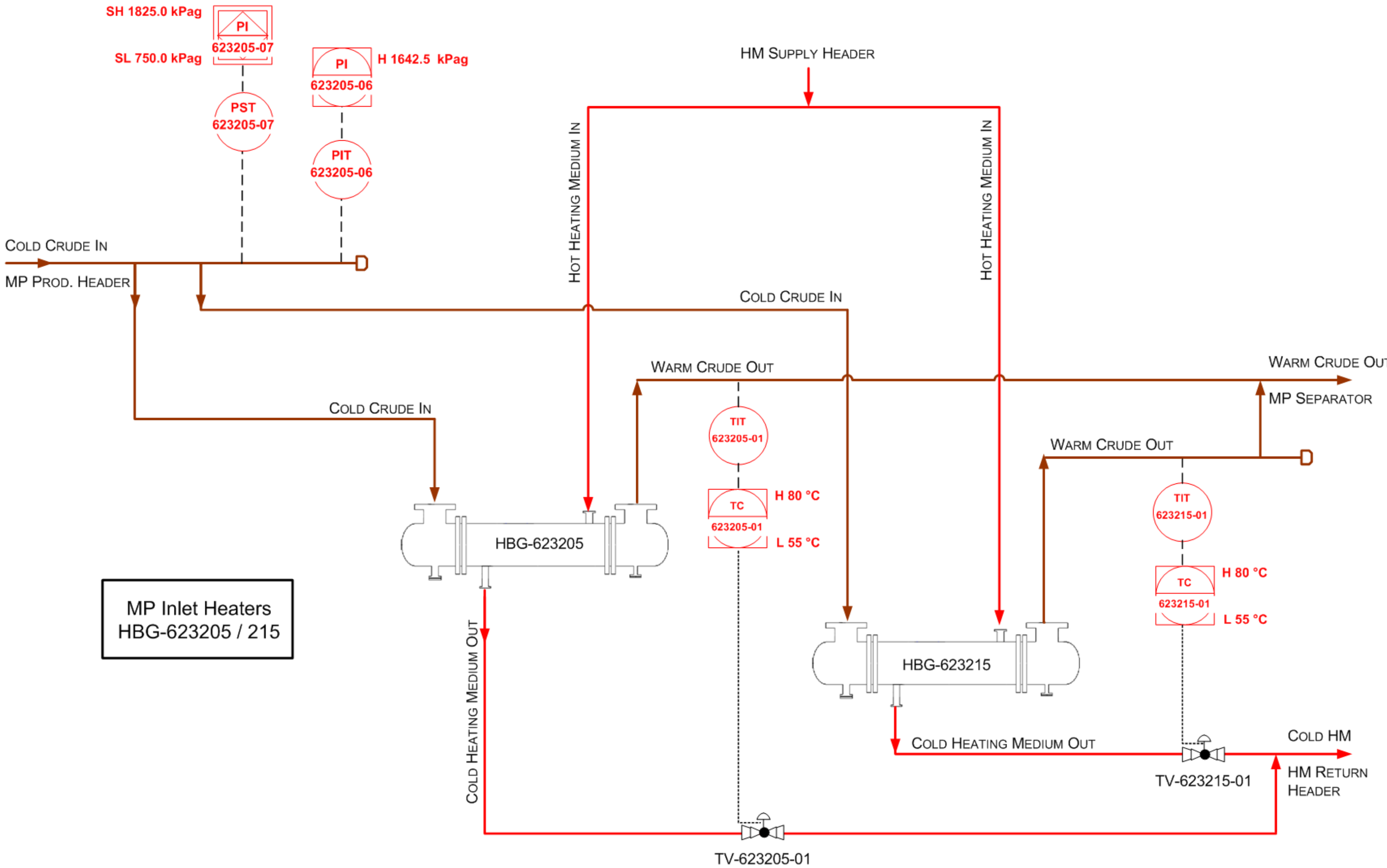
Pressure in the MP production header from the test and HP separators is monitored by a pressure indicator (PI-623205-06) which indicates an alarm at high pressure. A pressure indicator (PI-623205-07) activates a PSD trip if the header is over- or under-pressured.

TEMPERATURE

A temperature controller (TC-623205 / 215-01) receives a signal from a temperature indicating transmitter (TIT-623205 / 215-01) on the warm crude outlet line from each heater. The temperature controller maintains the temperature of the crude within the specified range by throttling the flow of heating medium via a temperature control valve (TV-623205 / 215-01) on the heating medium outlet from the exchanger.

WorleyParsons
resources & energy

FIGURE 38. MP INLET HEATER CONTROLS



4.5 MP Separator Controls

The MP separator (MBD-623202) is a three-phase separator operating at 900 kPag.

OIL LEVEL

The oil level is maintained by a level controller (LC-623202-01) which controls the discharge of crude from the MP separator by adjusting a level control valve (LV-623202-01) located downstream of the LP inlet heater.

The process is protected by a level indicator (LI-623202-02) that triggers a PSD at safety high or safety low oil level.

WATER LEVEL

The water level is maintained by the oil-water interface level controller (LC-623202-03) which adjusts the level control valve (LV-623202-03) located downstream of the produced water hydrocyclones. The level controller can be operator-selected for either gap (on/off) control or continuous level control.

INTERFACE

A level safety transmitter (LST-623202-05) monitors the interface level and signals the nucleonic level profiler in the unit control panel (UCP-623202-05).

The process is protected by an interface level safety low that trips on two-out-of-two voting (2oo2) from two level indicators (LI-623202-05 A/B). The trip closes the produced water outlet valve to prevent a further lowering of the interface. A trip also turns off both VIEC units.

PRESSURE

A pressure indicating controller (PIT-623202-02) signals a split-range pressure controller (PC-623202-01) which sends a signal to the MP compressor controller to modulate the compressor spillback control valves (FV-659202-01 A/B) for each compressor train. If high pressure occurs at the MP separator, the pressure controller opens a pressure control valve (PV-623202-01) to send gas to the HP flare.

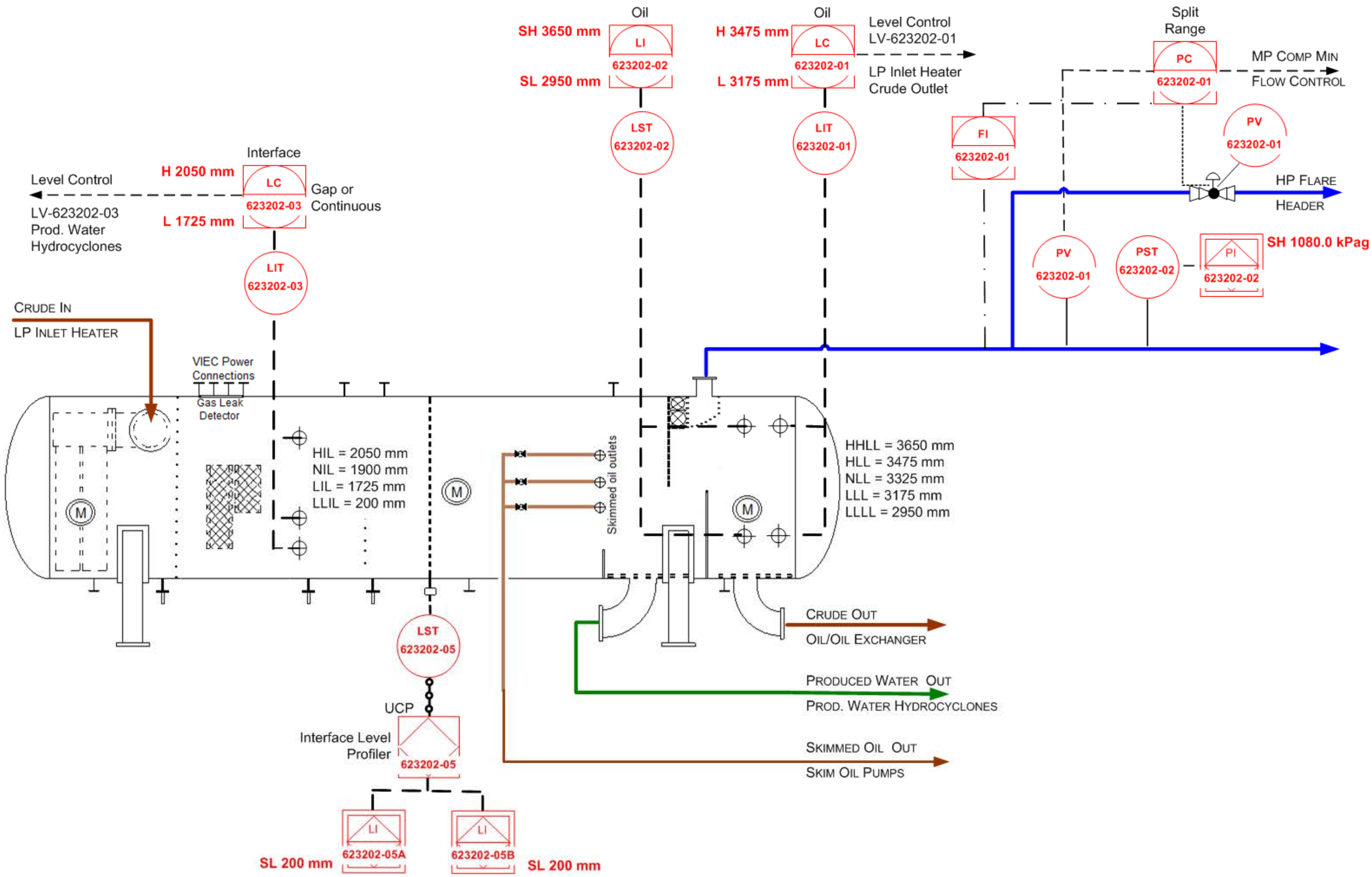
The compressors are protected against safety high pressure by a pressure safety transmitter (PST-623202-02) on the MP gas flow to the MP compressor. In the event of a safety high pressure, the pressure indicator (PI-623202-02) trips the compressor trains and the gas injection compressor. A PSD trip shuts in the MP wells and shuts off the gas supply to both MP compressor suction coolers by closing the shutdown valves on the gas supply (SDV-659202 / 222-05) and on the gas supply bypass (SDV-659202 / 222-06).

During initial production years with low produced water rates or during post start-up ramp up, the water levels in the MP Separator, LP Separator and Oil Water Separator may be maintained by running the oil-water interface level controllers in gap mode.

This is required for the MP Separator when water rates are below the minimum turndown for the Hydrocyclones in their current configuration. As the number of active liners in the Hydrocyclones increases, gap level control may also be required during facility restarts. The gap controller should be tuned such that flow at the minimum turndown rate can be maintained as long as possible.

A parallel 8” control valve (PV-623202-01B) is installed on a new 6”/8” line bypassing the main control valve (PV-623202-01). During early life, prior to start-up of the compression system, the main line should be isolated and the 8” valve should be in operation to control the separator pressure by releasing gas to HP flare. After the 2nd well is brought on line and Lift Gas operation is started, gas flow will increase and the main line can be put in operation. Net gas production will be used for Fuel Gas or re-injected. During later restarts the valve (PV-623202-01B) can be used until the first wells have stabilized with sufficient gas to restart the compression system. Starting high GOR wells first will minimize the time with gas flaring. Transition between the 2 valves will require manual operator intervention.

FIGURE 39. MP SEPARATOR CONTROLS



4.6 LP Inlet Heater Controls

The LP inlet heaters (HBG-623207 / 217) are 2 x 50% shell and tube exchangers operating in parallel to heat the crude from the oil/oil exchanger to 91-95°C.

TEMPERATURE

The temperature of the crude flowing to the LP separator is controlled by a temperature controller (TC-623207 / 217-01) on the crude outlet from the LP inlet heater. The temperature controller modulates a temperature control valve (TV-623207 / 217-01) that adjusts the flow of heating medium through the LP inlet heater.

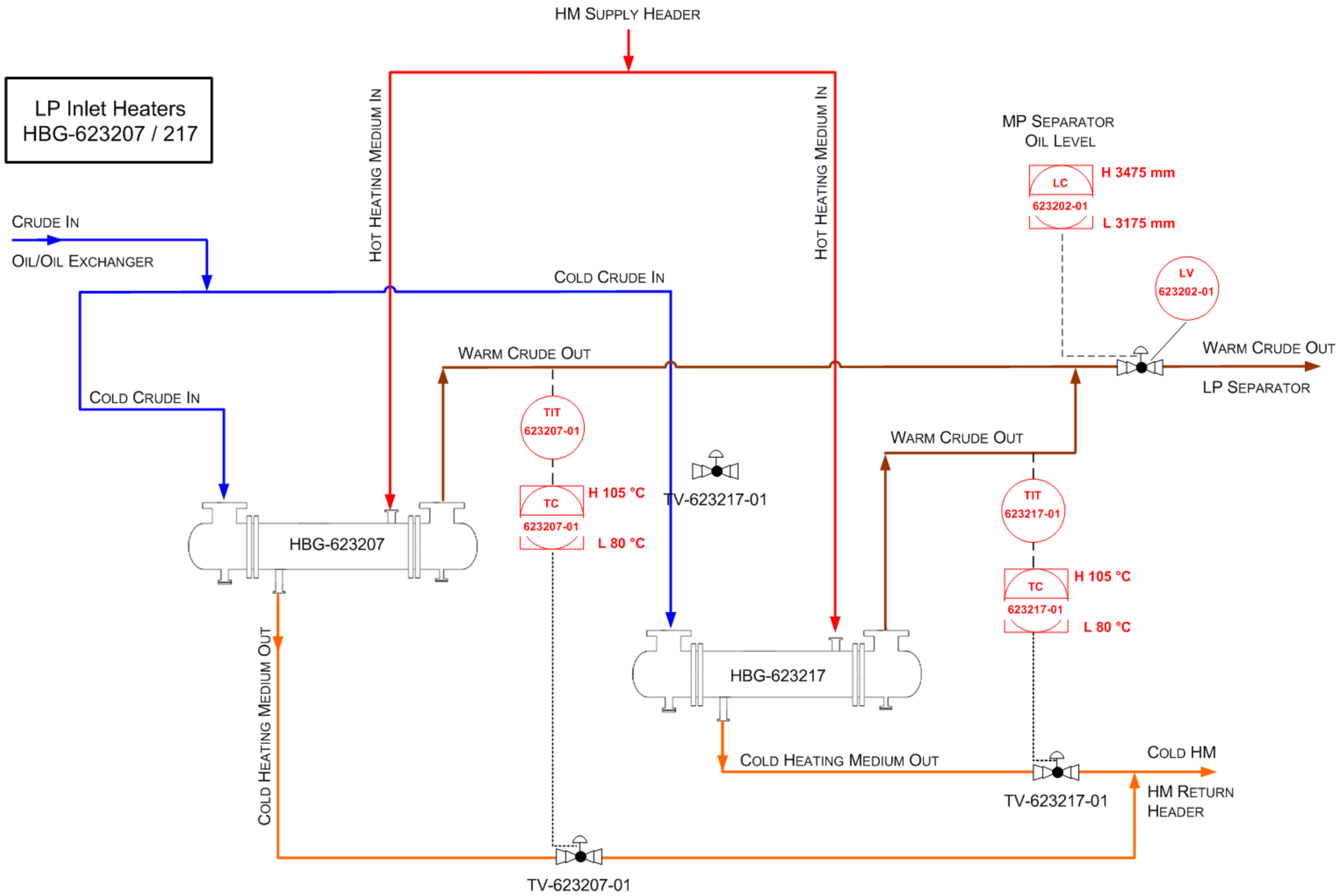
The set point of the temperature controller (TC-623207 / 217-01) can be changed via a hand switch (HS-623203-06) at the inlet to the LP separator, according to the source of fluids entering the LP separator.

FLOW

Flow of the crude (oil/water emulsion) from the LP inlet heater into the LP separator is controlled by a level control valve (LV-623202-01) on signal from a level controller (LC-623202-01) on the MP separator.

WorleyParsons
resources & energy

FIGURE 40. LP INLET HEATER CONTROLS



4.7 LP Separator Controls

The LP separator (MBD-623203) is a three-phase separator operating at 59 kPag.

TEMPERATURE

The temperature of the crude flowing to the LP separator is controlled by a temperature controller (TC-623207 / 217-01) on the crude outlet from the LP inlet heater (above). The temperature controller modulates a temperature control valve (TV-623207 / 217-01) that adjusts the flow of heating medium through the LP inlet heater.

The set point of the temperature controller (TC-623207 / 217-01) can be changed via a hand switch (HS-623203-06) at the inlet to the LP separator. The operator can change the set point when fluids from sources other than the LP inlet heater are directed to the LP separator in order to meet the true vapor pressure (TVP) specification for the crude. To minimize scaling problems, the temperature must be kept as low as possible while still meeting the TVP specification.

FLOW

Flow of the crude (oil/water emulsion) from the LP inlet heater into the LP separator is controlled by a level control valve (LV-623202-01) on signal from a level controller (LC-623202-01) on the MP separator.

OIL LEVEL

The oil level in the oil box, downstream of the overflow weir, is maintained by an oil level controller (LC-623203-01) which modulates a level control valve (LV-623203-01) controlling the flow of produced oil downstream of the crude oil cooler.

The process is protected by PSD in the event of either a safety low oil level or safety high oil level by a level indicator (LI-623203-02).

INTERFACE LEVEL

The level of the oil/water interface is maintained by a level controller (LC-623203-03) which adjusts a level control valve (LV-623203-03) on the discharge from LP produced water pumps (PBA-623210 A/B-02) downstream of the LP separator. The level controller can be operator-selected for either gap (on/off) control or continuous level control.

The process is protected against an oil/water interface safety low level by a level indicator (LI-623203-04).

GAS

A split-range pressure controller (PC-623203-01) maintains the LP separator pressure at 59 kPag. The pressure controller sends a signal to the 1st stage LP compressor controller which modulates the compressor spillback pressure control valves (PV-657202-02 A/B) for each compressor train. If high pressure occurs at the LP separator, the pressure controller opens a pressure control valve (PV-623203-01) to send gas to the LP flare.

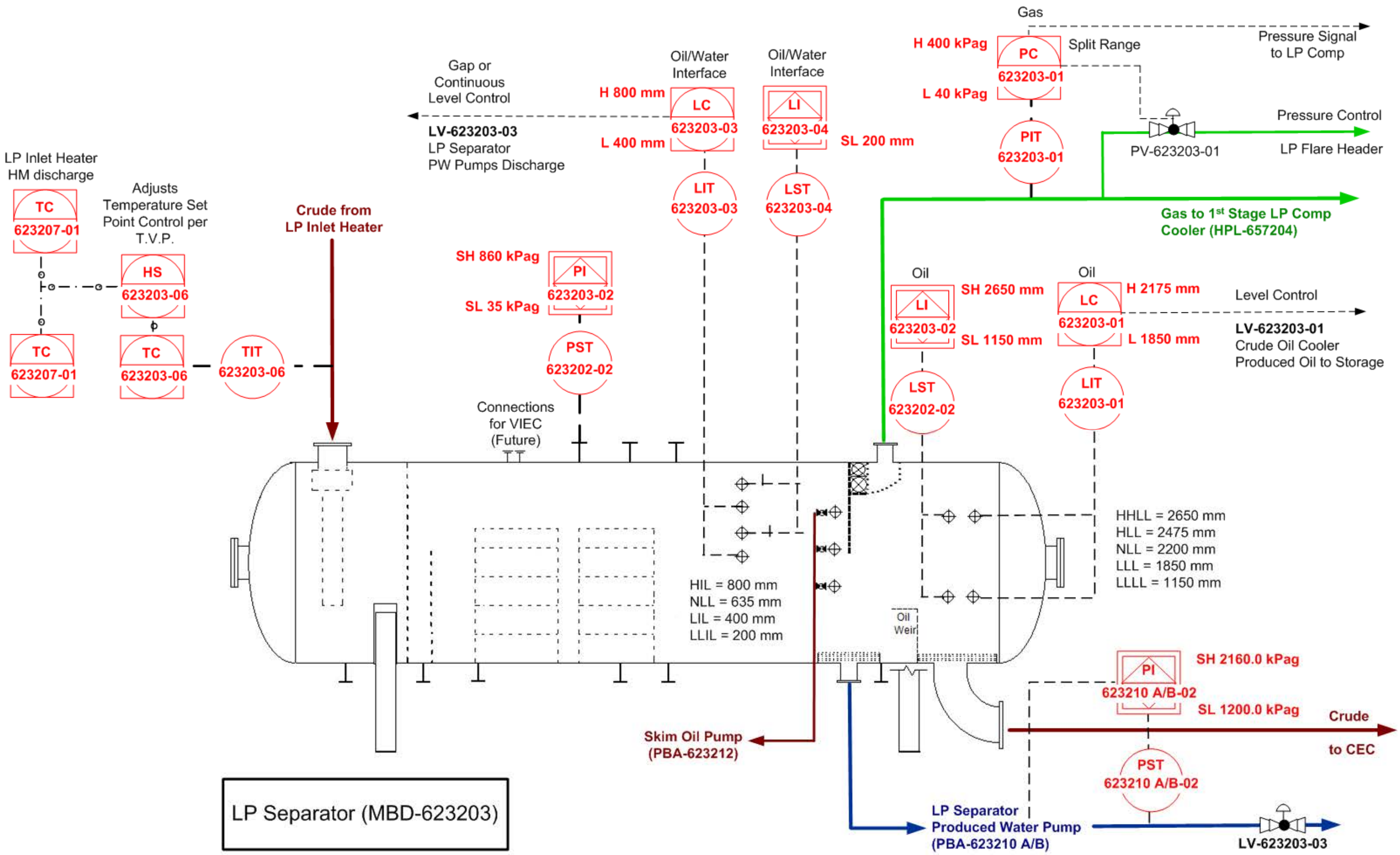
The process is protected from safety high or safety low pressure by a pressure indicator (PI-623203-02).

PRESSURE

The process is protected against safety high pressure or safety low pressure on the produced water pump discharge. A pressure indicator (PI-623210 A/B-02) stops the pump in the event of a PSL or PSH.

WorleyParsons
resources & energy

FIGURE 41. LP SEPARATOR CONTROLS



4.8 Compact Electrostatic Coalescer and Oily Water Separator Controls

4.8.1 CEC

LIQUID LEVEL

Oil flows from the LP separator at 88-93 °C to the compact electrostatic coalescer (CEC) (MAD 624201) which operates at 59 kPag, the same operating pressure as the LP separator. The oil/water emulsion is treated in the compact electrostatic coalescer (CEC) to enlarge water droplets which enhances the separation process in the downstream oil/water separator.

The process is protected against a safety low oil level in the CEC. A differential pressure level indicator (LI-624201-02) de energizes the CEC transformer at the safety low level.

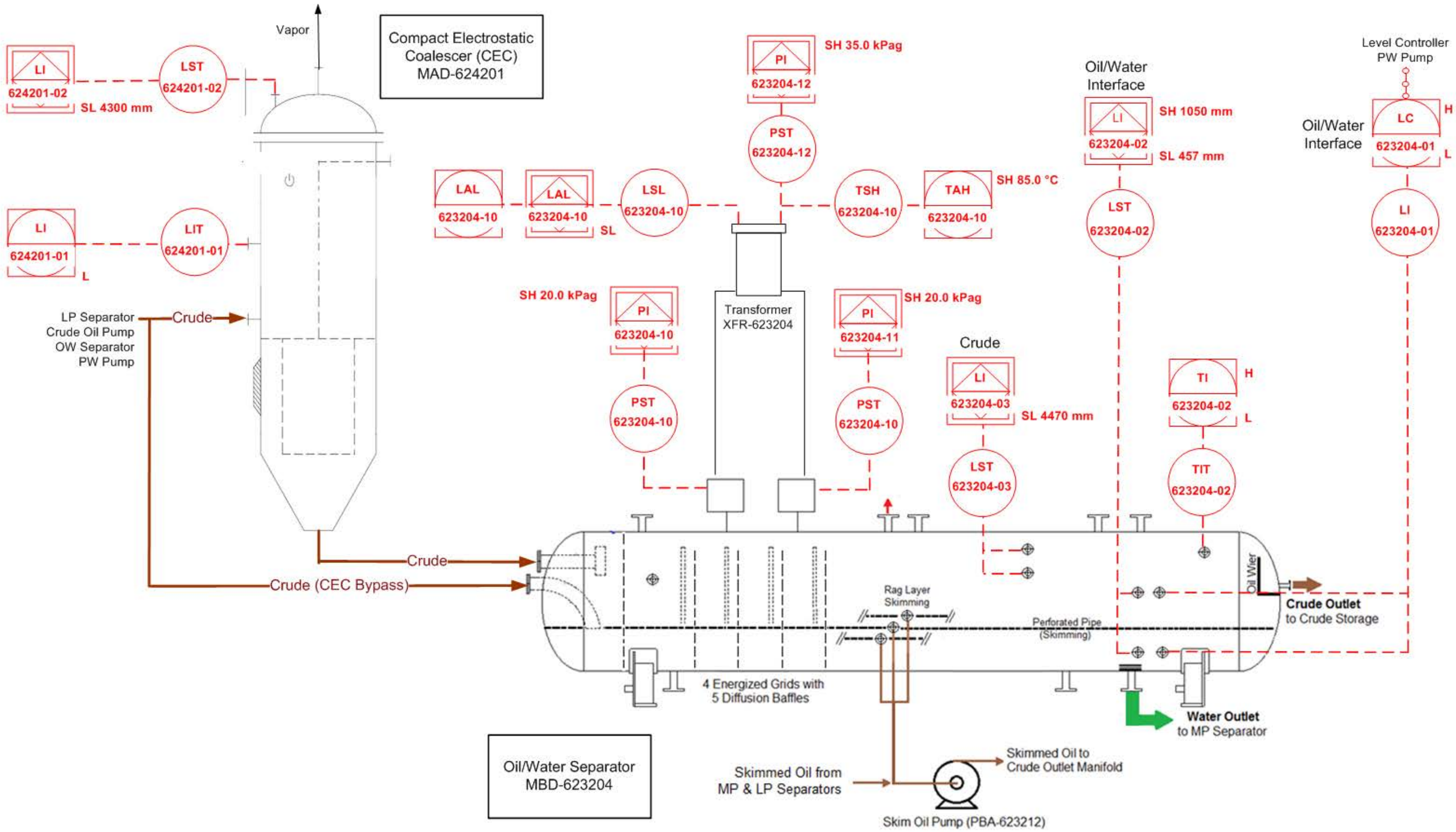
4.8.2 Oil/Water Separator

The oil/water (O/W) separator (MBD-623204) is a two-phase horizontal coalescer-type separator that is the final step in separating oil from water.

The process is protected by PSD shutdowns:

- Safety high pressure
- Safety high temperature
- Safety low oil level
- Safety high and low oil/water interface levels

FIGURE 42. CEC AND OIL/WATER SEPARATOR



4.9 Overpressure Protection

In the event of an overpressure, the pressure control in the process control system (PCS) vents the HP separator gas, test separators, or the MP separator to the HP flare by means of split range pressure control valves opening on high pressure set point. High pressure at the LP separator or oil water separator causes the split range pressure control valves to open to vent gas to the LP flare. If the pressure continues to rise, the safety instrumented system (SIS) high pressure trips are activated to initiate a process shutdown to shut-in the well heads. The HP production system is set to trips at 3480 kPag and the MP header will trip at 1825 kPag.

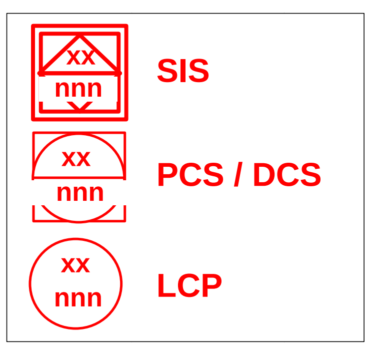
If the pressure continues to rise, the pressure safety valves (PSV) open to relieve the pressure to the HP or LP flares to protect the equipment and piping from overpressure. A list of pressure safety valves is shown in Appendix C.

4.10 System Alarms and Shutdowns

Table CC. Alarm and Shutdown Control Systems Acronyms

Controller	Control System	Display
SIS	Safety instrumented system (F&G / PSD / ESD)	Main control room
PCS	Process control system (DCS)	Main control room
PLC	Programmable logic controller / local control	Local control panel (LCP)
PLC (ND)	Signal not displayed on panel	Local control panel (LCP)

FIGURE 43. INSTRUMENT SYMBOL KEY



WorleyParsons
resources & energy

Table DD. Alarm and Shutdown / Interlock Functions

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
Test separators A/B (MBD-622201 / 221) Pressure	Safety high pressure	PSH-622201 / 221-02	3510 kPag	• Close chemical injection (defoamer & demulsifier) valve • Close wellhead valves on production well lined up to test separator [1] • Close pool 2 gas injection/production well	SIS
	High pressure	PAH-622201 / 221-01	3315 kPag	• Alarm	PCS
	Low pressure	PAL-622201 / 221-01	2340 kPag	• Alarm	PCS
	Safety low pressure	PSL-622201 / 221-02	750 kPag	• Close test separator outlet valve (SDV-622201 / 221-02) • Close chemical injection (defoamer & demulsifier) valve • Close wellhead valves on production well lined up to test separator [1] • Close pool 2 gas injection/production well	SIS
Test separators A/B (MBD-622201 / 221) Liquid level	Safety high liquid level	LSH-622201 / 221-02	1325 mm	• Close chemical injection (defoamer & demulsifier) valve • Close wellhead valves on production well lined up to test separator	SIS
	High liquid level	LAH-622201 / 221-01	1175 mm	• Alarm	PCS
	Low liquid level	LAL-622201 / 221-01	700 mm	• Alarm	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Safety low liquid level	LSL-622201 / 221-02	200 mm	• Close test separator outlet valve (SDV-622201 / 221-02) • Close chemical injection (defoamer & demulsifier) valve • Close wellhead valves on production well lined up to test separator	SIS
HP separator (MBD-623201) Pressure	Safety high pressure	PSH-623201-02	3480 kPag	• Close HP compressor suction cooler inlet valves on trains 1 & 2 • Shut in HP production wells • Close chemical injection (defoamer & demulsifier) valve • Close pool 2 gas injection/production well	SIS
	High pressure	PAH-623201-01	3159 kPag	• Alarm	PCS
	Low pressure	PAL-623201-01	1716 kPag	• Alarm	PCS
	Safety low pressure	PSL-623201-02	1560 kPag	• Close HP separator liquid outlet valve (SDV-623201-02) • Close HP compressor suction cooler inlet valves on trains 1 & 2 • Shut in HP production wells • Close chemical injection (defoamer & demulsifier) valve • Close pool 2 gas injection/production well	SIS
HP separator (MBD-623201) Liquid level	Safety high liquid level	LSH-623201-02	1625 mm	• Close HP compressor suction cooler inlet valves on trains 1 & 2 • Shut in HP production wells • Close chemical injection (defoamer & demulsifier) valve	SIS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	High liquid level	LAH-623201-01	1450 mm	• Alarm	PCS
	Low liquid level	LAL-623201-01	850 mm	• Alarm	PCS
	Safety low liquid level	LSL-623201-02	200 mm	• Close HP separator liquid outlet valve (SDV-623201-02)	SIS
MP production header (GAY-562206) Pressure	Safety high pressure	PSH-623205-07	1825 kPag	• Close test separator liquid outlet valve (SDV-622201 / 221-02) • Close HP separator liquid outlet valve (SDV-623201-02) • Close MP separator condensate return valve (SDV-623205-01) • Close MP separator crude outlet valve (SDV-623202-02) • Close MP separator produced water outlet valve (SDV-623202-03) • Stop MP separator VIEC units 1 & 2 (YS-623202-01/05) • Initiate PSD	SIS
	High pressure	PAH-523205-06	1642.5 kPag	• Alarm	PCS
	Low pressure	---	---	• Alarm Note: Pre-low alarm provided by PIT-623202-01 (PAL-623202-01)	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Safety low pressure	PSL-623205-07	750 kPag	• Close test separator liquid outlet valve (SDV-622201 / 221-02) • Close HP separator liquid outlet valve (SDV-623201-02) • Close MP separator condensate return valve (SDV-623205-01) • Close MP separator crude outlet valve (SDV-623202-02) • Close MP separator produced water outlet valve (SDV-623202-03) • Stop MP separator VIEC units 1 & 2 (YS-623202-01/05) • Initiate PSD	SIS
MP inlet heaters (HBG-623205 / 215) Crude outlet temperature	High temperature	TAH-623205 / 215-01	80 °C	• Alarm	PCS
	Low temperature	TAL-623205 / 215-01	55 °C	• Alarm	PCS
MP separator (MBD-623202) Crude level	Safety high level (crude)	LSH-623202-02	3650 mm	• Close test separator liquid outlet valve (SDV-622201 / 221-02) • Close HP separator liquid outlet valve (SDV-623201-02) • Close MP separator condensate return valve (SDV-623205-01) • Stop MP separator VIEC units 1 & 2 (YS-623202-01/05) • Initiate PSD	SIS
	High level (crude)	LAH-623202-01	3475 mm	• Alarm	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Low level (crude)	LAL-623202-01	3175 mm	• Alarm	PCS
	Safety low level (crude)	LSL-623202-02	2950 mm	• Close MP separator crude outlet valve (SDV-623202-02) • Stop MP separator VIEC units 1 & 2 (YS-623202-01/05) • Initiate PSD	SIS
MP separator (MBD-623202) Interface level	High level (interface)	LAH-623202-03	2050 mm	• Alarm	PCS
	Low level (interface)	LAL-623202-03	1725 mm	• Alarm	PCS
	Safety low level (interface)	LSL-623202-05 A/B 2oo2 voting	200 mm	• Close MP separator produced water outlet valve (SDV-623202-03) • Stop MP separator VIEC units 1 & 2 (YS-623202-01/05) • Close degassing drum produced water outlet	SIS
MP separator (MBD-623202) Gas outlet pressure	Safety high pressure (gas)	PSH-623202-02	1080 kPag	• Trips gas compressor trains 1 & 2 • Trips gas injection compressor	SIS
	High pressure (gas)	PAH-623202-01	HOLD	• Alarm Note: Split-range controller	PCS
	Low pressure (gas)	PAL-623202-01	200 kPag	• Alarm Note: Provides pre-low pressure alarm to MP production header (GAY-562206)	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
Oil/Oil exchanger (HPL-623206 A/B) Crude inlet strainer pressure differential	High pressure differential	PDAH-623206 A/B-01	100 kPag	• Alarm	PCS
Oil/Oil exchanger Crude side pressure differential	High pressure differential	PDAH-623206 A/B-02	200 kPag	• Alarm	PCS
Oil/Oil exchanger) Produced oil inlet strainer pressure differential	High pressure differential	PDAH-623206 A/B-03	100 kPag	• Alarm	PCS
Oil/Oil exchanger Produced oil side pressure differential	High pressure differential	PDAH-623206 A/B-04	200 kPag	• Alarm	PCS
LP inlet heater Crude temperature	High temperature (crude)	TAH-623207 / 217-01	105 °C	• Alarm	PCS
	Low temperature (crude)	TAL-623207 / 217-01	80 °C	• Alarm	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
LP separator (MBD-623203) Pressure	Safety high pressure	PSH-623203-02	860 kPag	• Close test separator outlet valve (SDV 622201 / 221-02) • Close MP separator crude outlet valve (SDV-623202-02) • Close LP separator condensate return valve (SDV-623203-05) • Close LP separator crude outlet valve (SDV-623203-02) • Close LP separator produced water outlet valve (SDV-623203-03) Note: Three-second time delay for pump run down to 6" or below • Stop LP separator produced water pumps (PBA-623210 A/B) • Initiate PSD • Stop flare knockout (KO) drum pumps	SIS
	High pressure	PAH-623203-01	400 kPag	• Alarm	PCS
	Low pressure	PAL-623203-01	40 kPag	• Alarm	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Safety low pressure	PSL-623203-02	35 kPag	• Close test separator outlet valve (SDV 622201 / 221-02) • Close MP separator crude outlet valve (SDV-623202-02) • Close LP separator condensate return valve (SDV-623203-05) • Close LP separator crude outlet valve (SDV-623203-02) • Close LP separator produced water outlet valve (SDV-623203-03) Note: Three-second time delay for pump run down to 6" or below • Stop LP separator produced water pumps (PBA-623210 A/B) • Initiate PSD • Stop flare knockout (KO) drum pumps	SIS
LP separator (MBD-623203) Crude level	Safety high level (crude)	LSH-623203-02	2650 mm	• Close test separator outlet valve (SDV 622201 / 221-02) • Close MP separator crude outlet valve (SDV-623202-02) • Close LP separator condensate return valve (SDV-623203-05) • Initiate PSD • Stop flare knockout (KO) drum pumps	SIS
	High level (crude)	LAH-623203-01	2475 mm	• Alarm	PCS
	Low level (crude)	LAL-623203-01	1850 mm	• Alarm	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Safety low level (crude)	LSL-623203-02	1150 mm	• Close LP separator crude outlet valve (SDV-623203-02) • Initiate PSD	SIS
LP separator (MBD-623203) Interface level	High level (interface)	LAH-623203-03	800 mm	• Alarm	PCS
	Low level (interface)	LAL-623203-03	400 mm	• Alarm	PCS
	Safety low level (interface)	LSL-623203-04	200 mm	• Close LP separator produced water outlet valve (SDV-623203-03) Note: Three-second time delay for pump run down to 6" or below • Stop LP separator produced water pumps (PBA-623210 A/B)	SIS
LP separator produced water pumps (PBA-623210 A/B) Discharge pressure	Safety high pressure	PSH-623210 A/B-02	2160 kPag	• Stops associated produced water pump	SIS
	High pressure	PAH-623210 A/B-01	2040 kPag	• Alarm	PCS
	Low pressure	PAL-623210 A/B-01	1550 kPag	• Alarm	PCS
	Safety low pressure	PSL-623210 A/B-02	1200 kPag	• Stops associated produced water pump	SIS
Oil/Water separator (MBD-623204) Interface level	Safety high level (interface)	LSH-623204-02	1050 mm	• De-energize O/W separator transformer (YS-623204-01)	SIS
	High level (interface)	LAH-623204-01	914 mm	• Alarm Note: LC-623204-01 set by operator for gap or continuous control	PCS
	Low level (interface)	LAL-623204-01	610 mm	• Alarm	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Safety low level (interface)	LSL-623204-02	457 mm	• Close O/W separator water outlet valve (SDV-623204-03) Note: Three-second time delay for pump run down • Stops O/W separator produced water pumps (PBA-623211 A/B)	SIS
Oil/Water separator (MBD-623204) Oil level	Safety low level (oil)	LSL-623204-03	4470 mm	• De-energize O/W separator transformer (YS-623204-01)	SIS
O/W separator transformer Oil pressure	Safety high pressure (oil)	PSH-623204-12	35 kPag	• De-energize O/W separator transformer (YS-623204-01)	SIS
O/W separator transformer Entrance tee pressure	Safety high pressure (tee)	PSH-623204-10/11	20 kPag	• De-energize O/W separator transformer (YS-623204-01)	SIS
Electrostatic coalescer (MAD-624201) Crude level	Low level (crude)	PAL-624201-01	4500 mm	• Alarm	PCS
	Safety low level (crude)	PSL-624201-02	4300 mm	• De-energize O/W separator transformer (YS-623204-01)	SIS
Electrostatic coalescer (MAD-624201) Junction box level	Low level (J-box)	LAH-624201-03 A/B	HOLD	• De-energize O/W separator transformer (YS-623204-01)	SIS
Crude oil cooler (HPL-623209) Produced oil temperature	Safety high temperature (produced oil)	TSH-623209-03	65 °C	• Initiates PSD if temperature remains high after 8-hour timer expires. The countdown timer to be displayed and generates an alarm one hour prior to expiring.	SIS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Safety high temperature (produced oil)	TSH-623209-03	65 °C	• Initiate PSD if temperature remains high after 30-minute timer expires. The countdown timer to be displayed and generates an alarm 15 minutes prior to expiring.	SIS
	Safety high-high temperature (produced oil)	TSHH-623209-03	65 °C	• PSD (timer expired)	SIS
	High temperature (produced oil)	TAH-623209-02	55 °C	• Alarm	PCS
	Low temperature (produced oil)	TAL-623209-02	40 °C	• Alarm	PCS
O/W separator crude oil pump (PBA-623208 A/B) Discharge pressure	Safety high pressure	PSH-623208 A/B-02	1650 kPag	• Stops associated crude pump	SIS
	High pressure	PAH-623208 A/B-01	1559 kPag	• Alarm	PCS
	Low pressure	PAL-623208 A/B-01	1100 kPag	• Alarm	PCS
	Safety low pressure	PSL-623208 A/B-02	400 kPag	• Stops associated crude pump	SIS
O/W separator produced water pump (PBA-623211 A/B) Discharge pressure	Safety high pressure	PSH-623211 A/B-02	2228 kPag	• Stops associated produced water pump	SIS
	High pressure	PAH-623211 A/B-01	2104 kPag	• Alarm	PCS
	Low pressure	PAL-623211 A/B-01	1485 kPag	• Alarm	PCS

Service	Parameter	Tag	Set Point	Alarm & Shutdown / Interlock Action	Controller
	Safety low pressure	PSL-623211 A/B-02	900 kPag	• Stops associated produced water pump	SIS

Notes:

[1] If the jumper valve (MV-562205-05) connecting the test headers A & B is opened (ZSO) or "not closed" (not ZSC), then test header A and test header B are considered to be joint and only one test separator will be in operation. (Refer to P&ID 21-562-0001-001) Only one production wellhead MOV shall be opened to the combined test header. If more than one production wellhead MOV is opened (ZSO) or "not closed" (not ZSC) to the combined test header, SIS will shut in all wellheads aligned to the combined test header.

For a list of shutdown functions, see Appendix F.

Feedback Exercises

Directions: Complete the following exercises. Use this module and specified drawings and supplementary material as references. Circle the correct answer.

1.) In the event of a safety high pressure in the MP separator, the pressure indicator _____________. (Circle all that apply.)

A. trips the compressor trains

B. trips the gas injection compressor

C. stops the MP separator VIEC units 1 & 2

D. closes valve on crude outlet from MP inlet heater

2.) The HP test separator A/B normal operating pressure is ______. (Circle the answer.)

A. 1900

B. 2210

C. 2300

D. 2900

3.) The test separator connected to MP header normal operating pressure is ______. (Circle the answer.)

A. 1284

B. 1312

C. 1350

D. 1380

4.) The LP separator normal operating pressure is _____- (Circle the answer.)

A. 59

B. 61

C. 63

D. 68

5.) The HP separator pressure safety low is set at _____ kPag. (Circle the answer.)

A. 1560

B. 1460

C. 1590

D. 1600

6.) The MP separator pressure safety high is _____ kPag. (Circle the answer.)

A. 1023

B. 1080

C. 2010

D. 2089

Module Review Exercises

Directions: Complete the following exercises. Use this module and specified drawings and supplementary material as references.

1.) Produced water is sent to the water treating system and then __________. (Circle all that apply.)

A. discharged overboard

B. injected into a well

C. routed to the LP separator

D. used for heating and cooling medium

2.) Liquid from the HP separator is mixed with medium pressure (MP) well fluid from pool _______ wells. (Circle the answer.)

A. 1

B. 2

C. 3

D. 4

3.) The LP separator normal operating pressure is ______. (Circle the answer.)-

A. 59

B. 61

C. 63

D. 68

4.) Hot, stabilized oil from the oil water separator exchanges heat with the LP separator feed at the oil/oil exchanger and crude oil cooler and is cooled to a final temperature of __-50° C for storage. (Circle the answer.)

A. 25

B. 33

C. 38

D. 45

5.) The water in oil leaving the MP separator is reduced to less than __% BS&W. (Circle the answer.)

A. 5

B. 10

C. 12

D. 15

6.) The HP well production flows to the HP separator where vapor is flashed and separated from the liquid at 2900 kPag and _______ ° C. (Circle the answer.)

A. 41

B. 47

C. 50

D. 52

7.) The LP separator is a three-phase separator operating at ___ kPag. (Circle the answer.)

A. 42

B. 55

C. 59

D. 63

8.) The oil flowing from the LP separator passes through electrostatic fields which ______ the water droplets causing them to coalesce into larger droplets. (Circle the answer.)

A. electrifies

B. polarize

C. heats

D. tempers

9.) The wax dissolution temperature (WDT) is __° C for pool 1. (Circle the answer.)

A. 50

B. 57

C. 60

D. 63

10.) DO NOT depend on your _________ for indicating the continuing presence of H_2S or for warning of hazardous concentrations. (Circle the answer.)

A. gas detector

B. eyes

C. hearing

D. sense of smell

11.) Test separators A/B use dual Coriolis flow meters in the liquid outlet piping of each test separator determine the water content of the oil by online ______ measurement. (Circle the answer.)

A. density

B. H_2O

C. hydrocarbon

D. gas

12.) The test separator pressure controller maintains a higher pressure (up to ____ kPag) in the test separator in comparison with the MP separator so the liquids in the test separator can flow into the MP separator.

A. 1210

B. 1312

C. 1350

D. 1400

WorleyParsons
resources & energy

Appendices

Appendix A: Separation Equipment Operating Parameters

Equipment		Pressure		Temperature		Process Flow		Basis
		In	Out	In	Out	Vapor	Liquid	
Number	Description	kPag	kPag	°C	°C	MSCMD	M^3/h	Year
MBD-622201 / 221	Test separator A/B HP well test	2900	2900	52	52	0.11	75.4	Note 1
MBD-622201 / 221	Test separator A/B MP well test	1312	1312	49	49	0.10	206	Note 2
MBD-623201	HP separator	2900	2900	52	52	1.27	341	2027
MBD-623202	MP separator	900	900	65	65	5.96	2366	2023
MBD-623203	LP separator	59	59	93	93	0.15	1221	2021
MAD-624201	CEC	59	59	93	93	---	1149	2021
MBD-623204	Oil/water separator	59	59	93	93	---	1149	2021
HBG-623205 / 215	MP inlet heater	1000	900	49	65	5.44	2327	2026
HPL-623206 A/B	Oil/oil exchanger (cold)	900	650	65	78	---	1186	2022
	Oil/oil exchanger (hot)	600	370	93	75	---	1022	2022
HBG-623207 / 217	LP inlet heater	650	454	78	92	022	1194	2022
HPL-623209	Crude oil cooler	370	145	80	50	---	1026	2021
PBA-623208 A/B	Crude oil pump	173	660	93	93	---	1035	2021
PBA-623210 A/B	LP separator produced water pump	221	1112	93	93	---	73	2021
PBA-623211 A/B	O/W separator produced water pump	176	1112	93	93	---	113.2	2021

Note 1: Normal for HP well testing, based on year 2025
Note 2: Normal for MP well testing, based on year 2022

WorleyParsons
resources & energy

Appendix B: Separation Equipment Specifications

Equipment Tag Number	Equipment Description	Design Condition				
		Pressure [kPag]	Temp. [°C]	Flow [m^3/hr]	Duty [kW]	Redundancy
MBD-622201 / 221	Test separators A/B	3900	-29 / 104	1804 (gas) 206 (liquid)	---	1x100% (Note 1)
MBD-623201	HP separator	3900	-29 / 104	1890 (gas) 341 (liquid)	---	1x100% (Year 2027)
MBD-623202	MP separator	2030	-29 / 100	29068 (gas) 2366 (liquid)	---	1x100% (Year 2023)
MBD-623203	LP separator	1010	-29 / 120	4970 (gas) 1221 (liquid)	---	1x100% (Year 2021)
MAD-624201	CEC	1040	-29 / 120	1149	---	1x100% (Year 2021)
MBD-623204	Oil/water separator	1110	-29 / 120	1149	---	1x100% (Year 2021)
HBG-623205 / 215	MP inlet heater Gas Liquid Heating Medium	2030 --- --- ---	--- --- -29 / 180 -29 / 208	--- 20138 2327 ---	39200 --- --- ---	2x50% (Year 2026)
HPL-623206 A/B	Oil/oil exchanger	2030	-29 / 120	1186 (cold) 1020 (hot)	9800	2x100% (Year 2022)
HBG-623207 / 217	LP inlet heater	2030	-29 / 180 (crude) -29 / 208 (HM)	1194	13200	2x50% (Year 2022)
HPL-623209	Crude oil cooler	1770	-29 / 120	1026	19100	1x100% (Year 2021)
PBA-623208 A/B	Crude oil pump	1770	-29 / 120	1035	140	2x100% (Year 2021)
PBA-623210 A/B	LP separator produced water pump	2400	-29 / 120	73	27	2x100% (Year 2021)
PBA-623211 A/B	O/W separator produced water pump	2400	-29 / 120	113.2	44	2x100% (Year 2021)

Appendix C: Pressure Safety Valves (PSV)

Instrument	Service	P&ID No.
SDV-622201-02	Test separator A liquid	CAHE-WP-PDPID-21-622-0001
SDV-622221-02	Test separator B liquid	CAHE-WP-PDPID-21-622-0002
SDV-623201-02	HP separator liquid	CAHE-WP-PDPID-21-623-0001
SDV-623205-01	Recycle header to MP header	CAHE-WP-PDPID-21-623-0002
SDV-623202-02	MP separator oil	CAHE-WP-PDPID-21-623-0004
SDV-623202-03	MP separator water	CAHE-WP-PDPID-21-623-0004
SDV-623203-05	1st and 2nd stage compressor scrubber condensate recycle	CAHE-WP-PDPID-21-623-0007
SDV-623203-02	LP separator oil	CAHE-WP-PDPID-21-623-0008
SDV-623203-03	LP separator water	CAHE-WP-PDPID-21-623-0008
SDV-623204-02	Oil/water separator - oil	CAHE-WP-PDPID-21-623-0010
SDV-623204-03	Oil/water separator - water	CAHE-WP-PDPID-21-623-0010
SDV-651204,224-01	HP separator vapor to train 1 and 2	CAHE-WP-PDPID-21-651-0001,0002
SDV-657202-05	LP separator vapor	CAHE-WP-PDPID-21-657-0001
SDV-659202-05,06	MP separator vapor to train 1	CAHE-WP-PDPID-21-659-0001
SDV-659222-05,06	MP separator vapor to train 2	CAHE-WP-PDPID-21-659-0002

Appendix D: Blowdown Valves (BDV)

Instrument	Service	P&ID No.
BDV-622201-04	Test separator A to HP flare	CAHE-WP-PDPID-21-622-0001
BDV-622221-04	Test separator B to HP flare	CAHE-WP-PDPID-21-622-0002
BDV-623201-04	HP separator to HP flare	CAHE-WP-PDPID-21-623-0001
BDV-623202-04	MP separator to HP flare	CAHE-WP-PDPID-21-623-0004-002
BDV-623203-04	LP separator to LP flare	CAHE-WP-PDPID-21-623-0008

WorleyParsons
resources & energy

Appendix E: Equipment Specifications

Equipment Number	Equipment Description	Design Condition				
		Press. [kPag]	Temp. [°C]	Flow [m^3/hr]	Duty [kW]	Basis
MBD-622201 / 221	Test separators A/B	3900	-29 / 104	1804 (gas) 206 (liquid)	---	1x100% (Note 1)
MBD-623201	HP separator	3900	-29 / 104	1890 (gas) 341 (liquid)	---	1x100% (Year 2027)
MBD-623202	MP separator	2030	-29 / 100	29068 (gas) 2366 (liquid)	---	1x100% (Year 2023)
MBD-623203	LP separator	1010	-29 / 120	4970 (gas) 1221 (liquid)	---	1x100% (Year 2021)
MAD-624201	CEC	1040	-29 / 120	1149	---	1x100% (Year 2021)
MBD-623204	Oil/water separator	1110	-29 / 120	1149	---	1x100% (Year 2021)
HBG-623205/215	MP inlet heater	2030	-29 / 180 (crude) -29 / 208 (HM)	20138 (gas) 2327 (liquid)	39200	2x50% (Year 2026)
HPL-623206A/B	Oil/oil exchanger	2030	-29 / 120	1186 (cold) 1020 (hot)	9800	2x100% (Year 2022)
HBG-623207/217	LP inlet heater	2030	-29 / 180 (crude) -29 / 208 (HM)	1194	13200	2x50% (Year 2022)
HPL-623209	Crude oil cooler	1770	-29 / 120	1026	19100	1x100% (Year 2021)
PBA-623208A/B	Crude oil pump	1770	-29 / 120	1035	140	2x100% (Year 2021)
PBA-623210A/B	LP separator prod water pump	2400	-29 / 120	73	27	2x100% (Year 2021)
PBA-623211A/B	O/W separator prod water pump	2400	-29 / 120	113.2	44	2x100% (Year 2021)

Note 1 Gas flow based on year 2123, liquid flow based on year 2022.

WorleyParsons
resources & energy

Appendix F: Shutdown Functions

Tag Number	Description	Set Points	Action	Service
PSH-622201/221-02 LSH-622201/221-02	Test separator A/B pressure safety high or level safety high	3510 kPag or 1325 mm	Close: SSV-5612xx-02 SSV-5612xx-03 SDV-5612xx-12 SDV-5612xx-05 ASV-5612xx-10 (XX = wellhead aligned to the test separator)	Master Wing MeOH Gas lift Annulus
PSL-622201/221-02 LSL-622201/221-02	Test separator A/B pressure safety low or level safety low	750 kPag or 200 mm	Close: SDV-622201 / 221-02 SSV-5612xx-02 SSV-5612xx-03 SDV-5612xx-12 SDV-5612xx-05 ASV-5612xx-10 (XX = wellhead aligned to test separator)	Liquid outlet Master Wing MeOH Gas lift Annulus
PSH-623201-02 LSH-623201-02	HP separator pressure safety high or level safety high	3480 kPag or 1625 mm	Close: SDV-651204 / 224-01 SSV-5612XX-02 SDV-5612XX-03 SDV-5612XX-12 SDV-5612XX-05 SDV-674205-02 SDV-675221-02 (XX = All HP Wells)	HP comp suction Master Wing MeOH Gas Lift De-mulsifier De-foamer

WorleyParsons
resources & energy

Tag Number	Description	Set Points	Action	Service
PSL-623201-02	HP separator pressure safety low	1560 kPag	Close: SDV-623201-02 SDV-651204/224-01 SSV-5612XX-02 SDV-5612XX-03 SDV-5612XX-12 SDV-5612XX-05 SDV-674205-02 SDV-675221-02	HP sep liquid out HP comp suction Master Wing MeOH Gas lift De-mulsifier De-foamer
LSL-623201-02	HP separator level safety low	200 mm	Close: SDV-623201-02	HP Sep Liquid Out
PSH-623205-07 PSL-623205-07	MP production header pressure safety high or pressure safety low	1825 kPag or 750 KPag	Close: SDV-622201/221-02 SDV-623201-02 SDV-623205-01 SDV-623202-02 SDV-623202-03 Initiates PSD	Test sep liquid out HP sep liquid out Recycle cond. to MP MP sep oil out MP sep water out
PSH-623202-02	MP separator vapor discharge pressure safety high	1080 kPag	SDV-659-202-05 SDV-659-202-06 SDV-659-222-05 SDV-659-222-06 SSV-5612XX-02 SDV-5612XX-03 SDV-5612XX-12 SDV-5612XX-05 SDV-674205-02 SDV-675221-02 (XX = All MP Wells)	MP comp suction MP comp SDV bypass MP comp suct MP comp suct bypass Master Wing MeOH Gas lift De-mulsifier De-foamer
LSH-623202-02	MP separator oil level safety high	3650 mm	Close: SDV-622201 / 221-02 SDV-623201-02 SDV-623205-01 LV-657203-01 Initiates PSD	Test sep liquid out HP sep liquid out Recycle cond. to MP 1st stg comp suction scrubber
LSL-623202-02	MP separator oil level safety low	2950 mm	Close: SDV623202-02, Initiates PSD	MP Sep oil out

Tag Number	Description	Set Points	Action	Service
LSL-623202-05	MP separator water Safety Low	200 mm	Close: SDV-623202-03	MP sep water out
PSH-623203-02PSL-623203-02	LP separator Pressure Safety High or Pressure Safety Low	860 kPag or 35 kPag	Close: SDV-622201,221-02S DV-623202-02 SDV-623203-02 SDV-623203-03 SDV-623203-05 SDV-612203-01 SDV-612203—02 Stop: 623210AB-01 612202AB-01 Initiate PSD	Test sep liquid out MP sep oil out LP sep oil out LP sep water out 1st,2nd stg LP comp condensate LP KO drum drain KO recovered oil LP sep PW pump LP flare KO pump
LSH-623203-02	LP separator oil Level Safety High	2650 mm	Close: SDV-622201,221-02 SDV-623202-02 SDV-623203-02 SDV-612203-01 SDV-612203—02 Stop: 623210AB-01 612202AB-01 Initiate PSD	Test sep liquid out MP sep oil out LP sep oil out LP KO drum drain KO recovered oil LP sep PW pump LP flare KO pump
LSL-623203-02	LP separator oil Level Safety Low	1150 mm	Close: SDV-623202-03 Initiate PSD	LP sep oil out
LSL-623203-04	LP sep water Level Safety Low	200 mm	Close: SDV-623203-03 Stop: 623210AB-01	LP sep water out LP sep PW pumps
PSH-623210 A/B-02	LP sep PW pump discharge Pressure Safety High	2160 kPag	Stop: PBA-623210 A/B	LP sep PW pumps
PSL-623210 A/B-02	LP Sep PW pump discharge Pressure Safety Low	1440 kPag	Stop: PBA-623210 A/B	LP sep PW pump
PSH-623208 A/B-02	Crude oil pump discharge Pressure Safety High	1650 kPag	Stop: PBA-623208 A/B Crude	Crude oil pumps

Tag Number	Description	Set Points	Action	Service
PSL-623208 A/B-02	Crude oil pump discharge Pressure Safety Low	400 kPag	Stop: PBA-623208 A/B	Crude oil pumps
TSH-623209-02	Crude oil to storage Temperature Safety High	65° C	Initiates PSD if temperature remains high for 8 hours. PSD CEC and O/W Separator trips: De-energizes MAD-623204,MAD-624201 Transformers Stops PBA-623211A/B Closes SDV-623204-03 after 3 sec delay Stops PBA-623208A/B Closes SDV-623204-02	O/W separator and CEC transformers O/W sep PW pumps O/W separator PW outlet crude Oil pumps O/W sep crude oil outlet
PSH-623211A/B-02	O/W separator pump discharge Pressure Safety High	2228 kPag	Stop: PBA-623211A/B	O/W sep produced water pumps
PSL-623211 A/B-02	O/W sep pump discharge Pressure Safety Low	900 kPag	Stop: PBA-623211 A/B	O/W sep produced water pumps
LSH-623204-02	O/W separator interface Level Safety High	1650 mm	De-energize MAD-623204 Transformer	O/W separator transformer
LS-L623204-02	O/W separator interface Level Safety Low	457 mm	Stop: PBA-623211 A/B Close SDV-623204-03 after 3 second delay from pump stop.	O/W sep produced water pumps o/w separator produced water outlet
LSL623204-03	O/W separator oil level Safety Low	200 mm	De-energize MAD-623204 Transformer	O/W separator transformer
LSL-623204-10	O/W separator transformer oil Level Safety Low	later	De-energize MAD-623204 Transformer	OW separator transformer
PSH-623204-10	O/W separator power entrance Tee oil Pressure Safety High	35 kPag	De-energize MAD-623204 transformer if pressure remains high for 2 seconds	O/W separator transformer

Tag Number	Description	Set Points	Action	Service
PSH-623204-11	O/W separator power entrance Tee oil Pressure Safety High	35 kPag	De-energize MAD-623204 transformer if pressure remains high for 2 seconds	O/W separator transformer
PSH-623204-12	O/W separator transformer oil Pressure Safety High	35 kPag	De-energize MAD-623204 transformer if pressure remains high for 2 seconds	O/W separator transformer
TSH-623204-10	OW separator transformer oil Temperature Safety High	100° C	De-energize MAD-623204	OW separator transformer
ISH-623204-10B Hold	OW separator Transformer Current Safety High	later	De-energize MAD-623204 transformer	OW separator transformer
LSH-624201-03A	CEC junction box Level Safety High	Factory default set point	De-energize MAD-624201 transformer	CEC transformer
LSH-624201-03B	CEC junction box Level Safety High	Factory default set point	De-energize MAD-624201 transformer	CEC transformer
LSL-624201-02	CEC transformer oil level Safety Low	4130 mm	De-energize MAD-624201 transformer	CEC transformer
PSL-624201-01 Hold	CEC panel purge Pressure Safety Low	5-inch H_2O hold	De-energize MAD-624201 transformer	CEC transformer

Record of Changes

(To be inserted at the end of the document when it is first Issued IFD, IFDC, IFC, IFU or IFI. This table shall remain a living part of the document for all subsequent document revisions at the end (last page) of the document.)

REV	LOCATION	ACTION	DESCRIPTION / REASON