Appendix F

MARMAC Report – Bayview Terminal Design Review

Pipeline Rupture and Fire
Bellingham, Washington
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OLYMPIC PIPE LINE COMPANY

Bayview Terminal Design Review

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Olympic Pipe Line Company
Bayview Terminal Design Review

1 Objective

This evaluation involved a review of pipeline operating controls, surge relief and safety devices at Olympic Pipe Line Company's Bayview Terminal. The primary objective of the evaluation was to perform design review and to suggest where changes could be made to improve the operation of the terminal (Refer to the DOT Amended Corrective Action Order Item 14(c)). The appropriateness of control valve set points or possible adverse interaction of the controls presently in place at the Terminal was investigated concurrently by Stoner Associates in their *Surge Analysis.*

Information examined in this *Design Review* included Piping and Instrumentation Diagrams, documented station operating procedures, electrical schematics, original engineering design documents and other information provided by Olympic Pipe Line Company's personnel. In addition, onsite field evaluations of the terminal have been performed.

2 Background

The Bayview Terminal's pumping equipment consists of three 1,250-horsepower units. Product transfer pump P-201 is dedicated to the 20" line out of Allen (B20"). Product transfer pump P-203 is dedicated to the 16" line out of Allen (B16"). Product transfer pump P-202 can operate as a spare for either line, or may operate in series with pump P-201 or P-203.

A 10,000 barrel transmix tank (TK-209) is provided for product interfaces arriving from the incoming Anacortes and Ferndale lines. The accumulated interface product is disposed of by injection into either the B16" and/or B20" pump suction lines.

All products from Ferndale or Anacortes must pass through Bayview. Bayview Terminal functions as a Bypass Metering Station providing line surveillance.

The Bayview Terminal functions in the following operating modes relative to the incoming and outgoing pipelines:

- It is the Receiving Terminal and storage facility for the Anacortes and Ferndale refinery products for delayed shipment to the two southbound pipelines. Product streams may be directed to five 100,000 barrel tanks for storage.

- It is an Originating Station from the Terminal for either the B16" or B20" lines that go to Allen Station.

- It can function as a Booster Station for either the B16" or B20" lines to Allen with a product tank "floating" on pump suction.
- It can operate as a Tight-Line Booster for either the Anacortes or Ferndale B16" or B20" lines to Allen Station.

Of the operating modes described above, the one having the greatest impact on Ferndale to Allen pipeline hydraulics is "tight-line" operating case. Tight-lining and boosting at Bayview is a desirable mode of operation as well, since it maintains product integrity during interface passage.

3 General Description of Operating Modes

Bayview Terminal is designed to improve the efficiency, capacity and reliability of Olympic Pipe Line Company by providing breakout storage near the origin of the product into the line. It allows Olympic to create true fungible products which releases additional capacity. It also permits Olympic to run all four of its mainline segments relatively independent of each other, thereby permitting each line to be run ratably, the most efficient way for a pipeline to be run.

Bayview operations include: (1) receipt of product into one of five storage tanks from either or both the Ferndale or Anacortes area refineries; (2) pumping product from one of five tanks into either the 16" Allen to Renton line and/or the 20" Allen to Renton line; or (3) tight-line product directly from either Ferndale or Anacortes refineries to the 16" Allen to Renton line or the 20" Allen to Renton line. Product may flow through Bayview without being re-pumped or the booster pumps at Bayview may be used to boost product being tight-lined. Tight-lining is defined as flowing through Bayview facilities without the product having an outlet to a tank. In tight-line operation, the Bayview pump station acts as a remote booster pump on the suction to Allen station pumps. Relief valves at Bayview protect both the ANSI 150 and 300 series piping from both over pressure and surges.

When a tank is both open to receiving product and providing suction to an outgoing line, the product is "floating on tankage".

3.1 Receipts into Bayview from Ferndale

The Ferndale to Bayview 16" line comes into Bayview Terminal through the Ferndale Receiver Trap and block valve MV-1902 and MV-1907. Control valve CV-1904 provides pressure reduction to protect the ANSI 300 series piping in the receiving manifold and pump station suction lines from high mainline pressure. CV-1904 will close to protect downstream piping from exceeding 500 PSIG.

Relief Valve RV-1919 provides secondary protection for the Terminal, relieving to Tank 209 if the pressure exceeds 600 PSIG. Should this relief flow start, an alarm from FS-1919 will be transmitted to Local OMI, the Renton Control Center and the Ferndale PLC. Once Ferndale senses relief flow from FS-1919 for 45 seconds, any Ferndale units running will be staged down by the Ferndale PLC.

Should CV-1904 and RV-1919 fail to protect the station piping from overpressure, pressure switch PS-1911 will close scraper inlet valve MV-1902 if pressures inside Bayview reach 700 PSIG. This valve closes in approximately one minute, isolating Bayview from the incoming Ferndale flow. Should this create a surge on the mainline that exceeds 1000 PSIG, the mainline relief valve RV-2229 will relieve to Tank 209. An alarm from FS-2229 will be transmitted to the Local OMI, the Renton Control Center and the Ferndale PLC. Once Ferndale senses relief flow from FS-2229, any Ferndale units running will be staged down by the Ferndale PLC after a one second delay.

Product received is metered through a turbine meter (not used for custody transfer). Downstream from the turbine meter is Control Valve CV-1951, which maintains a minimum backpressure on the meter facility. The operator can also set in a flow rate through the SCADA system or the OMI through CV-1951, which also maintains sufficient hill pressure to maintain line pack. From SCADA or from the Local OMI, the operator can set a lower pressure to effect an orderly shutdown and maintain backpressure after shutting down the upstream pump units.

Incoming flow can either be directed to tankage or may be tight-lined to the suction of P-201 or P-202 booster pumps. Tankage can be accessed through either the B16" Incoming Header or B20" Incoming Header, with access to the B16" Incoming Header by opening valve MV-2220 and the B20" Incoming Header by opening MV-2219. Automatic sequencing closes the other valve when the Ferndale incoming is commanded from SCADA or the Local OMI to switch headers. The Operator in the Control Center or at the Local OMI must also sequence the appropriate incoming manifold valves for the proper tank being filled when the incoming header product source is switched. For example: if Ferndale is delivering to Tank 206 through the B16" Incoming Header, prior to the switch being commanded to the B20" Incoming Header, the operator must open MV-2034, perform the switch (MV-2219 opens, then MV-2220 closes) and then close MV-2040.

3.2 Receipts into Bayview from Anacortes

The Anacortes to Bayview 16" line comes into Bayview Terminal through the Anacortes Receiver Trap and Block valve MV-1914 and MV-1912. Control Valve CV-1916 provides pressure reduction to protect the ANSI 300 series piping in the receiving manifold and pump station suction lines from high mainline pressure. CV-1916 is programmed to close off to protect downstream piping from exceeding 500 PSIG. From

SCADA or from the Local OMI, the operator can set a lower pressure to effect an orderly shutdown and maintain backpressure after shutting down the upstream pump units.

Relief Valve RV-1923 provides secondary protection for the Terminal, relieving to Tank 209 if the pressure exceeds 600 PSIG. Should this relief flow start, an alarm will be transmitted to Local OMI and the Renton Control Center.

Should CV-1916 and RV-1923 fail to protect the station piping from overpressure, pressure switch PS-1929 will close MV-1914 if pressures reach 700 PSIG. MV-1914 will close in approximately one minute.

Product received is metered through a turbine meter (not used for custody transfer). Downstream from the turbine meter is Control Valve CV-1946, which maintains a minimum backpressure on the meter facility. The operator can also set in a flow rate through the SCADA system or the OMI through CV-1946, which also maintains sufficient hill pressure to maintain line pack. (The flow rate setpoint can also be set to CV-1946 when delivering to tankage. Flow rate control should not be used in tight-line operations.)

Incoming flow from Anacortes can either be directed to tankage or may be tight-lined to the suction of either P-201, P-202 or P-203 pumps. Tankage can be accessed through either the B16" Incoming Header or B20" Incoming Header. Access to the B16" Incoming Header is gained by opening valve MV-2222. Flow from Anacortes to the B20" Incoming Header is achieved by opening MV-2221. Automatic sequencing closes the other valve when the Anacortes incoming is commanded from SCADA or the Local OMI to switch headers. The Operator in the Control Center or at the Local OMI must also sequence the appropriate incoming manifold valves for the proper tank being filled when the incoming header product source is switched. For example, if Anacortes is delivering to Tank 206 through the B16" Incoming Header, prior to the switch being commanded to the B20" Incoming Header, the operator must open MV-2034, perform the switch (MV-2221 opens, then MV-2222 closes) and then close MV-2040.

3.3 Delivery out of tankage to the 16" Allen to Renton line

Bayview Pump Station serves as a booster facility to the Allen Pump Station. To deliver to the 16" Allen to Renton line, the appropriate tank header valve on the B16" Outlet manifold must be opened along with MV-1999, the B16" Outlet Pump suction valve. Normally only Pump P-203 is dedicated to feeding the 16" Allen Station Pumps. This 1,250 horsepower pump starts with open suction and discharge valves.

Pump P-202 is designed to be a spare to Pump P-203 and may be used in series with Pump P-203. The Operator can start Pump P-202 from the SCADA or Local OMI as long as the unit is configured to feed the B16" Outlet Header. This requires closing valves MV-1986 and MV- 1990 and opening MV-1989 and MV-1987. When the valves have completed travel, the pump can start feeding the B16" Outlet Header. MV-1986 and MV-1990 will be "soft-tagged" out of service at the Renton Control Center.

The B16" Outlet Header is metered by Flow Meter FE-1969. The pump units will be shutdown if low flow is recorded for more than 2 minutes.

Since the Bayview pumps act in this alignment only as tank booster pumps feeding nearby mainline originating Pump Stations, the Operations Controller will not need to control discharge pressure and flow rate. Control valve CV-1969 therefore will be forced to 100% open (no PLC modulating control). Pressure switch PS-2010 will shutdown P-202 and P-203 if the case pressure reaches 700 psig. Downstream from CV-1969, Relief Valve RV-1941 provides protection downstream and is set to relieve into Tank 209 if the pressure exceeds 600 PSIG.

The discharge line then runs to the 16" Launcher and then 2.1 miles to Pump Units 1, 2 and 3 (16" line) at Allen Pump Station. Again, when originating out of Bayview tankage, the Bayview Booster Pumps act as tank boosters feeding Allen Station.

<u>3.4 Delivery out of tankage to the 20" Allen to Renton</u>

Bayview Pump Station serves as a booster facility to the 20"Allen Pump Station. To deliver to the 20", the appropriate tank outlet valve on the B20" Outlet manifold must be opened along with MV-2000, the B20" Outlet Pump suction valve. Normally both Pump P-201 and Pump P-202 are dedicated to feeding the 20" Allen Station Pumps. Pump P-201 would be started first. This 1,250 horsepower pump starts with open suction and discharge valves. From SCADA or the Local OMI, the Operator can also start Pump P-202 in series with or in place of Pump P-201.

To start Pump P-202 to the 20" Allen-Renton line, valves MV-1987 and MV-1989 must be closed and "soft-tagged" out of service at the Renton Control Center. Pump valves MV-1986 and MV-1990 will have to be open and Pump P-202 can then be started.

The B20" Outlet Header is metered by Flow Meter FE-1963. The pump units will be shutdown if low flow is recorded for more than 2 minutes.

As with the 16", when delivering to the 20" line from Bayview tankage, the Bayview Pump Station acts like a tank booster pump feeding a nearby Mainline station. It will not be necessary or desirable to control the discharge pressure or flow rate through CV-1963. Therefore, CV-1963 will be forced to 100% open (no PLC modulating control). Pressure Switch PS-1979 will shutdown P-201 and P-202 if the case pressure reaches 700 PSIG. Downstream from CV- 1963, the Relief Valve RV-1932 provides protection and is set to relieve into Tank 209 if the pressure exceeds 600 PSIG. The line then runs to the 20" Launcher and then the 1.8 miles to Pump Units 1 and 2 (20" line) at Allen Pump Station. Bayview Booster Pumps act as tank boosters feeding Allen Station.

3.5 Tight-line Operations Through Bayview

The number of product segregation's moved by Olympic will generally exceed the number of tanks available, requiring tight-lining through the Bayview Inlet manifolding. The crossover valves (MV-2219, MV-2220, MV-2221 and MV-2222) permit correct alignment of tight-lined product from either Ferndale or Anacortes sources to either the 16" Allen to Renton line or the 20" Allen to Renton line. While product can be delivered to tankage from either incoming header, tight-lined product must be properly aligned in the correct inlet header to feed the correct outgoing line.

The configuration of the Inlet manifold and crossover Valves is as follows for tight-line operations:

	MV-2219	MV-2220	MV-2221	MV-2222	MV-2007	MV-2008
Ferndale to B20"	OPEN	CLOSED	CLOSED*	OPEN *	OPEN	
Ferndale to B16"	CLOSED	OPEN	OPEN*	CLOSED *		OPEN
Anacortes to B20"	CLOSED+	OPEN +	OPEN	CLOSED	OPEN	
Anacortes to B16"	OPEN+	CLOSED+	CLOSED	OPEN		OPEN

* = Dependent on Anacortes Line Operation
+ = Dependent on Ferndale Line Operation

The crossover valves can be lined up prior to the arrival of the first tight-lined product to Bayview, making the proper alignment and valve swings with compatible product in both incoming headers.

Tight-lined products must be brought into Bayview adjacent to compatible products. Tight-lined products can be either stopped in the appropriate inlet header and then the line restarted as if from either Anacortes Station or Ferndale through the appropriate Allen Pump Station (16" or 20"). Alternately, SCADA and the OMI will permit swinging to the tight-lined product on the fly upon arrival in the header. A command is issued to open MV-2008 or MV-2007. When this valve is open, either MV-1999 or MV-2000 will close respectively.

Tight-lined product may be boosted by the Bayview Booster pumps or just allowed to flow through the station. During tight-lining operations, flow control should not be attempted on the incoming control valve CV-1946 or CV-1951.

3.6 Bayview Tank Transfer Operations

Product may be transferred under local control from one tank to another by use of the tank transfer pump, P-205. This 500 GPM centrifugal pump is manifolded to take suction directly from or discharge directly to the 6" product transfer line that runs from each tank (except Tank 209, the interface tank) or the 20" tank fill/suction lines. For Tank 209, the manifolding permits suction or discharge from/to the 16" tank and relief line only. Since each 6" tank transfer line is manifolded at each tank to be able to access the 4" line (which runs inside the tank to the sump), the transfer pump can be used to empty a tank to another tank for change of service. With the exception of Tank 209, it is also possible to circulate a tank using pump P-205.

3.7 Gasoline to Fuel and Fuel to Gasoline interface handling at Bayview

Gasoline to Fuel and Fuel to Gasoline Interfaces may be handled at Bayview in two ways.

1. Tight-lining the interface through Bayview:

This requires that the by-pass to pump valve(s) opens, (MV-2007 or MV-2008), then the open tank inlet valve on the Inlet Header closes along with the Outlet Header to the pump valves (MV-1999 or MV-2000). This could require isolation, draining and re-filling the associated Outlet Manifold to avoid product contamination (estimated volume in the Outlet Headers is 35 barrels). Tight-lining the interface requires carefully scheduling the arrival time, management of the arrival time (shutdown or slowdown of the incoming or outgoing stream) or Control Center created schedule changes (tender size reductions).

2. Taking the interface into Tank 209:

This requires taking the interfaces through tanked products and involves swinging to Tank 209 with the interface. All manifold valves on the Inlet Headers take 60 seconds to operate and one valve must be sequenced open at all times. This means that the amount of product taken to Tank 209 is likely to be determined by the flow rate and the time required to sequence the valves rather than the actual size of the interface. While swinging of the tank inlet valves will increase the amount of interface material that must be handled, this method does provide a great deal of flexibility in scheduling products.

3.8 Injection Pump Operations

The Gasoline pump at Bayview Terminal has the ability to inject interface material from Tank 209 into either outgoing stream. The injection pump, P-206, is a Wheatley Gaso duplex plunger pump. It is capable of injecting at a rate of 50 GPM, up to a pressure of 740 PSIG.

3.9 Full Flow Reliefs

The Bayview design includes full-flow relief valves to protect the ANSI 300 series and ANSI 150 series piping in the facility. On the incoming side of the facility, ANSI 300 series piping is protected by RV-1919 (Ferndale) and RV-1923 (Anacortes). Outgoing ANSI 300 series piping is protected by RV-1941 (B16" Outlet) and RV-1932 (B20" Outlet). The ANSI 150 series piping includes five (5) tank headers and two (2) outgoing manifolds, each of which is protected by an individual relief valve.

4 Bayview Terminal Control Description

The following is a description of the Bayview Terminal controls that are involved in receipt of products from the Ferndale 16", through the B20" Outlet Header and on to Allen Station. The receipt of products from Anacortes will involve a similar control configuration.

The incoming Ferndale 16" line pressure (ANSI 600# class) is PLC monitored by a pressure transmitter PT-1901. A new surge relief valve has been installed in the incoming line as a result of the Surge Analysis study to reduce potential pipeline pressures. The new valve is designated as RV-2229 and is set to open at 1,000 PSIG. A new flow switch FS-2229 will initiate an alarm condition to the PLC indicating that the relief valve is opened due to a product flow into transmix tank number TK-209. FS-2229 will also initiate shutdown of pumps at Ferndale.

An electro-hydraulic control valve CV-1904 regulates the incoming pressure. It is pressure controlled from Transmitter PT-1911 through the PLC. The pressure limiting set point on CV-1904 is 500 PSIG.

The intended function of control valve CV-1904 and relief valve RV-1919 is to ensure the pressure in the ANSI 300# pressure class rating from ANSI 600# to ANSI 300# downstream of CV-1904 is maintained within the ANSI 300# rating.

If the pressure reaches 700 PSIG on the 16" line (ANSI 300# class) downstream of CV-1904, PS-1911 will command MV-1902 to close, resulting in a station shutdown. An 8" relief valve, RV-1919, protects piping and equipment. This relief valve is set to open at 600 PSIG, relieving the product into transmix tank TK-209. A new flow switch, FS-1919, will initiate an alarm condition to the PLC. FS-1919 also initiates shutdown of Ferndale pumps after 45 seconds of relief flow.

Between CV-1904 and incoming flowmeter FE-1904, the line product is filtered through a strainer. The strainer is equipped with a PLC-monitored pressure differential transmitter DPT-1962. Thermal relief valves (1"), which protect piping and equipment, are set at 740 PSIG allowing the pressure to be thermally relieved into the high pressure drain header leading to the product sump (V-211).

Downstream from the flowmeter FE-1904 is an electro-hydraulic control valve CV-1951. The valve is a PLC controlled backpressure regulator using the signal from pressure transmitter PT-1951 and also from PT-1901 that ensures that the incoming pipeline will remain packed when the pipeline is shutdown. The control valve may also respond to a flowrate setting over-ride from FE-1904 provided the minimum pressure settings are satisfied.

After incoming metering, the product flows to a valve manifolding system and to tanks for storage and withdrawal. The five 20" lines to the tanks are each protected from overpressure by 8" relief valves open at 215 PSIG discharging into the transmix tank TK-209. The Ferndale and Anacortes Outlet manifolds are also protected from overpressure by 8" relief valves open at 265 PSIG. The five 20" lines and the two (2) outlet manifolds will each be equipped with new valve position switches to monitor the relief valve(s) opening and then send a signal to the PLC.

A 1,250 HP product transfer pump P-201 is dedicated to moving the Ferndale product to Allen Station. Product Transfer Pump P-202 is a spare unit, normally set for service to the B20" Outlet Header but can be put in service to the B16" Outlet Header.

Downstream of Pump P-201 is a strainer equipped with a PLC-monitored differential pressure transmitter DPT-1977. Thermal relief valves (1"),which protect piping and equipment, are set at 740 PSIG, allowing the pressure to be relieved into the high pressure drain header located underground.

Control valve CV-1963 is now forced to remain 100% open. Surge relief valve (8") RV-1932, open at 600 PSIG, is located downstream from the control valve and provides protection for the lower (ANSI 300#) class line. A new flow switch, FS-1932, will indicate a flow alarm condition to the PLC indicating that relief valve RV-1932 is open due to product flow into transmix tank TK-209. The product arrives at the (ANSI 600# class) scraper launcher and leaves Bayview for Allen Station.

5 Pump Controls Analysis

Each of the three existing pumping units is driven by a 1250 HP electric motor. Each motor is controlled by means of a Class E2 medium voltage starter. The starters are part of a 4160 V switchgear/MCC lineup located inside a walk-in enclosure, comprising a main circuit breaker, a fused switch feeding a step-down transformer and the three motor starters. This arrangement is considered standard for the industry and is typical for other stations and terminals along Olympic's pipeline.

The main circuit breaker and MCC bus are rated 1200 A at 4160 V. Metering and relaying for the main circuit breaker are provided by a Multilin PQM metering unit and a Multilin SR735 protective relay. These devices continuously monitor the main feeder conditions and will automatically trip the main circuit breaker in case of sustained overload or short-circuit.

Each motor starter comprises a set of three R rated fuses, a three-pole contactor, a Multilin 269 Plus protective relay, current transformers (CT) and other appurtenant devices. The fuses provide starter and feeder protection against short-circuit conditions. The function of the fused contactor is to close and open the motor circuit during normal operation, as well as during overload and fault conditions.

The Multilin 269 Plus relay is a microprocessor based device, designed to provide comprehensive protection for industrial motors and their associated mechanical systems. The relay will detect and alarm for motor and pump protective conditions (unbalanced phase currents, ground fault, motor winding and motor bearing high temperature, pump case and pump bearing high temperature). If conditions exist for an interval longer than a preset time delay, the relay will cause the contactor to open by means of its normally closed "Trip" contact wired in series with the start circuit.

Pumps can be started manually by placing the HOA selector switch located at the pump in the "Hand" position and pushing the manual "Start" button. Placing the HOA switch in the "Off" position will stop the pump. The Multilin relay will shutdown the pump if a trip condition is present. There are no other permissive interlocks (PLC or field devices) to inhibit starting and running the motor in manual mode. The manual mode is intended only for testing and maintenance purposes (such as to check for proper pump rotation).

The normal mode of operation is automatic, with the HOA selector switch placed in the "Auto" position. In automatic mode, the motor contactor is controlled by an output contact of the station PLC wired in series with the start circuit.

In automatic mode, start and stop commands are sent to the PLC from the Renton control center. The motor will run as long as the corresponding PLC output contact is closed, provided no Multilin trip conditions are present.

There is a stop shutdown pushbutton located at each pump to shut the unit off in an emergency. Its normally closed contact is wired in series with the motor start circuit in both manual and automatic modes of operation.

In conclusion, we found the configuration of the pumping unit controls to conform to recognized industry standards and practices and therefore we consider the unit controls adequate for safe operation of the system.

6 Electrical System Protection Coordination

Electrical system protection coordination diagrams have been prepared for Bayview. Each diagram includes curves for motor, motor relay, motor fuse, main circuit breaker relay, utility transformer and transformer primary fuse.

The motor relay settings were found to be adequate for equipment protection. While not critical, the following adjustments should be considered in order to achieve the best possible protection of the equipment:

The motor full load current (FLC) is presently set at 1.10 x motor nameplate FLC and the overload pickup level at 1.05 x FLC. To provide a more accurate protection the FLC value should be set equal to motor nameplate FLC and the pickup level at 1.15 x FLC for motors with 1.15 service factor.

The motor acceleration time is presently set at 5 seconds for all motors. This value should be set in accordance with actually determined values.

Rapid trip level and delay are set at 2.5 x FLC and 3 seconds. This feature is of questionable value in protecting centrifugal pumps and should be turned off.

The short circuit trip level is set at 9 x FLC (full load current) with zero time delay (instantaneous). This feature should not be used on Class E2 starters, where fuses provide the primary source of short circuit protection. Premature contactor failure is more likely if the starter opens under short circuit conditions.

The overload curve number is presently set at 2 for all motors. The curve should be selected in accordance with actual motor accelerating time: the longer the accelerating time, the higher the curve number.

To evaluate coordination between motor protective devices and electrical system components on their line side, curves for utility transformer, transformer primary fuse and main circuit breaker relaying were obtained. The most probable values based on utility practices were used to evaluate coordination between the Utility and the Bayview main circuit breaker.

The main circuit breaker is protected by:

- Feeder Protection Relay, Multilin # SR735, Microprocessor based.
- Power Quality Meter, Multilin # PQM, also Microprocessor based.

The Multilin # SR735 relay provides time overcurrent and adjustable instantaneous overcurrent protection. The main trip output of the relay is used to activate the main breaker trip coil in the event of a fault.

The PQM is a continuous monitoring device of electrical current, voltage, real and reactive power, energy use, power factor and frequency data. It includes basic alarm on over/under current or voltage, unbalance, power factor, and demand loads and if the power system exceeds or deviates from the nominal setpoints. The auxiliary output No. 1 of this device is wired to trip circuit of the main circuit breaker. The main circuit breaker will trip on a phase sequence reversal and/or abnormal undervoltage conditions.

7 Mechanical Design Evaluation

The tight-line operation mode at Bayview utilizes more equipment because the transfer through the Terminal involves piping systems and equipment that are not rated at the same pressure class as the incoming and outgoing pipelines. Previous Terminal control was complicated by the interaction of 2 modulating control valves on the incoming lines (Ferndale and Anacortes) as well as B16" and B-20" outlet lines (when considering Bayview Terminal booster pump operation in conjunction with Allen Station operation). This is being improved by minimizing control actions relative to the mode of operation being performed.

Pipeline booster stations along pipelines are more typically designed such that all the station piping, equipment, flanges and fittings are the same as the rest of the pipeline, in this case ANSI 600#. At Bayview the transitory piping and equipment is ANSI 300#. The original engineering design has required the use of more equipment being applied (3 piping class specifications) and has caused some equipment to be installed that is not functionally necessary . However, using more equipment than is functionally necessary does not violate applicable design codes.

The Bayview Terminal being a facility associated with an interstate pipeline is subject to design criteria specified in the Federal Pipeline Safety Standards delineated in 49 C.F.R. Part 195, subpart D – Construction. Incorporated by reference into the Federal Regulation is the industry design code, ASME/ANSI B31.4 "Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols".

Field investigators, during the course of this evaluation have noted some possible discrepancies relating to the welding of support brackets to the scraper trap assemblies. The aforementioned Federal Pipeline Safety Standard in §195.208 prohibits the welding of supports or braces directly to pipe that will be operated at a pressure of more than 100 PSIG. Subsequent interpretations of this performance standard by the Department of Transportation have addressed the basis for this restriction. In clarifying the intentions of the regulation, the DOT has affirmed that the welding of supports, braces and anchors in accordance with criteria set forth in §421.1 of ASME /ANSI B31.4-1974 will satisfy the requirements of §195.208 in Part 195.

As Built / Certified design drawings received from the fabricator of the scraper traps confirmed the method of welded attachment of the bracket to the scraper barrels. A ½" thick reinforcing saddle (wear plate) was used, rather than a full encirclement cylindrical reinforcement. The requirement for use of a full encirclement sleeve is further described in Section 421.1(d) of the B31.4 ASME design code that states:

"If pipe is designed to operate at or close to its allowable stress, all connections welded to the pipe shall be made to a separate cylindrical member which completely encircles the pipe, and this encircling member shall be welded to the pipe by continuous circumferential welds".

The fabricator's drawings also indicate that the traps have been built in accordance with the ANSI B31.4 design code using a design factor of 0.72. Allowable stress for the pipe used in the pig traps (20" x 0.500"w.t., API 5L X52 and 16" x 0.500"w.t., API 5L X52) is 0.72 x 52,000 PSI = 37,440 PSI. By using Barlow's formula, the stress at design pressure is:

16" = 23,040 PSI which is 61.5% of the allowable stress.
20" = 28,800 PSI which is 76.9% of the allowable stress.

It is the opinion of the scraper trap fabricator that the 120^0 wear plates they used will adequately resist any local stress imposed on the pipe at the supporting brackets. The scraper trap fabricator is very confident that their support design complies with the intent of B31.4 & DOT 195. See attached documentation from the scraper trap fabricator, Sagebrush Pipeline Equipment Co.

8 Recommendations

The installation of a reliable pressure relief valve on the incoming 16" Ferndale pipeline at Bayview providing additional mainline surge protection as recommended in the *Surge Analysis* has been completed. The new surge relief valve will open if the incoming pressure from Ferndale exceeds 1,000 PSIG.

The setpoints shown in Olympic Pipe Line's Intranet Operating, Maintenance and Procedures Manual for control valves CV-1904, CV-1916, CV-1963 & CV-1969 and relief valves RV-1919, 1923, RV-1933 & RV-1941 have been revised based on the results of the Surge Analysis Report, field testing and evaluations set forth in this report. All instruments have been field checked for ranges and settings and Bayview Terminal drawings (Piping and Instrumentation Diagrams (P&IDs), Logic Diagrams, and Electrical and Mechanical drawings) have been or are in the process of being updated. The Olympic Operating , Maintenance and Procedures Manual has been revised to reflect the Terminal modifications described in this report.

In order to achieve the best possible equipment protection and coordination between protective devices, adjust Multilin 269 Plus motor relay settings according to recommendations outlined in section "Electrical System Protection Coordination" above.

9 Summary of Changes to Original Design

All of the following changes have been implemented or are in the process of being implemented as further discussed below. These changes are characterized in one of three categories: 1. Overcoming design deficiencies, sections 9.2 and 9.5; 2. Providing design improvement, sections 9.3, 9.4, 9.6 and 9.7; and 3. Providing operational improvement, sections 9.1 and sections 9.8 - 9.17.

9.1 Anacortes System Bypass Piping

A temporary bypass was installed on the Anacortes system within the Bayview Terminal to allow it to remain in service while modifications were being made on the relief header system. This temporary bypass will be removed once a station check has been completed. Originally, this piping arrangement wasn't in place. This "temporary piping" allows product from Anacortes to bypass the Bayview Terminal, which facilitated the changes made at Bayview Terminal. This modification is an operational improvement.

9.2 Relief Valve Connection (P&ID – D-1902)

The piping connection for relief valves RV-1919 and RV-1923 was changed from bottom of pipe to top of pipe to prevent trash and debris accumulation impairing relief valve operation. Originally, the piping from the main headers (Anacortes and Ferndale Incoming) came off the bottom of the piping to these relief valves. This change modifies a design deficiency from the original construction

9.3 Relief Valve – Ferndale Line (P&ID – D-1902)

Although not required to maintain surge pressures below 110% of MAOP, as a result of the *Surge Analysis*, it was determined that a surge relief valve would be effective in reducing surge pressure on the pipeline that could result if MV-1902 were to close inadvertently against the incoming stream from Ferndale Station. Surge relief valve RV-2229, set to relieve at 1000 PSIG, along with flow switch FS-2229 have been installed. Actual surge flow testing in the field has resulted in changing the setpoint of RV-2229 to 900 psig so that the valve opens at 1000 psig. This surge valve is new, determined from case studies of the Surge Analysis Report. This modification is a design improvement, consistent with revised lower operating pressures on the Ferndale to Allen segment.

9.4 Relief Flow Indication (P&ID – D-1902 and D-1905)

Original design incorporated one flow switch, FS-2099, to indicate flow to TK-209 which could originate from multiple sources as follows:

Donut Manifold Relief Valves (RV-2002 and RV-2005)
Tank Header Relief Valves (RV-2065, RV-2072, RV-2077, RV-2082 and RV-2088)

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Sump Pump (P-208)
Incoming Pipeline Relief Valves (RV-1919, RV-1923, RV-1932 and RV-1941)

Flow switch, FS-2099, has been disabled to improve operator understanding of events. In addition to the new Relief Valve on the incoming Ferndale pipeline, RV-2229 and it's dedicated flow switch FS-2229, individual flow switches have been added to the following relief valves:

RV-1919, FS-1919 |
RV-1923, FS-1923 |== P&ID – D-1902
RV-1932, FS-1932 |
RV-1941, FS-1941 |

The flow switches are new. They are a design improvement to identify the ANSI 600 piping product flow to TK-209.

In order to provide better indication as to the flow source to tank TK-209, stem position indicator switches are being added to the relief valve piston and will indicate when the valve has begun to lift and flow:

RV-2002, XS-2002 |
RV-2005, XS-2005 |
RV-2065, XS-2065 |
RV-2072, XS-2072 |== P&ID – D-1905
RV-2077, XS-2077 |
RV-2082, XS-2082 |
RV-2088, XS-2088 |

These flow switches and position indicators on all the relief valves will provide better indication of relief valve flow source to TK-209. Because each relief valve will need to have its disk machined to receive the position indicator, this modification will take place by changing each relief valve out one at a time over the next 6 months. These changes are a design improvement to identify the source of product flow to TK-209.

If relief line flow is present at Bayview from relief valves RV-2229 or RV-1919, an alarm signal will be sent from Bayview to Renton. After a time delay (45 seconds for FS-1919 and 1 second for FS-2229), Bayview's PLC will send a signal to Ferndale's PLC to stage down any running Ferndale units. Logic will be incorporated in the Bayview PLC to allow periodic relief valve inspection or check without shutdown of Ferndale units.

9.5 Valve Closure Stops Removed

Stops on CV-1904 and CV-1916 (P&ID – D-1902 and D-1903), that prevented control valves CV-1904 and CV-1916 from fully closing, were removed in August. Removal of the closure stop modifies a design deficiency (to protect downstream piping by closing the valve(s)).

9.6 Control Sensor Moved

In July, downstream pressure control sensor for control valve CV-1904 was moved from PT-1951 (P&ID – D-1903) to PT-1911 (P&ID – D-1902) and downstream pressure sensor for control valve CV-1916 was moved from PT-1946 (P&ID – D-1903) to PT-1929 (P&ID – D-1902) for more stable control valve sensing. The original sensing tap was at the inlet side of the pump(s). Changing this sensing location facilitates the changes made in section 9.10. This change is a design improvement for quicker sensing for pressure control.

9.7 Control Valve and Surge Relief Settings

The following pressure settings have been changed:

- CV-1904 from PT-1911 set at 500 PSIG
- RV-1919, RV-1923, RV-1941 and RV-1932 set at 570 PSIG to open at 600 PSIG
- CV-1916 from PT-1929 set at 500 PSIG
- RV-2002 and RV-2005 set at 250 PSIG to open at 265 PSIG
- RV-2077, RV-2072, RV-2082, RV-2088 and RV-2065 set at 200 PSIG to open at 215 PSIG

Upon further operational review of the control valves in October, the changes outlined below provide a design improvement in the operation of the terminal:

	Current Inputs	Revised Inputs	
CV-1904	PT-1901 ++		
	PT-1911	PT-1911	|==P&ID – D-1902
	FT-1904 ++		
CV-1916	PT-1921 ++		
	PT-1929	PT-1929	|==P&ID – D-1902
	FT-1916 ++		

++ = Setpoint can be changed from Renton

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Control valves CV-1904 and CV-1916 will limit pressure downstream from the control valve and work in conjunction with RV-1919 and RV-1923 respectively to protect the ANSI 300# piping. The changes made were to make CV-1904 and CV-1916 primary function to limit pressure downstream from the control valves to protect the ANSI 300# piping system and minimize interaction between these control valves and other downstream control valves at Bayview.

	Current Inputs	Revised Inputs
CV-1951	PT-1951	PT-1951 | PT-1901++|==P&ID 1903– D- FT-1904 ++|
CV-1946	PT-1946	PT-1946 | PT-1921++|==P&ID – D-1903 FT-1916 ++|

++ = Setpoint can be changed from Renton

Control valves CV-1951 and CV-1946 will provide minimum back pressure to the incoming meter (PT-1951 and PT-1946 respectively), provide mainline backpressure/linepack (PT-1901 and PT-1921 respectively) and vary incoming flow rate (via FE-1904 and FE-1916 respectively). These changes were made to make CV-1951 and CV-1946 the primary incoming control valves affecting flow into the station and any pressure backup to the incoming pipelines.

	Current Inputs	Revised Inputs (none-100% open)
CV-1963	FT-1963 ++ PT-1971 ++	
		==P&ID – D-1903
CV-1969	FT-1969 ++ PT-1988 ++	

++ = Setpoint can be changed from Renton

Control valves CV-1963 and CV-1969 provided maximum discharge pressure control (PT-1971 and PT-1988 respectively) and control/vary outgoing flow rate (via FE-1963 and FE-1969 respectively). The control valves have been set to remain 100% open. ANSI 300# piping protection will be provided by RV-1932 (B20" Outlet) and RV-1941 (B16" Outlet) (P&ID – D1902) and control (case) pressure switches (P&ID – D-1903 – PS-1979 and PS-2010). Pressures (PT-1971 and PT-1988) and flows (FT-1963 and FT-1969) will become indication only. Originally, the design of the flow through the terminal, had 2 control valves modulating flow (consider one line only) to the suction of the pumps and control valve discharge modulating to a very close (proximity) pump station (Allen Station - which also controlled to minimize the station inlet pressure and maximize the station outlet pressure). The control interactions between the Bayview

Terminal and Allen Station equipment are improved by minimizing the number of controlled components at Bayview Terminal. The changes provide a design improvement in the operation of Bayview Terminal.

9.8 Setpoint Clamps – Bayview

None of the controllers were initially provided with "setpoint clamps". Local "setpoint clamps" have been added to all controllers that can be locally varied to prevent locally loaded settings outside of operating limits. These modifications are an operational improvement.

9.9 High Pressure Shutdowns/Alarms (P&ID – D-1903)

PS-1979 Control (Case) Pressure on B20" Outlet and PS-2010 Control (Case) Pressure on B16" Outlet shuts down the pumping units in the event of high control (case) pressure. While functional, they had not alarmed locally or remotely (Renton). Local and remote alarm indication has been implemented to provide better operational knowledge of unit shutdown cause. These modifications are an operational improvement.

9.10 Unit Suction Pressure Transmitters (P&ID – D-1904)

The individual pumping units were provided with pressure transmitters (P-201 – PT-2016, P-202 – PT-2022 and P-203 – PT-2028) that are used for unit suction pressure monitoring only, no control. PT-2022 is being relocated to the suction header for P-201 and P-202 upstream of CK-1985. PT-2028 is being relocated to the suction header for P-202 and P-203 upstream of CK-1991. PT-2016 is being eliminated. This change removes PLC control logic (used in previous control of station control valves) for transmitters that now provide only indication, not any pressure controller input. These changes simplify the information presented to Operations without compromising functionality. These modifications are an operational improvement.

9.11 Unit Starting Sequence

In the past starting sequence, motors start after suction valve is open and discharge valve is travel, but are not fully open. The unit suction/discharge valves are plug type double block and bleed type valves and until the valve is fully open can experience high velocities that can accelerate seat wear. The motors have sufficient acceleration speed/torque for "open valve" or "loaded" starting. Once Bayview can pump product, test starts will be performed to validate "open valve" or "loaded" starting. Originally, this starting sequence, along with the operation of pumps at Allen has caused nuisance shutdowns from Allen Station " pulling away " from Bayview Terminal. These modifications are an operational improvement.

9.12 Suction Manifold Vents (P&ID – D-1904)
In order to facilitate piping drain up, 1" vent valves were installed on the pump station suction manifold piping. These vents are new and facilitate the operation drain up. These modifications are an operational improvement.

9.13 Crossover Valves (P&ID – D-1905)
Crossover valves (MV-2219, MV-2220, MV-2221 and MV-2222) to switch the incoming Ferndale and Anacortes lines to the B16" and B20" Outlet Headers to Allen Station were installed to improve operational flexibility. Originally, this change of switching was accomplished at Allen Station. These modifications at Bayview will replace the switching previously done at Allen Station. These modifications are an operational improvement.

9.14 Replace MV-1985 with check valve CK-1985 (P&ID – D-1904)
This change is made to reduce circulation of product from the P-202 discharge back to suction during pump startup and will improve the operational characteristics of this pump (P-202). Originally, a motor -operated valve performed this function and this function is better handled mechanically with a check valve. This modification is an operational improvement.

9.15 Revise Surge Valves set pressure to protect ANSI 300 series piping
Surge relief valves which protect the ANSI 300 series incoming and outgoing piping were changed from original setpoint of 650 psig to a setpoint of 570 psig to be open at 600 psig. The pilot spring range was originally set at the high end of range (350-650 psig). Actual surge flow testing in the field has revised the setting to 570 psig so that the operability of the valve will be open at 600 psig. Originally and in practice today, the sensing line for the surge valves is on the body of the valve (no external sensing). Field flow testing in conjuction with the Surge Analysis Report provided by Olympic Pipe Line Co. has been utilized to increase the differential pressure range between the relief and and pipeline shutdown settings. The testing in the field has determined the setting for the relief valve based on the speed of signal response (pilot operated). These modifications are an operational improvement.

9.16 Revise Electrical Systems Motor Relay Protection Settings
Motor relay settings have been evaluated and revised to provide better equipment protection. The original motor relay settings were very adequate, but have been reviewed with regard to the rest of the Olympic Pipeline Stations to develop consistent settings for equipment protection. These modifications are an operational improvement.

9.17 Revise MV-1991 with check valve CK-1991 (P&ID –D-1904)
This change is made to reduce circulation of product from the P-203 discharge back to suction during pump startup and will improve the operational characteristics of this pump (P-203). Originally, a motor -operated valve performed this function and this function is better handled mechanically with a check valve. This is considered an operational improvement.