National Transportation Safety Board
Washington, D.C. 20594

Pipeline Operations Factual Report

Accident No.:	DCA-99-MP-008
Type of System:	Hazardous Liquids Pipeline
Type of Accident:	Rupture and fire
Location:	Dakin-Yew Water Treatment Plant, Bellingham, Washington
Date and Time:	June 10, 1999; 17:02 P.D.T.
Owner/Operator:	Olympic Pipe Line Company
Fatalities:	Three
Injuries:	Eight
Material Released:	Gasoline
Component affected:	16" steel pipeline

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The Accident

About 3:30 p.m. on June 10, 1999, a 16-inch diameter steel pipeline owned by Olympic Pipe Line Company (Olympic)[1] ruptured and released about one-quarter million gallons of gasoline into a creek that flowed through Whatcom Falls Park in Bellingham, Washington. The gasoline was ignited about 1½ hours after the rupture with the resulting fire burning approximately 1½ miles along the stream. Two young boys, both 10 years old, and a young man 18 years old were killed as a result of the accident. Eight additional injuries were documented. A single-family residence and the City of Bellingham's water treatment plant were severely damaged.

The Pipeline

The Olympic system consists of approximately 400 miles of pipelines transporting refined petroleum products from refineries in the northwest portion of Washington State to delivery locations as far south as Portland, Oregon. One 16-inch diameter pipeline originates adjacent to a refinery near Cherry Point, extends southward to a pumping station near Ferndale, Washington (Ferndale Station), that is adjacent to a second refinery, and then extends further southward through booster pumps at Bayview Products Terminal into another pumping station near Allen, Washington (Allen Station). This report will focus primarily on this segment of pipeline, which ruptured in Bellingham, Washington. A second 16-inch diameter pipeline originates near two refineries near Anacortes, Washington, and extends eastward through pumping units at Bayview Products Terminal into Allen Station. At Allen Station, these two pipelines interconnect. Extending southward from Allen Station are a 16-inch diameter pipeline and a 20-inch diameter pipeline running in parallel until a pumping station in Renton, Washington (Renton Station). A single 14-inch diameter pipeline extends from the Renton Station south to Portland. Additional lateral lines to various delivery locations form the balance of the Olympic pipeline system.

On the day of the accident, product was being pumped from Ferndale Station through the 16-inch pipeline into Allen Station and then on down the 16-inch pipeline to delivery facilities downstream of Renton Station. The following pumping facilities are located on the involved section of pipeline:

Pump Station Location	Milepost
Cherry Point[2]	0.0
Ferndale	0.0

[1] At the time of the accident, Olympic was a corporation consisting of three shareholders: Equilon Pipeline Company LLC (Equilon), Atlantic Richfield Company, and GATX Terminal Corporation, with Equilon under contract to manage operation of the pipeline for Olympic (This assertion is disputed by Equilon and is currently the subject of pending litigation to determine which entity was responsible for the operation of the pipeline at the time of the accident.). Since the accident several ownership and managerial changes have occurred within the Olympic organization with the overall result that BP is now the majority owner with responsibility for operation of the pipeline.

[2] Ferndale was the original northern terminus of the pipeline and the initial starting point for the original pipeline mileage stationing. The 5.0 miles of pipe from Cherry Point to Ferndale were added later.

Rupture Location	15.9
Bayview[3]	39.1
Allen[4]	41.4
Woodinville	86.8
Renton	112.9

Approximately 37.4 miles of the 16" diameter steel pipeline from Ferndale Station to Allen Station were originally installed in 1964. The pipeline was constructed of API X52 steel line pipe with a wall thickness of 0.312 inches with a layered coal tar, fiberglass wrap, and asbestos felt coating for corrosion protection. On February 26, 1965, this section of pipeline was hydrostatically tested to 1713 psig at Lake Samish near MP 21.8, with an approximate elevation of 260 feet. This corresponds to a test pressure of approximately 1450 psig at the high point elevation of 870 feet near MP 18.6 and 1820 psig at the low point elevation of 15 feet at the Nooksack River near MP 5.6. In January 1985, Olympic established the maximum allowable operating pressure on the pipeline segment from Ferndale to Allen at 1440 psig, which is the maximum rated working pressure for ANSI 600# components.

In 1966, a 724' section of the pipeline was rerouted to facilitate the construction of a water treatment plant by the City of Bellingham, Washington. This is the section that failed on June 10, 1999. The rerouted section of pipeline was also constructed of externally coated, API X52 steel line pipe with a wall thickness of 0.312 inches. At 2028 psig, the pressure within the pipeline would produce a hoop stress of 100 percent of the steel's specified minimum yield strength of 52,000 psi. The rerouted section of pipeline was hydrostatically tested to 1820 psig on June 20, 1966, prior to being placed into service. The maximum design pressure for this section of pipeline, as defined in 49 CFR 195.106(a), was 1460 psig. The maximum operating pressure based upon 80 percent of the initial hydrostatic test pressure and calculated in accordance with 49 CFR 195.406(a) was 1456 psig. In January 1985, Olympic established the maximum allowable operating pressure on the rerouted line section at 1440 psig. After the accident, the maximum allowable operating pressure on the rerouted line section that ruptured was restated to 1456 psig based upon the original hydrostatic testing.

At the time of the accident, the established maximum operating pressure listed for the 16-inch Ferndale to Allen segment of pipeline was 1370 psig at the Ferndale discharge with the normal operating pressure listed as 1320 psig.

The pipeline safety regulations in 49 CFR 195.406(b) limits the allowable pipeline pressure to 110 percent of the maximum operating pressure during surges and other variations from normal operations. At the rupture location, the maximum allowable surge pressure was calculated after the accident to be 1602 psig. At the Ferndale discharge and the inlet to Bayview,

[3] Construction of the Bayview Products Terminal was completed in 1998. Operations at the facility commenced in December of 1998. The Bayview Products Terminal will be discussed in detail later in the report.

[4] When Bayview was installed, additional pipeline was tied-in just upstream of Allen Station, installed past Allen Station to Bayview and then back to Allen, so the mileage increased by approximately 4 miles. Allen Station was located at MP 37.3 before the Bayview pipeline extension was completed. All references in this report to downstream locations will use the original mileage stationing.

the maximum allowable surge pressures were calculated to be 1507 psig and 1584 respectively.

After the accident, Olympic contracted with Stoner Associates to perform hydraulic modeling of its system to determine the pressure profile along the pipeline during the accident sequence. The Stoner hydraulic modeling indicates that the pressure reached 1422 psig at the rupture location. The model further predicted pressures of 1402 psig at the Ferndale discharge and 1515 psig at the inlet to Bayview. Pressures recorded in the Bayview PLC during the accident indicate that the pressure reached a maximum of 1500 psig at the Bayview inlet before the pipeline ruptured. The paper on the pressure-recording chart at Ferndale had run out the day before the accident.

A hydraulic surge analysis of the Olympic system was performed in 1991. No additional surge analysis was performed, prior to the accident, to predict the hydraulic behavior of the pipeline as a result of the addition of the Bayview Station into the pipeline system.

Pipeline Valves

After the accident and in accordance with a Corrective Action Order issued by the OPS[5], Olympic contracted with MARMAC Engineering to perform a review and analysis of its valve spacing across the Olympic system. MARMAC Engineering prepared two reports entitled "16" - Ferndale to Allen Block Valve and Check Valve Effectiveness Evaluation" and "16" - Bellingham and Vicinity Block Valve and Check Valve Effectiveness Evaluation" covering the portion of the Olympic system that was involved in the June 10, 1999, rupture and release.

At the time of the accident, remotely-operated block valves were located on the section of 16-inch pipeline from Ferndale to Allen at MP 0.0 (Ferndale Station), MP 6.8, MP 16.2, MP 39.4 (Bayview), and MP 41.4 (Allen).

After the accident and in accordance with the Corrective Action Order, Olympic installed a check valve adjacent to the block valve located at MP 16.2, just downstream of the rupture location. Although the MARMAC study concluded that the installation of this check valve did not reduce the static[6] release volumes calculated at the accident site because it was installed at the same location as an existing remotely-operated block valve, its quicker action would be expected to reduce release volumes in the event of an upstream failure.

As a result of the MARMAC study, another remotely-operated block valve was installed on the pipeline at MP 11.9. MARMAC concluded that the installation of this valve reduced the potential static release volume from selected locations on the pipeline between MP 11.9 and MP 16.2 (the rupture occurred at MP 15.9) by an average of 466 barrels. The greatest reduction of the static release volume, 1,108 barrels, was projected at MP 12.34.

As a result of the MARMAC study and the valve revisions performed after the accident, the largest potential static release volume reduction on the 16-inch Ferndale to Allen pipeline occurred as a result of the conversion of a hand-operated block valve to a remotely-operated block valve at MP 33.7. This reduced the predicted static release volume by 5,272 barrels (68%) from 7,733 barrels to 2,461 barrels at MP 35.3.

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[5] This review, along with many of the other activities undertaken by Olympic after the accident, was ordered by the Office of Pipeline Safety in its Corrective Action Order and in two subsequent amendments. The OPS orders will be discussed in detail later in this report.

[6] Static volumes are based entirely on drain-down due to elevation changes in the pipeline. The static volumes do not include product that is released before the leak is discovered and the pipeline shut in.

As a result of the valve modifications after the accident recommended by the MARMAC study, the largest potential static release on the Ferndale to Allen segment of pipeline was reduced by 3,799 barrels (49%) from 7,733 barrels to 3,943 barrels and would now occur at MP 32.7 (Samish River crossing).

Pipeline Operation

On the afternoon of the accident, two controllers were operating the Olympic pipeline system from its control center at Renton, Washington. One controller was operating the 16" pipeline from Cherry Point to the delivery point into Tosco's facility at Renton. At approximately 15:00, this controller began preparations to discontinue product delivery to Renton and to initiate delivery to the ARCO facility in Seattle. The following is a time line of key events[7] that occurred during the afternoon of June 10, 1999:

Delivery to Tosco Discontinued	15:17:43
Attempt to Start Pump at Woodinville Failed	15:18:58
Bayview Booster P-201 Goes Down	15:22:59
Uncommanded Bayview Station Shutdown	15:24:53
Inlet Block Valve at Bayview Begins to Close	15:24:53
High Pressure Alarm Upstream at Bayview	15:24:53
Last Event Recorded as Oly 2 Goes Off-line[8]	15:24:53
Inlet Block Valve at Bayview is Closed[9]	15:26:03
First Event Recorded on Oly 1 After Startup[10]	15:28:00
Event Log Reports Inlet Block Valve at Bayview is Closed	15:28:05
Pipeline Ruptures at Bellingham (MP 15.7) and Releases Gasoline[11]	15:28:23
Pump at Cherry Point Shuts Down	15:28:25
Pumps at Ferndale Station Begin to Shut Down	15:28:27
Last Event Recorded on Oly 1 as it is Shut Down	15:34:17
First Event Recorded on Oly 2 After Startup	15:44:43
First Non-communication Failure Related Event Recorded on Oly 2	15:48:39

[7] A detailed timeline is also included in the Paragon Study discussed later in this report.
[8] Although Oly 2 recorded events up to this point in time, it reportedly began to become unresponsive to the controller's commands by at least 15:18:58, when the attempt to start the Woodinville pump failed as discussed later in this report.
[9] Since the SCADA system was down, this time is based on the 1 minute, 10 second travel time reported for the valve to close.
[10] Although this was the first event recorded on Oly 1 as it became the primary, Olympic personnel reported that the Oly 1 computer became unresponsive shortly after it came on-line as discussed later in the report.
[11] This data was obtained from a PLC unit at Bayview Products Terminal. The clocks between the SCADA computers and the PLC weren't synchronized at the time of the accident. The PLC clock was approximately 55 seconds faster that the SCADA clock. All times recorded in this chart have been adjusted to match the SCADA clock time. In addition, approximately 57 seconds was required for the pressure drop signal to reach the Bayview PLC from the point of the rupture 23.2 miles away.

Controller Initiates Action to Open Closed Block Valve at Bayview	16:11:22
Controller Has Started a Pump at Cherry Point	16:16:29
Controller Has Started a Pump at Ferndale Station	16:17:34
Fire Department Receives its First Call of an Odor from Public[12]	16:24:14
Computer Leak Alert Received at Renton Control Center	16:29:22
Controller Has Started Another Pump at Ferndale	16:31:39
Pumps Go Down at Ferndale Station	16:32:07
Pump Goes Down at Cherry Point	16:32:16
Controller Initiates Mainline Block Valve Closures	16:32:55
Block Valves at Mileposts 7 and 16 are Closed	16:34:14
Ignition Reported to Fire Department[13]	17:02:36

After switching delivery locations, the pressure in the pipeline began to build in the system. The controller issued a command to start the 2nd pump at Woodinville at 15:18:35. The command was not executed. The other controller[14] reported that the computer system (OLY2) became unresponsive to his commands and that this condition was reported to another Olympic employee who was responsible for developing some of the graphical representations and historical databases for the SCADA system. This employee reported that he observed the lockup and shut down OLY2 causing the backup computer (OLY1) to come online and become the primary system. After OLY1 came online, it reportedly became unresponsive as well and was also shut down. The SCADA system and the computer shutdowns are described in detail in the Safety Board's report entitled "Specialist's Computer Study SCADA Control System."

The other controller reported that at some point when the system came back online, he noticed that the pipeline from Cherry Point to Renton had gone down and that the only pump still running was at Woodinville. He stated that he shut down this pump because the controller that was operating the ruptured section of pipeline had left the room and that he informed him upon his return that the line was down and that he had shut off the Woodinville pump. The event log indicates that commands were issued to shut down the remaining unit at Woodinville at 15:29:35 and again at 15:30:41. The event log also records an uncommanded shut down of the Woodinville unit at 15:31:04.

An electrician stationed at Allen Station reported that he was contacted by the controller at some time between 15:15 and 16:00 and asked to shut down a pumping unit at Allen Station because the controller had lost communications and was unable to do so remotely. He shut down one of the units and reported back to the controller. The event log indicates that the first unit at Allen Station was shut down at 15:23:34. The other two units at Allen Station went down at 15:28:06.

The other controller reported that he remembered that the control center supervisor

[12] This time was captured from the Bellingham Fire Dept records and is not synchronized with the SCADA time.
[13] Same as Footnote 12.
[14] The controller who was operating the pipeline that ruptured, and his immediate supervisor, have refused to answer questions posed by Safety Board investigators. The information contained herein is based on interviews with other Olympic employees and the event log recorded by the SCADA system.

(Supervisor of Products Movement) had come into the control center and was aware that the pipeline had shut down and that the controller was preparing to restart the pipeline. The other controller did not know what, if any, pressure trends or other information was evaluated by the controller to verify the integrity of the pipeline before he restarted it. The SCADA system had captured pressure data at Bayview that indicated a pressure increase from 215 psig at 15:27 p.m. to 1494 psig at 15:28 p.m. on the pipeline at the inlet to Bayview Station as the block valve closed and then a subsequent decrease to 230 psig at 15:29 p.m. as the pipeline ruptured. Olympic did not have a list of specific items for the controller to evaluate to ensure the integrity of the pipeline prior to commencing flow, nor did it have a method of documenting what had been evaluated.

Approximately 40 minutes after the pipeline ruptured, the controller opened the closed block valve at Bayview and then restarted pumps at Cherry Point and Ferndale bringing the pipeline back into service at about 16:16:29. The electrician at Allen Station reported that he was again contacted by the controller and asked to locally verify either the suction or discharge pressure (he couldn't remember which). He reported the pressure to the controller and stated that the controller responded that that sounded about right to him. He did not deem this activity abnormal and stated that the controller did not seem concerned about it either.

A computerized pipeline leak detection system (PLDS) software package was running on the Olympic system. The software utilized both volume balancing and real time transient modeling based upon pressure and other pipeline operating data collected through the SCADA system. Approximately 13 minutes after the system was restarted, at 16:29:22, the leak detection software issued a PLDS alarm to the controller of a potential leak.

Two minutes later, at 16:31:39, the controller started another pump at Ferndale. Then, one-half minute later, at 16:32:07, the pumps went down at Ferndale and then at Cherry Point and the controller initiated commands to close the mainline block valves at MP 6.8 and 16.2 at 16:32:55. By 16:34:34, the valves at MP 6.8 and 16.2 were closed and the section of pipeline that had ruptured was isolated.

Safety Board investigators interviewed ARCO personnel that operated the Cherry Point Refinery. The ARCO refinery had pumps that drew product from tanks and transferred it through approximately ½ to ¾ miles of 16" pipeline to the Olympic pumping station adjacent to the northwest corner of the refinery. The ARCO personnel indicated that the tender begins upon command from Olympic. On June 10, 1999, ARCO was asked to begin the tender at 15:20[15]. At that time product flow was initiated from ARCO's Tank 4. At approximately 15:35, Olympic contacted ARCO and asked them to shut down flow. At approximately 16:15, Olympic contacted ARCO and asked that product transfer be reinitiated. At approximately 16:35, Olympic again contacted ARCO and asked them to discontinue the transfer. ARCO personnel stated that it was not uncommon for shutdowns to occur and they were given no reason for the shutdown request. They also stated that the conversations were brief and to the point. ARCO personnel estimated that approximately 2,500 to 3,000 barrels were pumped from Tank 4 during the involved tender.

Safety Board investigators also interviewed ARCO personnel at the ARCO Harbor Island Terminal in Seattle. The ARCO personnel had notified Olympic that the valves were properly aligned and that they were prepared to receive product. After waiting about 10 minutes past the

[15] Times reported by ARCO were based on logs generated by their employees and are not synchronized with Olympic's SCADA system clock.

anticipated receipt time of 16:20, ARCO personnel contacted Olympic and asked them when they should anticipate product delivery to commence. The Olympic employee notified ARCO that they had a problem, but did not elaborate. At approximately 16:50, ARCO personnel again contacted Olympic. They were not given any indication of the nature of the problem, nor when flow might resume. Approximately 30 to 45 minutes later, after receiving a call from an ARCO employee that had witnessed a fireball ignition, ARCO personnel contacted Olympic to ask if the fire was Olympic's problem and to find out whether the valves into the terminal should be closed. They were told that it was and that they should go ahead and close the valves.

Bayview Station

In December 1998, construction of the Bayview Products Terminal was completed. The new Bayview facility was located approximately 2 miles upstream of the existing Allen Station. The Bayview Products Terminal consisted of five product tanks with a total storage capacity of 500,000 barrels and the associated delivery and return piping. A 10,000 barrel transmix tank, Tank 209, was also installed as a breakout tank at the facility. Three product transfer pumps were installed at Bayview. Two of these were capable of moving product on the 16-inch Ferndale to Renton pipeline.

Olympic contracted with Jacobs Engineering to design the facility. The system design utilized ANSI 300# rated components having a maximum design pressure of 740 psig. Since the pipeline entering the terminal was operated at higher pressures, overpressure protection was necessary to ensure that the station piping and components were not subjected to the full pipeline pressure. Three components were installed to provide such protection. A control valve, CV-1904, was installed on the inlet side of the station and set at 600 psig to throttle back the flow of product into the station. A relief valve, RV-1919, was installed just downstream of the control valve.[16] The relief valve was piped to discharge excess product into the transmix Tank 209 should the pressure exceed its set point. The settings for RV-1919 will be discussed in detail later in this report. A receiver manifold arrangement, consisting of three motor-operated and remotely-controlled block valves (MV-1902, MV-1903, and MV-1907), was installed on the 16-inch pipeline entering the Bayview facility upstream of the control valve. These valves were operated in conjunction with one another to ensure that, under normal operations, product would flow through one of two paths into the terminal. With MV-1903 closed, and MV-1902 and MV-1907 both open, then product would flow through the inlet receiver. If both MV-1902 and MV-1907 were closed, then MV-1903 was open and the product flow bypassed the inlet receiver. Either MV-1902 or MV-1903, depending upon the selected configuration, was set to close in approximately 60 seconds and completely block the flow of product into the terminal when a set pressure of 700 psig was reached inside the facility downstream of the control valve. Overpressure protection was also provided by high discharge pressure limits placed on the pumps at Ferndale Station. Pumps would automatically shut down when the discharge pressure reached approximately 1400 psig.

After the accident and in accordance with the OPS Corrective Action Order, Olympic contracted with MARMAC Engineering to conduct a review of the design of the Bayview

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[16] After the accident, RV-1919 was taken into custody by the Safety Board and examined and tested under controlled conditions. The results of that examination and testing are presented in a report prepared by Stress Engineering Services, Inc. report entitled *Testing of Pressure Relief Valve "RV 1919"* dated December, 2000, (This report is included in the Safety Board's public docket on this accident) and in the Safety Board's Relief Valve Factual Report.

Products Terminal. MARMAC's January 13, 2000, report entitled "Bayview Terminal Design Review" discusses the review and several changes proposed to improve operations at the terminal. This report will summarize selected changes from the MARMAC report.

One of the changes directly involves RV-1919. The piping connection from the incoming Ferndale pipeline header to the relief valve was originally designed and installed to tee off from the bottom of the incoming pipeline. As a result of the MARMAC study, which concluded that trash and debris accumulation in this interconnection might impair the operation of RV-1919, the piping configuration was revised so that the tee comes off the top of the incoming pipeline. According to MARMAC, this revision corrected a design deficiency. The interconnection from the incoming Anacortes pipeline to RV-1923 was configured in an identical fashion. The presence of trash and debris was noted during the removal of RV-1919 after the accident and during the post-accident testing of RV-1923 performed by Olympic.

A second design change affected as a result of the MARMAC study indirectly involves RV-1919. As originally designed, a flow switch, FS-2099, was installed on the pipeline to the transmix Tank P-209 that produced a SCADA alarm in the control center whenever product was flowing into the tank. The flow switch was triggered by product flow from one of several possible sources; the donut manifold relief valves, the tank header relief valves, the sump pump, or the incoming pipeline relief valves, such as RV-1919. As a result of the accident, individual flow switches have been installed on each of the incoming pipeline relief valves, including RV-1919. This is intended as a design improvement to provide the pipeline controllers with a better understanding of what's occurring within the facility.

A second relief valve, RV-2229 was also added. This valve is located upstream of the inlet block valve to Bayview and is intended to protect the pipeline from overpressurization.

Control Valve 1904

As designed, the inlet control valve, CV-1904, was intended to throttle product flow into the Bayview Station to limit pressures within the facility. An outlet control valve, CV-1963, was to be located on the discharge side of the pumps to maintain an adequate suction pressure to the pumps. The parallel piping from Anacortes was configured in an identical fashion, with inlet control valve, CV-1916, and outlet control valve, CV-1969. Specification sheets prepared by Jacobs Engineering indicate that the inlet control valves were to be rated to ANSI 600# and the outlet control valves rated to ANSI 300#.

Correspondence indicates that after the specification sheets were issued for purchase, a representative of the vendor supplying the valve controllers contacted Jacobs to determine whether Olympic wanted extended piston stops to be set within the operator to limit valve travel. In the correspondence, it is suggested that normally stops are set within the outlet control valves so that they do not close completely, eliminating the possibility of accidentally pumping against a closed valve. Olympic responded that they would prefer full closure on the inlet control valves (CV-1904 and CV-1916) and extended piston stops installed on the outlet control valves (CV-1963 and CV-1969) in accordance with the vendor's proposal.

After the valves were installed and Bayview Station came online, Olympic control room personnel discovered that the inlet control valves did not close completely. An Olympic automation specialist went to the Bayview Station and calibrated the SCADA system so that when the valve travel reached the limits imposed by the stop, the controller would regard that as the zero percent open setting. In other words, 0 to 100 percent of flow corresponded with the minimum flow allowed by the stop to full flow.

After the accident, it was determined that extended piston stops were set in both the ANSI 600# inlet control valves to limit the travel of the valve to 90% of full closure[17], but were not set in either of the ANSI 300# outlet control valves.

A representative of the vendor providing the operators indicated that it was necessary to watch the valve travel indicator to determine at what location the stops were set. He said that stops were present in all the operators, but were not necessarily set above full closure unless requested by the customer. The representative further indicated that the stops could be adjusted as necessary in the field without removing the valve from service.

Electronic programming determines the valve operator's response to changes in the pipeline's pressure and the associated valve position. The valve operator vendor's representative stated that the control valve should maintain a pressure within just a few psi of the intended set pressure. When properly tuned, the valve should provide a controlled response that quickly dampens pressure fluctuations caused by the valve itself.

Two of the changes Olympic made to the Bayview facility as a result of the accident and the aforementioned MARMAC study involved CV-1904. The stop in CV-1904 (and in CV-1916) was repositioned to allow the valve to fully close. The pressure sensing control line tap downstream of CV-1904 was also relocated to provide for quicker sensing.

Relief Valve 1919

During construction of the Bayview Products Terminal, Olympic assigned its mechanic to act as a mechanical inspector on the project. The mechanic reported that he went and checked the relief valves, including RV-1919, and compared the serial numbers to either an equipment list or construction drawing provided by the contractor to make sure that Olympic had received the proper materials.

Olympic personnel reported that during the middle of the night from December 16 into December 17, 1998, as they were filling the pipeline after completing tie-ins to bring the Bayview facility into operation, they discovered that RV-1919 kept relieving product at a pressure of approximately 100 psig. Without consulting the manufacturer's literature on the valve, which was available, they decided that they could adjust the set point by replacing a spring within the pilot operator. One of the mechanics had a spring in his truck, so they replaced the spring that was originally within the pilot operator and adjusted the set point. The relief valve quit relieving into the transmix tank, thus allowing the pipeline to be filled and pressurized. On December 18, 1998, an Olympic mechanic sent an e-mail stating that he had established the set point of RV-1919 at 700 psig. Olympic personnel ordered four springs to replace the mechanic's spring that they had used and to replace the springs in three other identical relief valves.

Hoffman Instrumentation Supply is a company that Olympic used to purchase replacement parts. A Hoffman employee based in Renton, Washington, recalled receiving a phone call from an Olympic mechanic that was having trouble adjusting the set points on some valves that Olympic had purchased. The Hoffman employee referred the Olympic mechanic to another Olympic mechanic that was familiar with the valves. The Hoffman employee stated that

[17] Although the stop prevented the final 10% of travel of the valve controller, given the internal configuration of the valve orifice, this does not correlate to a flow of 10%. The flow was limited to a value potentially much less than 10%.

one of the Olympic mechanics then contacted him on December 17, 1998, and told him that they had figured out what the problem was and that they needed to order four of the 350-650# springs from Fisher Rosemount because they had springs for the wrong pressure range.

The Hoffman employee based in Portland, Oregon, having heard about the problems Olympic was having adjusting the set points, stated that he contacted the Fisher Rosemount Petroleum plant in Georgia to discuss the appropriate equipment, which he found out included a combination of a new piston, pilot valve cover and o-ring, needed to achieve the higher set points for the pilot control valves. The Hoffman employee stated that after receiving this information from Fisher Rosemount, he faxed the information to the second Hoffman employee in Renton, Washington, who normally worked directly with Olympic. The January 11, 1999, fax from the Hoffman employee in Portland to his counterpart in Renton noted:

> "The 1760 pilot they called out on the original sales order was set @ 100 psi and was the 70-180 spring.
>
> It turns out you cannot simply change the spring to get a higher rating. You need to also change the piston, cover and piston O-ring."

The fax also listed the part number of the piston, cover, and O-ring that would be needed, in addition to the spring, to make this conversion. The fax also included the parts list, with the required part numbers highlighted. Hoffman also provided copies of orders placed to Fisher Rosemount and dated July 14, 1999, for the piston, O-ring, and cover identified in the January 11 fax. The Hoffman employee in Renton stated that he probably called one of the mechanics at Olympic to pass along this information, but he didn't specifically remember doing so. He was told that they had been able to set the pressures as intended after all. The Olympic mechanic interviewed by the Safety Board stated that he had not received such a call.

Olympic records and logs indicate the set point of the pilot control valve for RV-1919 was recorded as follows:

Original Design Documents:	740 psig
October 14, 1998 Design Document:	650 psig
December 18, 1998 Bayview Commissioning:	700 psig
May 12, 1999 Adjustment:	650 psig

RV-1919—Eighteen days after the accident on June 28, 1999, inspection and testing of RV-1919 and its pilot control valve were conducted under the direction of the Office of Pipeline Safety representative at the request of the Safety Board's investigator-in-charge. Representatives from Olympic, Equilon, Fisher Rosemount, and the Washington Department of Ecology were also present. When these tests were conducted, RV-1919 was still installed in the pipeline system at the Bayview terminal.

The residual positive pressure on the top of the piston for RV-1919 was relieved to determine if the piston would move and thereby open the relief valve. As the pressure was relieved, product was heard to flow through the relief valve and discharged into a bucket. Valves in two of the sensing lines in the pilot control system were then closed: the sensing line from the inlet side of the relief valve to the inlet port on the pilot control valve, and the sensing line from the pilot control valve to the top of the piston on the relief valve.

A dead weight test device was then used to measure the set point of the pilot control valve. According to the test group, the test results indicate that the pilot control valve opened at 440 psig and reseated between 212 and 232 psig.

Fisher Rosemount personnel that attended the valve testing reported that the adjustment stem on RV-1919 was screwed out from 1 ½ to 2 turns more than on the pilot for RV-1923.

Other Tests—Between July and December 1999, a contractor working for Olympic conducted dynamic tests on the other relief valves in Olympic's pipeline system. The set points of the pilot control valves, the actual pressure at which the relief valve opened, and the pressure at which the relief valve reseated were recorded. In all test runs for all valves, the actual pressure the relief valve opened was greater than the measured set point of the pilot control valve. The differences between the set point pressure and the actual relief pressure ranged from 8 psi (test run 35) to 130 psi (test run 15). As a result of this testing, Olympic decided to set the pilot operators on their system to 30 psig below the value they intended for them to function at.

Other Relief Valves—Three additional relief valves within the Bayview facility were configured in identical fashion with the improper components installed within the pilot operator; the relief valve on the incoming line from Anacortes, RV-1923, and the relief valves on both pipelines on the discharge side of the station, RV-1932 and RV-1941.

RV-1923 was tested in place after the accident when investigative personnel tested RV-1919. The pilot on RV-1923 operated at 650-660 psig on both tests conducted. During the flow testing Olympic conducted after the accident, RV-1923 did not function.

Pipeline Shutdowns

Once operations at the Bayview Products Terminal commenced in December of 1998, Olympic controllers discovered that operational fluctuations downstream of Bayview would cause the pressure inside the station to exceed the set pressure of 700 psig for triggering the closure of the block valve on the 16-inch pipeline coming into the Bayview facility from Ferndale. Between December 16, 1998, when operations at Bayview commenced, and the accident on June 10, 1999, the inlet block valve at Bayview closed approximately 59 times. On 41 of these occasions, the inlet block valve closed due to high pressure within the station. On 13 of these occasions, the pressure on the pipeline side of the inlet block valve exceeded 1000 psig after the valve had closed with a maximum pressure of 1339 psig reached on one of these occasions. The inlet block valve closed 6 times between May 12, 1999, when the Olympic mechanic lowered the set point of RV-1919 to 650 psig, and the accident due to high pressure within the Bayview facility. Olympic did not view these events as abnormal operations because the block valve was closing as intended by the design of the facility.

The Olympic pipeline controllers that were interviewed by the Safety Board were aware of the operational difficulties that had occurred as a result of the installation of Bayview and the repeated closures of the inlet block valve that shut down the pipeline. They stated that they thought Olympic's mechanic had gone out numerous times to check out the operation of RV-1919. The mechanic, however, only recalled returning to adjust the set point of RV-1919 on the one occasion in May.

The controllers felt that a lot of the problem was because Bayview was located so close to Allen Station. They felt that there was not sufficient time to respond to situations occurring in Allen and/or on downstream to prevent pressure buildup within Bayview. The controllers also expressed a general sense of frustration with management's lack of response to the problems that they were observing. They felt that management should have provided them with additional guidance on how to best operate the system with the new Bayview facility online.

Prior to the accident, the controllers voiced concerns about a variety of issues with the Bayview operations. On May 10, 1999, one of the controllers sent an e-mail to several Olympic employees, including those in the management ranks outlining a couple of the issues they were concerned about. In the e-mail he asks, "Are we ever gonna have any "classes" on Bayview? I just found out on my last shift that the Bayview screens have poke points that you can click on that are different than our other screens. Receiving email msgs about these things are nice, but showing us would be even better."

Based upon the concerns of the controllers, Olympic's best practices coordinator sent out an e-mail on May 11, 1999, that starts "I propose that a meeting be held to discuss issues surrounding Bayview Products Terminal and Olympic's operations as a whole." He asked that issues, along with possible solutions, be submitted prior to the meeting for review. Included on his list of issues that may be discussed were "BPT general operating practices," "Control Center and Field Operations/Maintenance Issues," "Communications," and "Training."

The distribution for this e-mail included Olympic's Vice President and General Manager. In response to the e-mail he wrote, "I must say that I am increasingly concerned over our seeming inability to take charge of Bayview and make it work for us. If we can't operate Bayview after five months, then we have no hope of being able to operate Cross-Cascades. Bayview is now an essential part of Olympic Pipe Line and an essential part of each of our jobs."

When interviewed by Safety Board investigators, the best practices coordinator stated that several of the controllers had expressed concerns to him that included surge indications at Bayview and that one of the controllers had told him about the uncommanded block valve closure at Bayview. He said that he was having a difficult time trying to get people to express their concerns in writing in advance of the proposed meeting. He also said that he, and several of his coworkers were surprised and disappointed by the response from the Vice President. They viewed it as critical of their efforts to troubleshoot Bayview and that "he [the VP] really didn't understand or comprehend the issues that many folks had surrounding Bayview. And they were – we were looking for leadership and guidance from someone relative to production of manuals and – and training and not only out in the field but in the control room." The proposed meeting to discuss and resolve the issues at Bayview was never held.

The best practices coordinator felt that many of Olympic's employees were trying to address and correct problems on their own, with little guidance from management. He characterized the manner in which Olympic conducted its operations as "empowerment…had run amuck."

Paragon Study

After the accident, the Safety Board contracted with Paragon Engineering Services Incorporated to conduct an independent evaluation of the design of the Bayview Products Terminal and the associated operational issues. Paragon's January 2001, report entitled "Olympic Pipe Line Company's Pipeline Rupture Incident Review and Analysis" is included in the public docket for this accident.

Olympic Pipe Line Company Procedures

At the time of the accident, Olympic had several manuals of company procedures that addressed various aspects of its operations.

Operations Manual for Controllers—This manual provided guidance for the pipeline controllers working in the Renton Control Center. The manual predates the installation of the Bayview Products Terminal. It was not updated with information on Bayview prior to commencement of operations at the facility or before the accident.

The Forward to this manual states that the prevention of releases and the minimization of the consequences should a release occur takes priority over pipeline schedules and cost minimization. The Forward states that "If there is any reason to believe that a release might occur or has occurred, the pipeline system should be immediately shut down and promptly investigated."

Chapter 5 of the manual covers abnormal operations. Section 5.1 refers to unintended mainline block closures. In subsection 5.1.2, the controller is instructed to "investigate the cause of the high pressure by using all information available to find the cause and determine the level and duration of the high pressure reported by the equipment. The Controller should then call his supervisor to discuss the situation. The Controller will not restart the pipeline without concurrence from his supervisor." Subsection 5.1.3 then states "If conditions indicate that a loss of fluid from the pipeline might have occurred, the pipeline will remain down and appropriate employees will be sent to investigate." Subsection 5.1.4 also states "If a loss of fluid from the pipeline is not apparent a static pressure test by segment is required…If pressure is not lost, the pipeline may be restarted with concurrence from the supervisor."

Section 5.2 covers unintended shutdowns of a pump unit or pumping station. Section 5.2 states that "A pump unit shutdown caused by pressure changes such as high discharge, high case or low suction should be investigated immediately by the Controller to determine the cause for the pressure change. Data such as computer trends, protective device settings, and computer alarm limits will provide needed information to determine probable cause."

Section 5.7 of the manual provides guidance to the controllers in the event of a control center computer failure. This section states:

> "If both computers fail, the computer personnel and the Control Center Supervisor should be notified immediately. Employees should be dispatched to man critical locations. Non-critical systems should be shut down by the field employees. Critical systems should continue under local control until the master station computers are repaired."

Chapter 7 of the manual provides more local information for handling abnormal operations. In Section 7.20, which addresses unauthorized operation of valves states that "Valve malfunctions are to be reported to the Supervisor of Products Movement and a Maintenance Log written regarding the malfunction."

Section 7.22 requires that "Any operation that deviates from the normal mode of operations must be documented by the Operations Controller and by the field personnel involved… This information is invaluable to prevent the same situation from occurring again and to assist personnel in rectifying this event."

Operations and Maintenance Manual—Olympic added a chapter to the Facility Index section of this manual effective November 23, 1998, that applies to the Bayview Products

Terminal. It contains a description of the facility, a list of equipment, a list of local alarm and remote indications, a table of set points for the various protective devices, a list of valves with their associated function, and a station inspection checklist.

The remainder of the manual, including the Miscellaneous Operations and General Abnormal Operating Procedures sections, was not updated to include any reference to the Bayview facility.

The Miscellaneous Operations Section of the manual contains an "Operations Controller Prestart Check List" that outlines the general steps the controller should take prior to starting flow in the pipeline. The list includes checking the pumping schedules, notifying the applicable refineries and terminals of the estimated schedules, verify alignment of the valves at the receipt point, resetting the pump station shutdowns and pressure settings, checking to make sure that applicable stations are free of alarms, checking the status of intermediate block valves, and verifying the alignment of valves at the delivery facility. The last item on the list is "Double check all of the above functions. If anything appears to be wrong or reacts in an inconsistent manner, the line will remain shut down until problem is corrected or until Operations Controller is satisfied that the pipeline can be operated in a Safe and Efficient manner." This section of the manual also contains specific procedures for starting the pipeline when receiving product from Anacortes and delivering it to Seattle. The list delineates what pumping units to start and in what sequence, anticipated times and flow rates, and information on the ideal pressure settings. The manual also has a detailed shut down procedure for the same pipeline configuration. The manual does not contain a startup procedure for the pipeline configuration that was in operation on the day of the accident. Neither the prestart checklist or the restart procedures contain any guidance on what actions the controller should take or what pipeline data they should review and examine to ensure the integrity of the pipeline.

The General Abnormal Operating Procedures section of the manual contains similar guidance material for handling and documenting abnormal operations as contained in the Operations Manual for Controllers.

Texaco Operations and Maintenance Manual—While preparing for the OPS pipeline safety audit that was to be conducted in the spring of 1999, Olympic's compliance personnel became concerned about the adequacy of Olympic's procedures. In consultation with OPS, Olympic decided to adopt the Texaco Operations and Maintenance Manual. This manual had already been reviewed in detail by OPS inspectors and approved as being in compliance with the pipeline safety regulations.

Other Olympic personnel, including the Operations Manager, did not recall using Texaco's procedures.

Section 15 of the manual on abnormal operations states that as the result of an unintended valve closure, "Determine the cause of the unintended valve closure and take corrective action."

Section 16 of the manual contains a general pipeline startup procedure that the pipeline should be "Start up in the proper sequence and in a controllable manner to prevent surges in the pipeline system." There is no guidance given on what should be done to verify pipeline integrity prior to start up of the pipeline.

Office of Pipeline Safety Activities

On March 15-19, 1999, OPS representatives conducted an inspection of the Olympic pipeline system to determine whether Olympic's facilities and operations were in compliance with applicable pipeline safety regulations. As a result of the inspection, OPS issued a Letter of Concern to Olympic citing 4 areas of concern. OPS did not issue a notice of any probable violations of the pipeline safety regulations as a result of its inspection.

The first concern was related to Olympic's operations and maintenance procedures. The pipeline safety regulations in 49 CFR 195.402(a) require:

> "Each operator shall prepare and follow for each pipeline system a manual of written procedures for conducting normal operations and maintenance activities and handling abnormal operations and emergencies. This manual shall be reviewed at intervals not exceeding 15 months, but at least once each calendar year, and appropriate changes made as necessary to insure that the manual is effective. This manual shall be prepared before initial operations of a pipeline system commence, and appropriate parts shall be kept at locations where operations and maintenance activities are conducted."

In its Letter of Concern, OPS stated:

> "OPL [Olympic] has recently adopted Texaco's operations and maintenance manuals that were reviewed within the last couple of years by a team of OPS inspectors. These manuals were accepted in their entirety as being in compliance with 49 CFR Part 195. Also, in discussions with OPL personnel, it was discovered that OPL will more than likely adopt the Equilon manuals as soon as they are combined from the Texaco and Shell manuals. OPL has an ongoing plan to incorporate their site specific plans and procedures into these newly adopted manuals. Eventually, OPL will complete this manual transformation. Until that time, care must be taken to ensure compliance with current procedures contained within the applicable manuals by operations and maintenance personnel."

The remaining three areas of concern involved clearing areas of the pipeline right-of-way to allow aerial patrols, corrosion of the flange bolts in a valve pit, and moving pipelines under pressure.

As a result of its investigation into the June 10, 1999, accident, OPS issued a Notice of Probable Violation and Proposed Civil Penalty to Olympic that cited as follows:

Code Section	Code Requirement	Probable Violation
195.442	Requires inspections of excavation activities near the pipeline to be conducted "as frequently as necessary during and after the activities to ensure the integrity of the pipeline."	Olympic did not adequately inspect excavation activities during the water treatment plant additions in 1994.
195.401	Requires the operator to take immediate corrective action whenever it discovers a condition that could adversely affect the safe operation of its system.	Olympic did not take adequate action after its internal inspections conducted in 1996 and 1997 discovered anomalies in the vicinity of the water treatment plant.

195.403	Establishes training requirements for operations and maintenance personnel.	Olympic did not adequately train its control room operations personnel.
195.402	Each operator must have written procedures for abnormal operations.	After the rupture occurred during an abnormal event on June 10, 1999, Olympic did not have adequate procedures in place to respond to and to evaluate that event before restarting its pipeline.
195.262	Requires that each safety device be tested under conditions approximating actual operations and found to function properly before a pumping station may be used.	Olympic did not adequately test RV-1919 before commissioning operations at the Bayview Products Terminal. Futhermore, after repeated instances when RV-1919 did not relieve at its intended set point, Olympic did not take actions to test RV-1919.
195.402	Requires operations and maintenance procedures for responding to, investigating, and correcting the cause of abnormal operations including unintended valve closures.	Olympic did not respond to, investigate, or correct the repeated closures of the block valve at Bayview Products Terminal and the associated failures of RV-1919 to operate.
195.404	Requires each operator to maintain records of discharge pressures at each station and abnormal operational events for 3 years.	Olympic did not have records documenting the discharge pressure at Ferndale Station on the day of the accident or the unintended closures of the block valve at Bayview.

As a result of these probable violations, the OPS proposed that a civil penalty of $3,050,000 be assessed against Olympic.

After the accident, on June 18, 1999, the OPS found that “the continued operation of this pipeline without corrective measures would be hazardous to life, property, and the environment,” and issued a Corrective Action Order restricting Olympic’s operations and outlining specific actions that Olympic must complete prior to returning its pipeline to full operation. The OPS subsequently issued two amendments to the Corrective Action Order. The cumulative requirements of the items can be summarized as follows:

With respect to the Ferndale to Allen, Washington segment:

- The first three items are to be completed prior to operating the pipeline segment.
- Review the Supervisory Control and Data Acquisition System (SCADA) to determine the cause of the deficiencies that occurred on June 10, 1999, and correct these deficiencies.
- Test mainline valves intended to isolate sections of the pipeline traversing populated and environmentally sensitive areas and take any needed remedial actions.
- Install a check valve at milepost 16.22.
- Develop a plan to address the following to the extent they are involved in the release:

  - Review the existing mainline block valves and check valves and plan for additional installations as necessary to minimize the consequences of a pipeline release. Valves will have remote operation capability as deemed appropriate by the review.
  - Review the SCADA system to detect any deficiencies and develop a schedule for modifications.
  - Cathodic protection surveys with scheduled remediation.
  - Pressure testing.
  - Internal inspection tool surveys and remedial action to insure the integrity of the pipeline using the best available technology appropriate for assessing the system based on the type of failure that occurred on June 10.
- Restrict the MOP of the pipeline segment to 1056 psig, which is 80% of the normal operating pressure or 80% of the surge pressure at the point of failure, whichever is lower.
- Restrict the MOP of the 16" Allen to Renton pipeline segment to 80% of its normal operating pressure or 80% of the surge pressure at the point of failure, whichever is lower.
- Include consideration of the Allen to Renton pipeline segment in the plan developed to address the Ferndale to Allen segment.
- For a minimum period of one (1) after the last modifications to the SCADA system are performed as a result of this Order, monitor the SCADA system's operation and report any anomalies to the OPS within 2 weeks.
- Within 3 months of the 1st amendment, perform the following with respect to personnel involved with controlling the operations of the pipeline through the SCADA system:
  - Develop and implement a training program for controllers that includes responding to abnormal operations and starting up and shutting down any part of the pipeline system.
  - In addition to the training, review the qualifications of each controller to recognize conditions that are likely to cause emergencies and be able to predict the consequences of facility malfunctions or failures such as those that occurred on June 10.
  - Provide specific, specialized, technical training to controller personnel responsible for maintenance and operation of the hardware and software components of the SCADA system and review the qualifications of these personnel.
  - Include classroom instruction, practical exercises, and the use of a pipeline simulator as appropriate in the training under this item.
- Perform a design review of the Ferndale to Renton segment to ensure the station safety devices will shut the segment down within applicable parameters. The review should include at least the following:
  - A surge analysis using the worst case scenario.

  - A test of the relief valves to determine that capacity is adequate and that they operate reliably.
  - A design review of the physical piping in the Bayview Products Terminal that includes the interaction of all station safety devices.
- In conducting any internal inspection, excavate and visually examine any anomaly that could be associated with excavation damage located on the top half of the pipe and take appropriate remedial action.
- In conducting any internal inspection, consider the possibility of internal corrosion in conducting the inspection and analyzing the results.
- Review existing procedures for normal, abnormal, and emergency operations of the Ferndale to Allen pipeline segment and make any necessary changes to ensure that they address operations at the Bayview Products Terminal.
- Notify the OPS prior to undertaking any testing, repairs, or construction needed to prepare for the return of the pipeline to service.
- Restrict normal operating pressures to 80% of the previously established MOP on the 20" Allen to Renton segment, the 14" Renton to Portland segment, the 16" Anacortes to Allen segment, and the remaining various short delivery segments on the system.
- Conduct hydrostatic pressure testing at a test pressure of 90% of SMYS for a minimum period of 8 hours as follows:
  - Pressure test the 16" Ferndale to Allen segment in its entirety.
  - Pressure test any sections of the remainder of the Olympic system that are constructed of pre-1970 ERW pipe manufactured by Lone Star.
  - Pressure test any remaining sections of the Olympic system if indicated by the evaluation and plan provided for in the next item.
  - Metallurgically test any failure that occurs in a manner which will identify the cause of the failure.
- If, during the pressure testing, a failure occurs on line pipe which is not manufactured by Lone Star, evaluate the need to pressure test the remainder of the Olympic system and plan any testing that the evaluation indicates is advisable.
- A pressure test conducted pursuant to the Order may not be used to establish a higher MOP than that previously established for the segment without written approval of OPS.
- In conducting internal inspections on the Olympic system, do the following:
  - Select internal inspection devices that can accurately detect metal loss, pipe deformation and enable strain calculations.
  - Complete the analysis of internal inspection data and any remedial actions for anomalies that affect pipeline integrity within six months of completion of the internal inspection. The analysis shall include a comparison of metal loss with pipe deformation.
  - Develop and follow written procedures for the conduct of the internal inspections that includes fitness for service criteria for identifying, prioritizing, and correcting

defects. These shall include criteria for deciding on direct pipeline examination, further integrity assessment, and corrective measures including repair, replacement, or operational restrictions. At a minimum, the criteria established in ASME B31.4 and ASME B31-G should be considered.

- Within 6 months of completion of the management audit provided for in the City Agreement, implement any corrective measures that cover matters regulated under 49 CFR Part 195 and report progress on the implementation to the OPS no less frequently than every 3 months.

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