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MAINLINE VALVE OPERATIONS AND MAINTENANCE PROGRAM ON THE TRANS ALASKA PIPELINE

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ABSTRACT

Alyeska Pipeline Service Company (Alyeska) is the operator of the Trans Alaska Pipeline System (TAPS) which transports crude oil from the North Slope of Alaska to ships loaded at the Valdez Marine Terminal.

In 1997, Alyeska initiated a systematic maintenance upgrade and testing program for the mainline and facility isolation valves. This program, called the TAPS Valve Program, was established to:

1. Determine if the valves in the system still met operational requirements after 20 years of nearly continuous service.
2. Service all primary isolation valves and upgrade maintenance practices, data control systems and documentation.
3. Develop a long range maintenance management plan to economically and safely extend TAPS Service Life.

The program reviewed operational history, including maintenance practices and repairs. In addition, an assessment of the current condition of the valves, operators and actuators was performed and what effect the current maintenance practices has on that condition. From the information collected in the review, the TAPS Valve Program identified valves that did not meet Alyeska's in-service performance criteria and highlighted maintenance practices that needed updating. Repairs were performed, procedures updated, and training increased to enhance the long term functionality and life cycle of the valves.

INTRODUCTION

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In 1997, Alyeska initiated a systematic review and testing program for the mainline and facility primary isolation valves after a series of valve problems and to meet Alyeska's strategic goal to extend TAPS service life. This program, called the TAPS Valve Program, was established to determine if valves in the system still met operational requirements after 20 years of nearly continuous service and what steps were required to upgrade and extend their expected service life.

The Program reviewed operational history, prior and current maintenance practices, data control systems, documentation, and cost/risk of repairs. A field assessment was performed wherein each valve actuator/operator was serviced and minor maintenance performed to verify the valve was in good mechanical condition. Mainline and primary isolation valves were tested for internal leak-through. From the information collected in the review, the TAPS Valve Program identified valves that did not meet Alyeska's in-service performance criteria and highlighted maintenance practices that needed updating. Repairs were also initiated, procedures updated, and training increased to enhance the long term functionality and life cycle of the valves.

A key objective of the TAPS Valve Program was to establish an engineering standard for valve performance for each valve. A review of the applicable government regulations as well as a review of operations and maintenance practices within the oil and chemical industries did not provide a clear basis for establishment of performance criteria for in-service valves. Stakeholder expectation on this issue ranged from requirements for "bubble tight seal", to no requirement for determining if a valve sealed once it was in service.

In developing performance criteria for in-service valves, Alyeska recognized that the program could be setting a precedent for future regulation of the industry. With this concern in mind, Alyeska adopted a cost/risk based compliance approach similar to a 1997 risk based US DOT pilot program. A formal risk assessment was then undertaken in 1997. The assessment used a combination of historical data from the original TAPS design risk assessment, input from external consultants, input from internal subject matter experts, and input from the TAPS oversight regulatory agency.

The 1997 risk assessment and subsequent use of the associated risk model and valve prioritization, led to establishing separate performance criteria for each mainline valve. The performance criteria were based on internal leak-by potential for typical and worse case valve degradation in combination with the effect of a nearby one-inch diameter hole in the TAPS 48" pipeline. The one-inch hole leak size was determined from historical industry data to be the most likely leak size due to corrosion or third party damage. This process allows for the incorporation of significantly different consequences associated with the risk of a valve sealing depending on the location of the valve.

Once the performance criteria was established a valve testing program was initiated. The testing program was scheduled to test all 177 TAPS mainline valves over a three-year period completing in year 2000. To date Alyeska has tested 148 of the 177 valves and of those tested two valves have not met the criteria. The two valves, a remote gate valve (RGV 80) and a check valve (CKV 122), were replaced and repaired during a 1998 pipeline maintenance shutdown that lasted 28 hours.

NOMENCLATURE

When discussing valves, some special terminology is often used, some of which are commonly used acronyms and terms used in unique ways not normally found in standard references. Some terms defined below are a result of this program:

API Specification 6D: API specification for the manufacture and testing of pipeline valves. Most pipeline valves are manufactured or factory rebuilt and tested to this specification, and if so, can be identified with the API 6D monogram. Federal regulation 49 CFR, Part 195, Paragraph §195.116 (d) requires each valve to pass both hydrostatic shell and seat testing to at least the requirements of Section 5 of API Specification 6D.

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Body Double Block and Bleed Valves: Defined in API Specification 6D as a valve with the capability of obtaining a seal across the upstream and downstream seat rings of a double-seated valve when the body pressure is bled off to atmosphere through blow down valves or vent plugs. Useful in testing for integrity of seats (sealing ability) and in accomplishing minor stem or body repairs while the valve is in-service.

Equivalent Orifice Leak-through Area: The calculated equivalent orifice size (in square inches) of leakage through the valve.

"Maintain Valves in Good Working Order": Required by 49 CFR Part 195 Paragraph §195.420(a). Interpreted by Alyeska to mean sound maintenance practices in the effort to keep valves in good working order based on an in-service performance criteria.

Seat: The part of a valve against which the closure element (gate, ball, or clapper) makes contact contributing to a tight shut-off. In many ball and gate valves, the seat is a floating member containing a soft seating element (usually an O-ring).

Leak-by: For double-seated valves, an internal valve leak. Condition in a gate or ball valve where crude oil can leak past either the upstream or downstream seat into the valve body, thereby pressurizing the valve body. *(Note: For single-seated valves, see leak-through below.)*

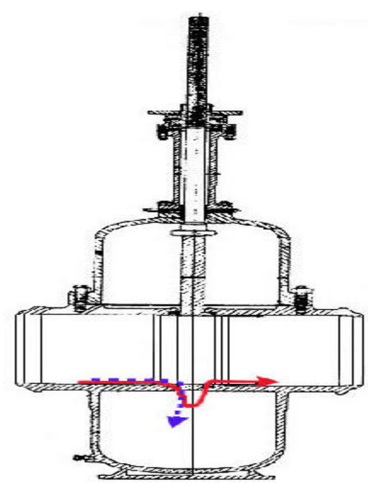

Figure A. Leak-by vs. Leak-through

Leak-through: Condition in a gate or ball valve where crude oil can leak past both valve seats causing the valve to leak from the high pressure side of the valve to the low pressure side when the valve is closed. *(See Figure A).*

For single-seated valves, such as check valves, a condition where crude oil can leak by the valve seat causing the valve to internally leak past the valve when the valve is in the closed position. (*See Figure B*).

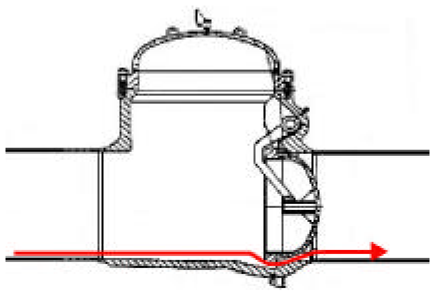

Figure B. Leak-Through

BACKGROUND

The federal and state stipulations for the Grant and Lease of Right-of-Way for the Trans Alaska Pipeline System (TAPS), augmented by 49 CFR Part 195, includes requirement for providing "...remotely controlled shutoff valves at each pump station" and "…remotely controlled mainline block valves intended to control spills". These requirements imply that these valves close on command and shut off tight enough to control an oil spill. To demonstrate compliance with these requirements, industry practice has been to stroke or close the valves 10% of range twice each calendar year. Currently, TAPS valves are stroked 20% of range twice a year to demonstrate operability and to ensure full greasing of the valve stem nut. Stroking the valves does not, however, ensure a tight shut-off when the valve is closed.

After years of service, a valve may perform differently than when it was originally supplied by the manufacturer. Normal wear from operation and corrosion erodes close manufactured tolerances. Smooth surfaces needed for seating of the valve coarsen, pit, and degrade with exposure to crude oil, water, and mechanical damage by foreign objects in the crude stream. Even the best maintenance practices cannot prevent changes in a valve's in-service performance.

There are currently no industry wide in-service performance criteria for valves. Similarly Alyeska had no such criteria for its TAPS primary crude block valves other than the original manufacturing criteria for new valves where API Standard 6D specifies no visible leakage during hydrostatic testing and that valves operate upon command. 49 CFR §195.420 only requires valves be maintained "in good working order." 49 CFR §195.260 requires pump station battery limit valves to "…permit(s) isolation of the pump station." Good working order and station isolation had to be defined by an acceptable in-service "leak-through" performance criteria.

In 1997, Alyeska began a comprehensive risk assessment for all TAPS primary crude block (isolation) valves (i.e., mainline and station manifold valves) to develop this performance criteria. The risk assessment established a relative risk level for each valve, prioritized maintenance and testing, and outlined performance criteria based on a "most likely pipeline leak" model. The risk assessment was part of the TAPS Valve Program and structured to address specific maintenance, testing, performance, and repair requirements outlined in an Alyeska/Joint Pipeline Office (JPO)/DOT Valve Memorandum of Agreement. The resultant in-service performance criteria then became an integral part of the Alyeska Quality Program and maintenance plan for determining conforming or non-conforming valve conditions. If a valve is determined to be non-conforming (outside the in-service performance criteria) it passes into a decision model for determining repair, replace, or use-as-is.

PRIMARY VALVE FUNCTIONS

TAPS primary crude block valves have the following functions:

- Primary pressure containment of the oil inside the valve. Crude does not seep through the valve body, stem packing, grease and drain fittings, flanges, or other fittings.
- Mainline block valves minimize spill volumes between pump stations. Valves should seal sufficiently to prevent additional oil from "leaking-through" the valve contributing to a spill if a leak occurs in the pipeline.
- Mainline block valves at pump station battery limits (BL's) isolate the pump station. Valves should seal sufficiently to prevent additional oil from "leaking-through" the valve contributing to a spill if a leak occurs within the pump station. In some cases the BL valves will also minimize spill volumes if a leak occurs in the pipeline (from pump station head pressure).
- Control flow in the pipeline on the mainline, at pump stations and in the Valdez Marine Terminal.
- Remote mainline valves must close and open on command from Pipeline Controller or on local command. Valves should not close or open without a command to do so.
- Mainline check valves prevent reverse flows in the pipeline and can be locked open when required (for example, to pass a pig).
- Provide mainline blockage for maintenance of the pipeline, pump stations and the Valdez Marine Terminal.

TAPS mainline gate valves are double seated where there are two sets of sealing elements. With the valve in the closed position, if both seats do not seal the liquid can internally "leak through" the valve. However, a leak past one seat in these valves does not mean the valve will leak-through. On the other hand, mainline check valves have a single seat, and if that seat or clapper corrodes or becomes damaged over time the check valve will not seat tightly which will result in leak-through.

When the double-seated valves are in the open position, if both seats seal, pressure in the valve body will reduce to zero. When one or more of the seats do not seal sufficiently the pressure in the valve body cannot be reduced to zero and pressure will quickly increase when draining of the valve body is stopped (or in higher leak conditions, will be unable to reduce body pressure at all). This testing is normally performed during routine winterization Preventive Maintenance (PMs) tasks for mainline valves prior to injecting glycol into the valve body cavity to keep water dropout from freezing under arctic conditions.

VALVE PROGRAM OVERVIEW

The TAPS Valve Program was structured to be an aggressive company-wide valve maintenance review where a core team of subject matter experts (SMEs) could act in the capacity of operations, field maintenance, and support group teams. It was originally intended that funding, staffing, and other resources would be supplemented to normal baseline operations and maintenance organizations and budgets instead of a unique one time Project structure. Using this approach would ensure that established maintenance and operations organizations would hold responsibility for some actions/processes to accelerate their learning curve, but not so much that their workloads would adversely affect normal field operations.

The two main goals of the TAPS Valve Program were:

- To establish a minimum service level condition for all valves, supported by trained personnel and verified data base systems;
- To develop a long-term maintenance program that will maintain and manage TAPS service-critical valves for an extended service life.

Valve and actuator/operator servicing, document/data verification, and systems data population took place during 1997-99 and was transitioned back into the baseline operations and maintenance organizations during 1999/2000. The main work groups of the TAPS Valve Program were:

- Pump Station and Valdez Marine Terminal Valve Maintenance Upgrades
- Mainline (M/L) Valve Testing and Repair
- Actuators/Operators Maintenance Upgrades
- Priority Valve Refurbishment and Rebuilds
- Valve Maintenance Database Development
- Develop and Transition into the baseline maintenance and operations organizations a TAPS Valve Maintenance Management Plan.

The primary scope of the TAPS Valve Program encompasses: 177 48” mainline valves and their 6” by-pass valves; mainline refinery off-take valves; approximately 600 pump station (12 stations) primary crude and gas isolation valves; and approximately 330 Valdez Marine Terminal (VMT) primary crude/water valves. The PS01 to PS4 fuel gas mainline (FGL) valves (50) were also to be part of the TAPS valve program. This paper focuses on mainline 48” valve testing and repair.

Valves are unique major TAPS components because they:

- Maintain product pressure boundaries
- Control pipeline hydraulic flow and operation Are susceptible to internal and external corrosion
- Require specific maintenance
- Have the potential that an operation failure could over-pressure the pipeline
- Require some of the most complex components on TAPS to operate (i.e., actuators/operators and controls)
- A sealing failure could substantially increase the volume of a spill from a pipeline leak.

TESTING VALVES FOR INTERNAL LEAKAGE

DOT regulation 49 CFR §195.420 (a) stipulates that *"Each operator shall maintain each valve that is necessary for the safe operation of its pipeline systems in good working order at all times."* The Department of the Interior (DOI) Bureau of Land Management (BLM) Pipeline Stipulations and Grant and Lease of Right-of-Way also emphasize the need for control of spills. Given the importance of RGVs and CKVs in mitigation of oil spills, it is good business practice to periodically verify the potential sealing capability of valves.

General industrial practice recommends testing or examination at approximately half of the expected life of the piece of equipment. For example, useful life expectancies of storage tanks are at least 20 years; therefore, API Specification 653 requires examination of a tank on 10-year cycles (or half of the remaining expected life). This principle of testing frequency can be applied to valve seats for internal “leak-through” in the closed position. Manufacturers of valves have not defined the expected life of a valve but using the original Prudhoe Bay field design life of 30 years, testing at half of the design life would result in approximately 15-year cycles.

VALVE MANUFACTURER DESIGN

When mainline valves were specified and designed, the valves were required to seal with a low differential pressure and to operate and seal in accordance with API Specification 6D as modified by Alyeska Specification. The specification in effect at the time of purchase contained test acceptance criteria that allowed a ±2% variance over in test pressure during the 60-minute seat test. The 2% test volume range when applied to pipeline in-service conditions becomes negligible and was never used for any in-service performance development. Alyeska also looked at applicability of the API Standard 607 Fire Test for soft-seated quarter turn (ball) valves. However, the design intent for TAPS mainline gate and check valves had more complex performance requirements.

LEAK-THROUGH PERFORMANCE BASED ON RISK ASSESSMENT

In establishing a risk-based performance standard, it was determined that using the original TAPS design risk assessment and then updating the risk factors based on historical events and current regulatory/business practices would provide a sound baseline. The results determined that the most likely mode of failure for the pipeline to be a one-inch diameter hole in the mainline pipe. Therefore, there was no single “leak-through” rate that is acceptable for all the in-service mainline valves. Valve location, potential environmental impact, safety of personnel and facilities all contribute to an acceptable “leak-through” rate. A result of the risk assessment concluded that a valve's performance is considered acceptable if it meets one of the following criteria:

1) Based on the most likely leak scenario, a nearby mainline leak would not exceed original design spill calculations (or approved revision).
2) A nearby mainline valve leak can be stopped or controlled using conventional sealing techniques.
3) Mitigate measures, including aggressive valve sealing, are in place to limit uncontrolled mainline leakage to original design spill calculations (or approved revision).
4) Another method of blocking the line is available, such as a manual gate valve (MGV).
5) Additional study concludes that the expected leakage falls within tolerable risk limits.

The in-service performance criteria ultimately adopted was established during the TAPS Valve Program technical review of the risk assessment and senior management review of business objectives. A more conservative approach was adopted that required that valve sealing performance would not add to a pipeline leak based on the most likely leak scenario. This performance criteria was then calculated using the risk assessment test prioritization and incorporated into Alyeska’s Master Specifications that governs maintenance and inspection requirements. If the performance criteria is not met, a “quality flag” triggers Alyeska’s Quality Program, specifically Conformance/Non-conformance (NCR) Reporting. This “quality flag” and resultant NCR disposition process for determining if the valve should be repaired, replaced or used-as-is, is embedded into the Decision Model Process *(See Figure C for concept)* as part of the TAPS Valve Maintenance Management Plan. The result: An integrated long term valve maintenance management process directly aligned with Alyeska’s Quality Program. This integration (including being based on the risk assessment) is key for buy-in from internal quality/inspection personnel and external regulators, as it provides them the visibility and formal decision process needed to document that Alyeska is “maintaining valves in good working order”.

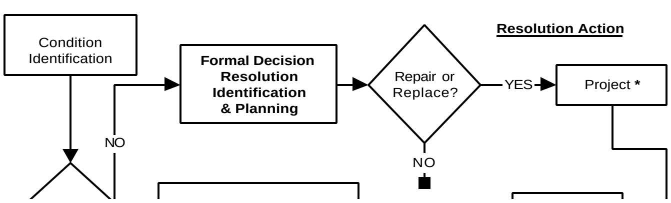

Figure C. TAPS Valve Maintenance Management Plan

CONCLUSIONS

Assuring the integrity of TAPS valves and upgrading Alyeska’s maintenance program was recognized early on as a key element to achieving overall Alyeska’s strategic goal of Operational Excellence and Regulatory Compliance. The original challenges Alyeska faced to achieve these goals were: development and implementation of the company wide TAPS Valve Program; prioritization of valve work for substantial completion before year-end 2000; repair/replacement of valves that did not meet Alyeska developed performance standard; and development and use of a maintenance management plan to extend TAPS service life.

The testing program identified two valves out of 148 tested to-date that did not meet Alyeska’s criteria and were repaired or replaced each at a cost over $4 million each. This level of success after 20 years of service helps validate that TAPS valves are in good working order. Future year testing will be determined after all 177 mainline valves are tested and will be based on each valve’s performance during routine maintenance and its service criticality.

The final element for completion of the TAPS Valve Program to meet the above challenges was integrating the TAPS Valve Maintenance Management Plan into the baseline maintenance and operations organizations. This evergreen plan provides a managed plan approach for the valve maintenance work effort. *(See Figure D.)*. Pro-active planning of maintenance activities increased margins for safety, reliability, and better prioritization of funding and resources. All of these elements of valve operation and maintenance are centered on the objective of “Moving oil safely, reliably and efficiently.”

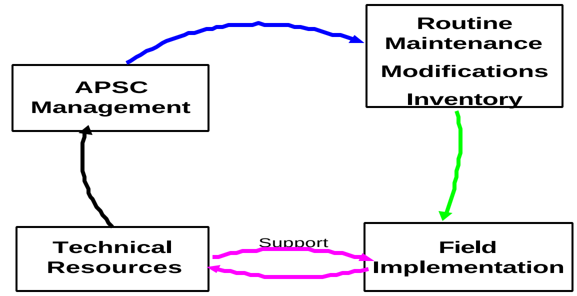

Figure D. TAPS Valve Maintenance Management Process

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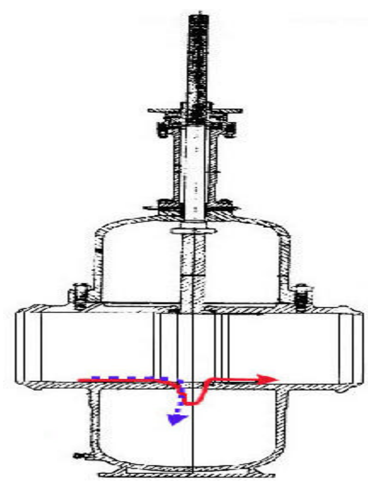

Figure A. Leak-by vs. Leak-through

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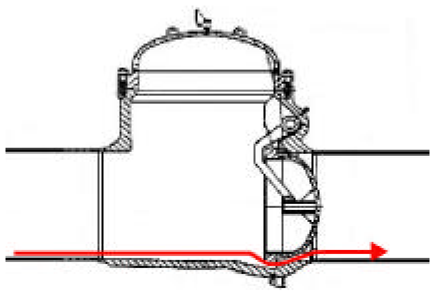

Figure B. Leak-Through

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- Primary pressure containment of the oil inside the valve. Crude does not seep through the valve body, stem packing, grease and drain fittings, flanges, or other fittings.
- Mainline block valves minimize spill volumes between pump stations. Valves should seal sufficiently to prevent additional oil from "leaking-through" the valve contributing to a spill if a leak occurs in the pipeline.
- Mainline block valves at pump station battery limits (BL's) isolate the pump station. Valves should seal sufficiently to prevent additional oil from "leaking-through" the valve contributing to a spill if a leak occurs within the pump station. In some cases the BL valves will also minimize spill volumes if a leak occurs in the pipeline (from pump station head pressure).
- Control flow in the pipeline on the mainline, at pump stations and in the Valdez Marine Terminal.
- Remote mainline valves must close and open on command from Pipeline Controller or on local command. Valves should not close or open without a command to do so.
- Mainline check valves prevent reverse flows in the pipeline and can be locked open when required (for example, to pass a pig).
- Provide mainline blockage for maintenance of the pipeline, pump stations and the Valdez Marine Terminal.

TAPS mainline gate valves are double seated where there are two sets of sealing elements. With the valve in the closed position, if both seats do not seal the liquid can internally "leak through" the valve. However, a leak past one seat in these valves does not mean the valve will leak-through. On the other hand, mainline check valves have a single seat, and if that seat or clapper corrodes or becomes damaged over time the check valve will not seat tightly which will result in leak-through.

When the double-seated valves are in the open position, if both seats seal, pressure in the valve body will reduce to zero. When one or more of the seats do not seal sufficiently the pressure in the valve body cannot be reduced to zero and pressure will quickly increase when draining of the valve body is stopped (or in higher leak conditions, will be unable to reduce body pressure at all). This testing is normally performed during routine winterization Preventive Maintenance (PMs) tasks for mainline valves prior to injecting glycol into the valve body cavity to keep water dropout from freezing under arctic conditions.

VALVE PROGRAM OVERVIEW

The TAPS Valve Program was structured to be an aggressive company-wide valve maintenance review where a core team of subject matter experts (SMEs) could act in the capacity of operations, field maintenance, and support group teams. It was originally intended that funding, staffing, and other resources would be supplemented to normal baseline operations and maintenance organizations and budgets instead of a unique one time Project structure. Using this approach would ensure that established maintenance and operations organizations would hold responsibility for some actions/processes to accelerate their learning curve, but not so much that their workloads would adversely affect normal field operations.

The two main goals of the TAPS Valve Program were:

- To establish a minimum service level condition for all valves, supported by trained personnel and verified data base systems;
- To develop a long-term maintenance program that will maintain and manage TAPS service-critical valves for an extended service life.

Valve and actuator/operator servicing, document/data verification, and systems data population took place during 1997-99 and was transitioned back into the baseline operations and maintenance organizations during 1999/2000. The main work groups of the TAPS Valve Program were:

- Pump Station and Valdez Marine Terminal Valve Maintenance Upgrades
- Mainline (M/L) Valve Testing and Repair
- Actuators/Operators Maintenance Upgrades
- Priority Valve Refurbishment and Rebuilds
- Valve Maintenance Database Development
- Develop and Transition into the baseline maintenance and operations organizations a TAPS Valve Maintenance Management Plan.

The primary scope of the TAPS Valve Program encompasses: 177 48” mainline valves and their 6” by-pass valves; mainline refinery off-take valves; approximately 600 pump station (12 stations) primary crude and gas isolation valves; and approximately 330 Valdez Marine Terminal (VMT) primary crude/water valves. The PS01 to PS4 fuel gas mainline (FGL) valves (50) were also to be part of the TAPS valve program. This paper focuses on mainline 48” valve testing and repair.

Valves are unique major TAPS components because they:

- Maintain product pressure boundaries
- Control pipeline hydraulic flow and operation
  Are susceptible to internal and external corrosion
- Require specific maintenance
- Have the potential that an operation failure could over-pressure the pipeline
- Require some of the most complex components on TAPS to operate (i.e., actuators/operators and controls)
- A sealing failure could substantially increase the volume of a spill from a pipeline leak.

TESTING VALVES FOR INTERNAL LEAKAGE

DOT regulation 49 CFR §195.420 (a) stipulates that *"Each operator shall maintain each valve that is necessary for the safe operation of its pipeline systems in good working order at all times."* The Department of the Interior (DOI) Bureau of Land Management (BLM) Pipeline Stipulations and Grant and Lease of Right-of-Way also emphasize the need for control of spills. Given the importance of RGVs and CKVs in mitigation of oil spills, it is good business practice to periodically verify the potential sealing capability of valves.

General industrial practice recommends testing or examination at approximately half of the expected life of the piece of equipment. For example, useful life expectancies of storage tanks are at least 20 years; therefore, API Specification 653 requires examination of a tank on 10-year cycles (or half of the remaining expected life). This principle of testing frequency can be applied to valve seats for internal “leak-through” in the closed position. Manufacturers of valves have not defined the expected life of a valve but using the original Prudhoe Bay field design life of 30 years, testing at half of the design life would result in approximately 15-year cycles.

VALVE MANUFACTURER DESIGN

When mainline valves were specified and designed, the valves were required to seal with a low differential pressure and to operate and seal in accordance with API Specification 6D as modified by Alyeska Specification. The specification in effect at the time of purchase contained test acceptance criteria that allowed a ±2% variance over in test pressure during the 60-minute seat test. The 2% test volume range when applied to pipeline in-service conditions becomes negligible and was never used for any in-service performance development. Alyeska also looked at applicability of the API Standard 607 Fire Test for soft-seated quarter turn (ball) valves. However, the design intent for TAPS mainline gate and check valves had more complex performance requirements.

LEAK-THROUGH PERFORMANCE BASED ON RISK ASSESSMENT

In establishing a risk-based performance standard, it was determined that using the original TAPS design risk assessment and then updating the risk factors based on historical events and current regulatory/business practices would provide a sound baseline. The results determined that the most likely mode of failure for the pipeline to be a one-inch diameter hole in the mainline pipe. Therefore, there was no single "leak-through" rate that is acceptable for all the in-service mainline valves. Valve location, potential environmental impact, safety of personnel and facilities all contribute to an acceptable "leak-through" rate. A result of the risk assessment concluded that a valve's performance is considered acceptable if it meets one of the following criteria:

1) Based on the most likely leak scenario, a nearby mainline leak would not exceed original design spill calculations (or approved revision).
2) A nearby mainline valve leak can be stopped or controlled using conventional sealing techniques.
3) Mitigate measures, including aggressive valve sealing, are in place to limit uncontrolled mainline leakage to original design spill calculations (or approved revision).
4) Another method of blocking the line is available, such as a manual gate valve (MGV).
5) Additional study concludes that the expected leakage falls within tolerable risk limits.

The in-service performance criteria ultimately adopted was established during the TAPS Valve Program technical review of the risk assessment and senior management review of business objectives. A more conservative approach was adopted that required that valve sealing performance would not add to a pipeline leak based on the most likely leak scenario. This performance criteria was then calculated using the risk assessment test prioritization and incorporated into Alyeska's Master Specifications that governs maintenance and inspection requirements. If the performance criteria is not met, a "quality flag" triggers Alyeska's Quality Program, specifically Conformance/Non-conformance (NCR) Reporting. This "quality flag" and resultant NCR disposition process for determining if the valve should be repaired, replaced or used-as-is, is embedded into the Decision Model Process *(See Figure C for concept)* as part of the TAPS Valve Maintenance Management Plan. The result: An integrated long term valve maintenance management process directly aligned with Alyeska's Quality Program. This integration (including being based on the risk assessment) is key for buy-in from internal quality/inspection personnel and external regulators, as it provides them the visibility and formal decision process needed to document that Alyeska is "maintaining valves in good working order".

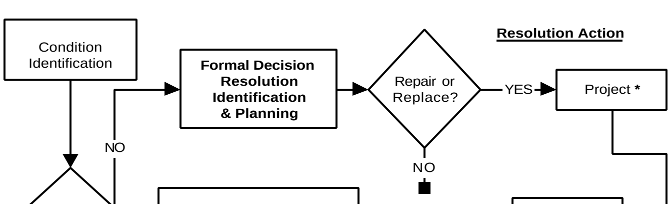

Figure C. TAPS Valve Maintenance Management Plan

CONCLUSIONS

Assuring the integrity of TAPS valves and upgrading Alyeska's maintenance program was recognized early on as a key element to achieving overall Alyeska's strategic goal of Operational Excellence and Regulatory Compliance. The original challenges Alyeska faced to achieve these goals were: development and implementation of the company wide TAPS Valve Program; prioritization of valve work for substantial completion before year-end 2000; repair/replacement of valves that did not meet Alyeska developed performance standard; and development and use of a maintenance management plan to extend TAPS service life.

The testing program identified two valves out of 148 tested to-date that did not meet Alyeska's criteria and were repaired or replaced each at a cost over $4 million each. This level of success after 20 years of service helps validate that TAPS valves are in good working order. Future year testing will be determined after all 177 mainline valves are tested and will be based on each valve's performance during routine maintenance and its service criticality.

The final element for completion of the TAPS Valve Program to meet the above challenges was integrating the TAPS Valve Maintenance Management Plan into the baseline maintenance and operations organizations. This evergreen plan provides a managed plan approach for the valve maintenance work effort. *(See Figure D.)*. Pro-active planning of maintenance activities increased margins for safety, reliability, and better prioritization of funding and resources. All of these elements of valve operation and maintenance are centered on the objective of "Moving oil safely, reliably and efficiently."

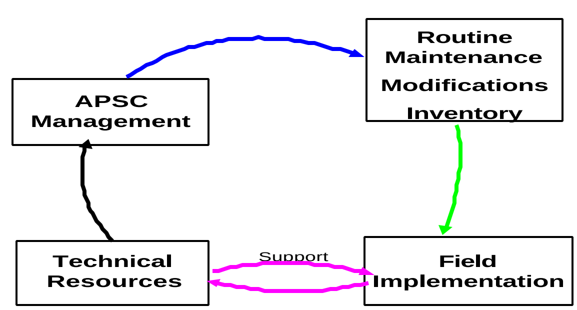

Figure D. TAPS Valve Maintenance Management Process

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