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**PUBLIC SERVICE COMMISSION**

September 8, 2011

Mr. Patrick Fahn  
North Dakota Public Service Commission  
600 E. Boulevard, Dept. 408  
Bismarck, North Dakota 58505-0480

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VIA ELECTRONIC DELIVERY AND COURIER

Re: August 15, 2011, Data Request

Dear Mr. Fahn:

In response to your request on August 15, 2011, TC Oil Pipeline Operations, Inc. submits the enclosed information which summarizes of our monthly report and work plan submittals to the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) as required under the Amended Corrective Action Order (CAO) issued on June 23, 2011. As Ms. Sacco requested in her email dated May 17, 2011, we are providing documents that do not require FOIA protection.

If you have any questions regarding the enclosed documents, please contact me at.

Sincerely,

A handwritten signature in cursive script that reads "Ken Crowl".

Ken Crowl  
Manager, U.S. Pipeline Compliance – U.S. Pipeline Operations  
TransCanada Corporation  
717 Texas Street  
Houston, Texas 77002

CPF No. 3-2011-5006H – Keystone Pipeline Corrective Action Order  
August 2011 Monthly Report

**Executive Summary**

In accordance with the Corrective Action Order (CAO) issued by PHMSA on June 3, 2011 and amended on June 23, 2011, TC Oil Pipeline Operations, Inc. submits the following information in the a report format.

Item 7 of the CAO required completion of a root cause failure analysis (RCFA) that is supplemented and facilitated by an independent third party expert acceptable to the director. An interim report was submitted to PHMSA on August 1, 2011 pending final results by the independent dynamic analysis being performed by SWRI.

Item 8 B of the CAO required that a third party contractor specializing in vibration and pulsation analysis be retained to design evaluation methods, facilitate and review any required training, perform analysis of field test results and provide recommendations. An interim report was submitted to PHMSA as part of the July 31, 2011 monthly report. The final report has been completed.

As communicated in the July Monthly Report, as part of TC Oil Pipeline Operations, Inc.'s ongoing efforts to address integrity threats associated with piping vibration caused by Pressure Control Valve (PCV) operations, TC Oil Pipeline Operations, Inc. completed modifications to branch connections on the pump station piping outside of the unit valves. Follow up testing and analysis is in the process of being completed. Testing indicates expected results that raised natural frequency and lowered vibration levels.

As communicated in the July Monthly Report, TC Oil Pipeline Operations, Inc. has completed trimming of pump impellers at Ft. Ransom, Freeman, and Seneca A1 pumps and implemented stage-4 LPC settings at all pump stations. This was part of TC Oil Pipeline Operations, Inc.'s efforts to optimize operating conditions resulting in less throttling of the Pressure Control Valves.

**Introduction**

TC Oil Pipeline Operations, Inc. operates the Keystone oil pipeline system from Hardisty, Alberta to delivery terminals in Wood River and Patoka, Illinois and Cushing, Oklahoma. On May 7, 2011 the system experienced a reportable oil release of approximately 400 barrels at the Ludden, ND pump station. On May 29, 2011 a second reportable oil release of approximately 10 barrels occurred at the Severance, KS pump station.

As a result of the above mentioned oil releases a Corrective Action Order (June 3, 2011) and subsequent Amended Corrective Action Order (June 28, 2011) were issued to TC Oil Pipeline Operations, Inc.

The July 2011 Monthly Report communicated the successful re-start of the Keystone Pipeline to full volumes. The following Monthly Report is submitted per Item 11 of the CAO.

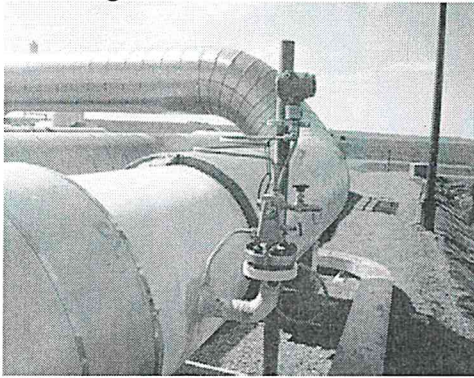
### **Root Cause Failure Analysis**

Item 7 of the CAO required a Root Cause Failure Analysis (RCFA) to be completed within 60 days. An interim report was sent to PHMSA on August 1, 2011, within the prescribed time frame. The report has now been finalized with recommendations and forms part of the basis of the Remedial Work Plan that will be submitted by September 1, 2011. The RCFA report includes the finalized independent technical study by SWRI according to the proposal approved by PHMSA on June 24, 2011.

### **Work Plan – August 2011**

As communicated in the July Monthly Report, as part of TC Oil Pipeline Operations, Inc.'s ongoing efforts to address integrity threats associated with piping vibration caused by Pressure Control Valve (PCV) operations, the following remedial action plan was implemented during an outage at fixed speed stations that took place August 2 to 8, 2011.

- Pressure Transmitters (PT103, PT201, PT202, PT203) – The scope included cutting and capping the old connection, installing a new ½ inch connection and isolation valve, and remotely mounting the three way manifold. The following pictures are representative of the changes.

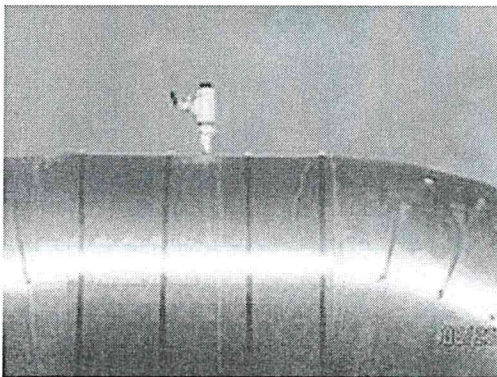


PT -201 Before

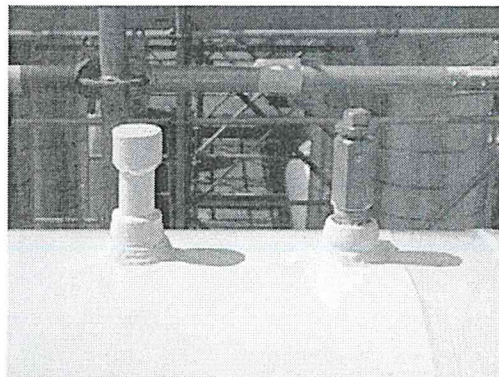


PT-201 After

- High Point Vents (each pump suction and discharge expansion loop) – The scope included cutting and capping the old connection and installing a new 1 inch connection with a vented plug. The following pictures are representative of the changes.

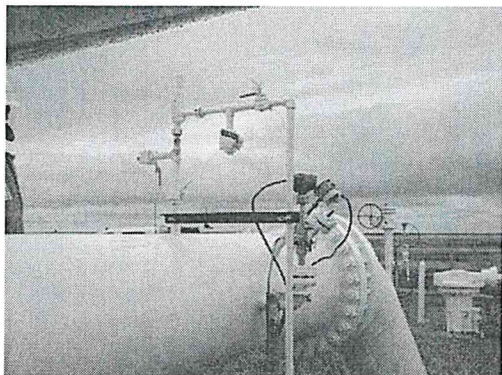


HPV Before

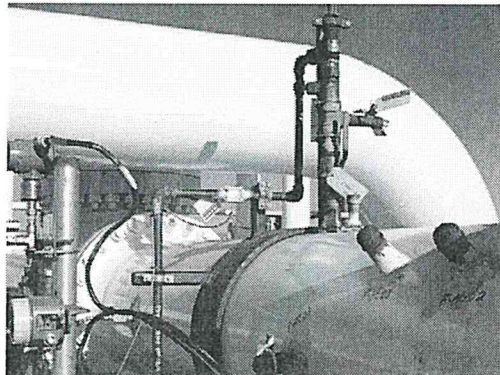


HPV After

- Pressure Safety Valve Piping – The scope of work included a new piping design and brace. The original connection was cut and capped. The following pictures are representative of the changes.



PSV – Before w/ Temporary Brace

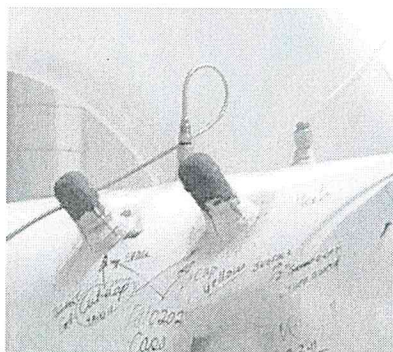


PSV After

- Thermowells – The scope of work included off-mounting of the existing temperature transmitters, cutting and capping of the thermowell connections on the station discharge, and installation of new low profile thermowells. The existing thermowell connections remain in place on the station suction piping. The following pictures are representative of the changes.



2 Thermo wells – Before



2 Thermowells – After

It should be noted that high level of strain was detected at the PT connections to the main bore piping. Accordingly, additional testing was completed just prior to the outage on station suction and discharge thermowell connections, and a 4" connection on the downstream side of the unit valves. As a result of the testing, modifications were made to the scope of work that was outlined in the July 31, 2011 monthly report. The results of the pre-outage testing and resulting actions are detailed below.

### **Additional Pre-Outage Testing**

Testing was completed at the Severance Pump Station just prior to the outage in order to incorporate the findings of the SWRI interim report and refine the scope reported on in the July 31 monthly report.

The testing of the Station Suction Thermowell TT-101 indicated that the station suction piping was within acceptable limits and did not respond significantly to pressure control valve operations. As such both thermowell connections were left. As an added precaution the temperature transmitters were off mounted.

The Thermowells on the station discharge piping showed higher levels of strain and vibration. As a result, both connections were removed instead of removing only one connection as proposed in the July 31 monthly report. As an added precaution the temperature transmitters were off mounted.

The 4" connection located on the down stream side of the discharge valve showed low levels of vibration and low levels of strain as a result these connections were left in place.

### **Post Modification Vibration Testing**

Follow up testing and analysis is in the process of being completed at all fixed speed stations to determine the effectiveness of the modifications. Testing indicates that the piping attachment natural frequencies were raised and that vibration levels were lowered, as was expected.

TC Oil Pipeline Operations, Inc. conducted a pinch test that operated the Severance Pump Station in a condition that would not normally exist in typical operations in order to simulate a potential "worst case" scenario. The test scenario consisted of running an additional pump not required for operations at that point in time. This resulted in levels of energy dissipation by the pressure control valve that would exceed any normal operating mode. The total head pressure produced by the pump was subsequently dissipated through the Pressure Control Valve, resulting in high levels of broadband energy available to excite the station small bore components.

### **Component Natural Frequencies**

The natural frequencies of each of the connections were tested and are shown in the following table.

Component Natural Frequencies in Hz		
Component	Before	After
PT-201-X	30	357
PT-201-Y	30	388
PT-202-X	30	353
PT-202-Y	30	358
PT-203-X	30	387
PT-203-Y	30	340
PSV-X	22 (no brace)	51
PSV-Z	20 (no brace)	49

### **Pressure Transmitters**

All Pressure Transmitter connections were well within the vibration screening criteria.

### **High Point Vents**

The high point vent on the discharge of unit-4 expansion loop was tested and found to be within the vibration screening criteria.

#### **Pressure Safety Valve Piping**

All Pressure Safety Valve connections were well within the vibration screening criteria.

#### **Impeller Trim & LPC Settings**

As reported in the July monthly report TC Oil Pipeline Operations, Inc. completed trimming of the impellers of the Ft. Ransom, Freeman and Seneca A1 pumps to reduce that level of PCV throttling at these fixed speed sites.

#### **Independent Technical Evaluation - SWRI**

The latest results from the SWRI testing at the Fort Ransom Pump Station revealed an operational scenario at unit start-up that resulted in brief period of high vibration and strain in attachments in close proximity to the unit discharge valve when the valve opens and the PCV is in operation. The recent modifications to PT 202 involved removal of the attachment tested and the replaced with a different design. Testing of the Severance Pump Station involved starting and stopping of units during testing. No significant increase in vibration was noted during these transient events. TransCanada will include testing for this operating state as part of it integrity verification process. This proposed work will be incorporated in the Remedial Work Plan that will be submitted to PHMSA on September 1, 2011.

#### **Next Steps and Timelines**

##### **Small Bore Piping Bracing**

On August 25 and 26, installation and testing of a brace was performed at a fixed speed and a VFD site. The bracing is intended to reduce vibration response of Pressure Transmitter and Thermowell branch connections for unmodified unit and station branches. The effectiveness of the support will be evaluated and modified as required prior to implementation.

##### **Work Plan**

Additional future work to ensure the long term integrity of the pump station piping is defined in the Work Plan developed to fulfill Item 8 of the CAO. This plan will be submitted to PHMSA on September 1<sup>st</sup>, 2011.

#### **Index of Attachments**

Attachments omitted due to confidential, privileged, proprietary and/or security sensitive information contained within the documents.

CPF No. 3-2011-5006H – Keystone Pipeline Corrective Action Order  
Remedial Work Plan – August 31, 2011

**Executive Summary**

In accordance with the Corrective Action Order (CAO) issued by PHMSA on June 3, 2011 and amended on June 23, 2011, TC Oil Pipeline Operations, Inc. submits the following work plan.

A significant amount of testing, evaluation and modifications have been completed to ensure the integrity of the Keystone Pipeline following the releases on May 7, 2011 and May 29, 2011. The information compiled in the following work plan and attachments constitutes all of the remedial work that was completed to date, and the actions that will be completed in the future.

The work plan contains provisions for additional testing, verification and remediation of the causal factors, and where appropriate, specific technical and procedural actions that will be taken. The work plan provides the approach utilized to address the recommendations of the independent evaluators and investigation by TC Oil Pipeline Operations, Inc.

TC Oil Pipeline Operations, Inc. is committed to ensuring the integrity of the Keystone Pipeline and strives to continuously improve the operation of the facilities. Consistent with this philosophy, measures will be taken to ensure the integration of the applicable documentation into the appropriate management system to ensure that the lessons learned are retained and accessible.

**Introduction**

TC Oil Pipeline Operations, Inc. operates the Keystone oil pipeline system from Hardisty, Alberta to delivery terminals in Wood River and Patoka, Illinois and Cushing, Oklahoma. On May 7, 2011 the system experienced a reportable oil release of approximately 400 barrels at the Ludden, ND pump station. On May 29, 2011 a second reportable oil release of approximately 10 barrels occurred at the Severance, KS pump station.

As a result of the above mentioned oil releases a Corrective Action Order (June 3, 2011) and subsequent Amended Corrective Action Order (June 28, 2011) were issued to TC Oil Pipeline Operations, Inc.

**Response to Corrective Action Order Item #8 (Work Plan Submittal)**

Corrective Action Order CPF No. 3-2011-5006H item # 8 states;

*Within 90 days following receipt of this Order, submit a remedial work plan ("Work Plan") to the Director for approval that includes corrective measures. The Work Plan must provide for the verification of the integrity of the pipeline and must address all*

*factors known or suspected that caused or contributed to the May 7 and May 29, 2011 failures and other known related releases, including, but not limited to:*

*A. The integration of the results of the RCF A and other failure analyses and actions required by this Order with all existing relevant operating data including all historical repair information, construction, operating, maintenance, testing, leak history, metallurgical analysis or other third party consultation information, and assessment data on sections of Keystone pump stations having small diameter piping and fittings;*

*B. The performance of additional field testing, inspections, and evaluations to determine whether and to what extent the conditions associated with the failures, or any other integrity-threatening conditions are present elsewhere on the pipeline. A third party contractor specializing in vibration and pulsation analysis, upon acceptance by the Director, shall be retained to design evaluation methods, facilitate and review any required training, perform analysis of field test results and provide recommendations. Include a detailed description of the criteria to be used for the evaluation and prioritization of any integrity threats and anomalies that are identified;*

*C. The performance of repairs or other corrective measures that fully remediate the condition(s) associated with the pipeline failures and any other integrity threatening condition, including those identified per Items 4 and 5, everywhere along the pipeline where they are identified. Include a detailed description of the criteria and method(s) to be used in undertaking any repairs, replacements, or other remedial actions;*

*D. The implementation of continuing long-term periodic testing and integrity verification measures to ensure the ongoing safe operation of the pipeline considering the results of the analyses, inspections, and corrective measures undertaken pursuant to this Order; and*

*E. A schedule for completion of the Items A-D.*

Based on all of the items listed above, TC Oil Pipeline Operations, Inc. submits the following information in support of completing the requirements of the above Corrective Action Order line item. The areas of improvement identified include, mechanical/technical, process, and management of change and continuous operations.

### **Key Findings**

The following work plan was designed to address the key findings from the independent consultants, as well as the internal review of the design and operation of the components involved in the Ludden and Severance pump station failures. These assessments included a review of technical and procedural aspects of managing projects. Based upon the

RCFA performed by Exponent, Independent testing by SwRI and TC Oil Pipeline Operations, Inc.'s field vibration surveys, following are the key findings;

1. The main cause of high levels of vibration and dynamic strain is the use of the station pressure control valve, (REXA valve) to dissipate excess amounts of hydraulic head to operate within the maximum operating pressure of the pipeline.
2. Areas downstream of the pumps are the most prone to vibrational excitation from the REXA valve, but instrumented areas around the pumps were seen to have vibrational response to varying extents.
3. Transient levels of high vibration and strain in localized piping may result from Unit MOV operation during Unit start up.
4. The current piping system is very flexible considering the level of shaking forces being experienced. The existing supports provide weight support, but virtually no dynamic restraint.
5. Nominal flow velocities in the piping were found to be at levels considered to be low. They are not expected of themselves to be a cause of significant vibration.
6. VFD sites are less prone to piping system vibration as a result of minimal REXA valve throttling during pipeline operations.
7. The design process (assumptions and design reviews) did not identify or analyze vibration as a significant load condition for the pump station piping, despite requirements in the engineering design specifications and pipe stress analysis criteria to consider the effects of vibration.
8. The incident analysis activities (conducted in accordance with the Incident and Issue Management Processes) missed opportunities to identify the full significance of vibration on the pump station piping attachments prior to the reportable events. Although it is not clear that a more effective implementation of the Incident and Issue Management Process for these vibration events could have prevented the incidents.
9. Exponent noted that many good practices are employed by TC Oil Pipeline Operations in the conduct of its work. The TC Oil Pipeline Operations team had many actions and measures underway to address the pump station pipe vibration issue.

## **Work Plan**

### Mechanical/Technical

*TransCanada will continue it's program to modify attachments and supports as described in this work plan and assess all repairs or modifications through additional field testing, inspection, and/or engineering evaluation to determine the effectiveness of the work performed to ensure the long term integrity of the pipeline.*

- At all Fixed Speed and VFD sites, replace all schedule 80 swage nipples used on the thermal relief valves with schedule 160 fittings to minimize the effect of operational vibration and over torque during operations. Completed May, 2011.

- Complete vibration surveys at all fixed speed sites and complete an evaluation Completed June, 2011.
- Complete vibration surveys at all VFD sites and complete an evaluation. Completed July, 2011.
- At all Fixed Speed sites, remotely mounted the station pressure transmitters (PT103, PT201, PT202, and PT203) to remove the inertial mass from the manifold valve, reducing the stress at the threaded nipple. Threaded schedule 80 swage nipples were also replaced with schedule 160 nipples. Completed June, 2011
- At all Fixed Speed sites, remotely mounted the Unit pressure transmitters (PT10X1 and, PT10X3) to remove the inertial mass from the manifold valve, reducing the stress at the threaded nipple. Completed June, 2011
- At all fixed, VFD, and In-Line Inspection sites, install bracing on the thermal relief valve piping assemblies to minimize the levels of operational vibration and stress on susceptible joints on the piping assembly. Completed July, 2011.
- At all fixed speed sites, complete NDE Inspections of PT fittings, PSV fittings, Temperature Transmitter connections, Drains, and pig traps to check for surface breaking defects. Completed June, 2011.
- At all fixed speed and variable speed sites, off mount secondary isolation valve and threaded pipe nipple on high point vents to minimize the effect of vibration during PCV operations. Completed June, 2011.
- At all fixed and variable speed sites, implement a planned program to upgrade line pressure control settings to optimize the control of the PCV. Completed August, 2011.
- At Freeman A1 pump, Ft Ransom A1 and the Seneca A1 pump complete trimming of the pump impellers to reduce the amount of PCV throttling. Completed August, 2011.
- At all fixed speed sites, complete modifications to branch connections on the pump station piping outside of the unit valves to minimize the effect of vibration during PCV operations. Completed August, 2011
  - Pressure Transmitters (PT103, PT201, PT202, PT203) – The scope included cutting and capping the old connection, installing a new ½ inch connection and isolation valve, and remotely mounting the three way manifold
  - High Point Vents (each pump suction and discharge expansion loop) – The scope included cutting and capping the old connection and installing a new 1 inch connection with a vented plug
  - Pressure Safety Valve Piping – The scope of work included a new piping design and brace. The original connection was cut and capped.

- Thermowells – The scope of work included off-mounting of the existing temperature transmitters, cutting and capping of the thermowell connections on the station discharge, and installation of new low profile Thermowells.
- Validate through additional field testing, inspection, and/or engineering evaluation the effectiveness of the recent modifications made in order to ensure the long term integrity of the pipeline. Completion no later than October 31, 2011.
- At all Fixed Speed and VFD sites, inspect for proper support of installed tubing and flexible hoses to ensure ongoing effectiveness of recent modifications and rectify any deficiencies. Completion no later than December 31, 2011.
- Implement a program to brace or modify branch connections susceptible to high levels of vibration at fixed speed, variable speed, delivery sites and validate through additional field testing, inspection, and/or engineering evaluation the effectiveness of the modifications made in order to ensure the long term integrity of the pipeline.

FIXED SPEED STATIONS – Completion no later than December 31, 2011

- Refine Permanent PSV bracing at Fixed Speed sites as necessary
- Install bracing on 2” Unit MOV suction valve relief bypass line
- Implement modification(s) to all Unit Pressure and Temperature transmitter attachments
- Install new design PSV piping and supports on Pigging Traps
- Implement modifications to Sump Injection Pump discharge piping supports.

VARIABLE SPEED STATIONS – Completion no later than March 31, 2012

- Off-mount VFD Station Unit Pressure Transmitters
- Off- mount all Temperature Transmitters from Station Piping
- Install bracing on 2” Unit MOV suction valve relief bypass line
- Install Permanent PSV bracing at VFD sites
- Implement modification(s) to all Unit Pressure and Temperature transmitter attachments
- Implement modification(s) to all VFD site Station Pressure and Temperature transmitter attachments
- Install new design PSV piping and supports on Pigging Traps
- Implement modifications to Sump Injection Pump discharge piping supports.

Product Receipt and Delivery Sites – Completion no later than December 31, 2011

- Install new design PSV piping and supports on Pigging Traps
- Implement modifications to Pressure Transmitter attachments in proximity of the Cushing Pressure Control Valve

- Complete a field study to determine the affect of Unit valve operations on transient piping vibrations. Completion no later than December 31, 2011
- Develop an Operating Procedure to be executed when greater levels of energy dissipation by the PCV are expected as part of future operations. This procedure will provide for testing to be conducted in order to verify the integrity of the pipeline. Completion no later than December 31, 2011.
- Complete an evaluation of modifying or supplementing large bore piping supports. Completion no later than March 31, 2012

#### Management System/Process

- Develop and implement a standard design review process to verify that all design specification requirements have been identified and adequately addressed in the design documentation. Completion no later than March 31, 2012.
- A review of the Keystone Pipeline design will be conducted to determine if the specified design loads in the DBM were considered in the design. Completion no later than March 31, 2012.
- A formal design review oversight process (third party oversight) for the external engineering companies will be developed and implemented. This will include the accountability for final sign-off (outside of the engineering supplier) within the project engineering team. Completion no later than March 31, 2012.
- Develop a design standard for small bore piping attachments for LVP liquid pipelines. Completion no later than March 31, 2012.
- Develop an inspection and testing plan for LVP liquid pipelines that encompasses the range of expected conditions post-start up for future pipeline projects. Completion no later than March 31, 2012
- Updated the Incident Management Process to include both the steps for managing an incident and the steps for managing issues. These changes will detail the relationship between incidents and issues and include RACI Chart(s) for managing equipment incidents and issues. Completion no later than March 31, 2012.
- Update the incident & Issue Tracking (IIT) application to require the entry of cause and potential severity on issues. Completion no later than March 31, 2012.

### Management of Change

- Develop and implement a process to manage project design changes. Completion no later than March 31, 2012.
- Review and update Incident and Issue Management Guides to identify changes required to track and report component failures associated with the Oil Pipeline line of business. Completion no later than March 31, 2012.
- Develop and implement changes to the IIT application that will require the accountable person to determine if it is appropriate to initiate a root cause investigation, and if initiated, assure the completion of the investigation. Completion no later than March 31, 2012.

### Continuing Operations

TC Oil Pipeline Operations, Inc. will ensure that all maintenance task procedures applicable to the operations and maintenance of the Keystone Pipeline System are modified as necessary to ensure the following work is performed at the indicated periodicity in order to ensure the on-going safe operation of the pipeline;

- Review and modify TC Oil Pipeline Operations, Inc. Facility Integrity Inspection TOP to ensure that periodic inspection and measurement of vibrations are made. Completion no later than December 31, 2011.
- Develop a formalized Vibration Escalation Process to be utilized in conjunction with Operator Integrity Inspections for the Field. Completion no later than December 31, 2011.
- Review and modify existing maintenance and inspection programs to ensure periodic inspection of tubing, flexible hoses, clamps, braces and any other supporting devices are effective in their installation and intended purpose(s). Completion no later than March 31, 2012.
- Develop a long term program to provide for periodic non-destructive testing of selected small bore piping components. Completion no later than March 31, 2012.
- Develop a piping inspection and testing procedure that encompasses the range of operating conditions expected post start up for future pipeline projects. Completion no later than March 31, 2012.