

Date: 6 January 2023
From: **Redacted by TC Energy**
To: **File**
CC: **Redacted by TC Energy**
RE: STL CB MP14 Review of Prior ILI Results
Revision: 0

1 Purpose

The purpose of this memo is to document the review of prior in-line inspection (ILI) results following the MP 14 incident as per CPF No. 3-2022-074-CAO (“CAO”), Required Correction Action number 3 – Review of Prior ILI Results.

2 Background

On December 7, 2022, TC Energy experienced an accident on the NPS 36 Keystone Pipeline south of the Steele City pump station at MP 14 in Washington County, KS. There was no ignition, no fatalities and no injuries reported as a result of the failure. An approximate location of the release point is shown in Figure 1. The release was approximately 100 ft downstream of the Mill Creek 3 crossing.



Figure 1: Overview Image of Release Location

On December 8, 2022, the Pipeline Hazardous Materials Safety Administration (PHMSA) issued a Corrective Action Order (CAO) to TC Energy outlining the required corrective actions. One of the corrective actions from the order is outlined below:

3. Review of Prior In-line Inspection (ILI) Results:

- a. Within 30 days of receipt of the CAO, TC Oil must conduct a review of any previous ILI results of the *Affected Segment*. In its review, TC Oil must re-evaluate all ILI results from the past 10 calendar years, including a review of the ILI vendors' raw data and analysis. TC Oil must determine whether any features were present in the failed pipe joints from the December 7, 2022, failure. Also, TC Oil must determine if any features with similar characteristics are present elsewhere on the *Affected Segment*. TC Oil must submit documentation of this ILI review to the Director within 45 days of receipt of the CAO, as follows:
 - i. List all ILI tool runs, tool types, and the calendar years of the tool runs.
 - ii. List, describe (type, size, wall loss, etc.), and identify the specific location of all ILI features present in the failed joint and other pipe removed.
 - iii. List, describe (type, size, wall loss, etc.), and identify the specific location of all ILI features with similar characteristics present elsewhere on the *Affected Segment*.
 - iv. Explain the process used to review the ILI results and the results of the reevaluation.

Note that for the purposes of this CAO, the “Affected Segment” is considered to be the segment of pipe between the Steele City and Hope Pump Stations, and lies entirely within the Keystone Segment 10 (KS10) piggable segment. The extent of the Affected Segment is shown in Figure 2.



Figure 2: Affected Segment (Green) in Relation to KS10 (Yellow)

Investigation on site has revealed that the failure feature was located in the vicinity of GWD 13530, which is a circumferential weld which connects a 3D elbow fitting to the pup that came from the fabrication shop. Photos of the failure feature are shown in Figure 3 and Figure 4.



Figure 3: Failure Feature Location Circled in Red

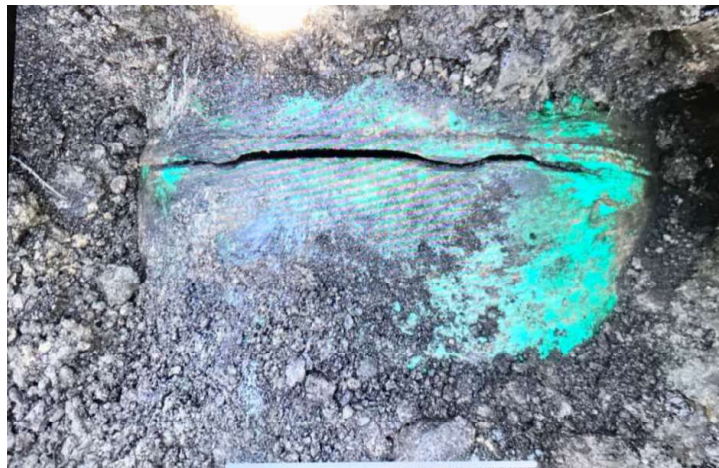


Figure 4: Photo of Failure Feature. Note that the feature is on the pup side of GWD 13530

In addition to the circumferentially oriented failure, during excavation, a bulge was also noted upstream of the elbow. This bulge is shown in Figure 5.



Figure 5: Photo of Bulge Upstream of Elbow

This document will outline what has been completed as part of the review of previous ILI results within the affected segment, as well as the review for ILI features with similar characteristics to the failure feature.

3 ILI History

A summary of the in-line inspections completed within KS10, including the Affected Segment are shown in Table 1.

Table 1: KS10 ILI History

Inspection Name	Technologies	Inspection Date
TDW Post Construction Caliper	Caliper	Oct 2010
BHI Profile Tool Run	Caliper	Dec 2012
Baker Hughes GEMINI (MFL/Caliper)	MFL, Caliper, IMU	Sept 2013
BHGE MFL4 (MFL/Caliper)	MFL, Caliper, IMU	Nov 2018
NDT Eclipse	UT Crack Detection	Sept 2020

4 ILI Features on Failure Joint & Cut-out Section

4.1 ILI Review Process

As part of the review of prior ILI results at the failure location, a first pass was completed looking at what features were reported in each of the inspections over the last ten years. The results of that review are shown in Section 4.2. Following the review of reported features, requests were sent to the respective ILI

vendors to complete manual reviews of the raw inspection data to determine if there were any signals that may have been mistakenly not reported, or did not meet the respective reporting characteristics. The results of these manual reviews for each of the inspections are explained in further detail in Section 4.3.

Finally, due to the circumferential orientation of the failure, the available IMU data from the 2013 and 2018 inspections was reviewed by the vendor looking for changes in the pipe position and strain measurements to determine if there was any movement of the pipe in between the inspections. The results of that review are documented in Section 4.4.

4.2 Reported Features

As previously mentioned, the failure occurred at the girth weld between a 3D elbow and a pup. The reference GWD number is 13530. The elbow in question, as well as three (3) feet downstream and five (5) feet upstream of the elbow was cut out and sent for metallurgical analysis. From an ILI perspective, this cut-out would include joints 13510 to 13530. As per corrective action 3(ii) of the CAO, this segment will look at ILI features within the cut-out segment.

Except for the post construction caliper inspection in 2010, all of the reported features from the inspections listed in Table 1 are contained in a data integration platform called PiMSlider. A listing of all the reported features from these inspections is shown in Table 2. Note that in order to avoid mass duplication, the 2013 BHI MFL Caliper ILI is used as the reference ILI as it pertains to girth welds and bends within the associated extents. Also, note that there were no reported features in this extent from the 2020 Eclipse inspection.

Table 2: Reported Features within Cut-out Extent

Inspection	Redacted by TC Energy
2013 BHI MFL Caliper	Redacted by TC Energy
KS10 2018 BHGE MFL4	
2012 BHI Profile	
2013 BHI MFL Caliper	
2013 BHI MFL Caliper	
2013 BHI MFL Caliper	
KS10 2018 BHGE MFL4	
2013 BHI MFL Caliper	
2013 BHI MFL Caliper	
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The following sections will go into further detail on the review conducted for each of the various inspections.

4.3 Vendor Review of Inspection Data

4.3.1 2012 Baker Hughes Profile Inspection

The only reported feature within the extent of the failure joint and cut-out from the 2012 profile inspection *Redacted by TC Energy*



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4.3.2 2013 Baker Hughes MFL (GEMINI) + Caliper Inspection

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This feature does not interact with the failure feature.

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The location of the bulge (just upstream of GWD 13520) was also reviewed in the raw data by Baker Hughes. Baker Hughes indicated that within the 2013 data, there was some small caliper movement immediately upstream of GWD 13520, though this movement is within background variation magnitudes and could not be sized meaningfully for reliable identification and sizing of any associated geometry feature.


4.3.3 2018 Baker Hughes MFL (MFL4) + Caliper Inspection

The 2018 inspection of the pipe in question *Redacted by TC Energy* within the cut-out extents. Neither of these features are interacting with the failure feature or bulge identified in the field. In

addition to the reported feature, a manual review was completed of the MFL4 data by Baker Hughes and no additional metal loss features were identified through the manual review.

It was noted by Baker Hughes that an ID restriction was apparent within the associated caliper data, though was sized such that it was below the applicable reporting thresholds.

Following the Freeman leak in 2017, the MFL4 technology was validated to identify circumferential cracks, and was able to see the failure feature at Freeman. A girth weld flaw analysis was completed by Baker Hughes following the 2018 inspection and no features were identified within the cut-out section. Following the failure, Baker Hughes reviewed the raw data of the girth welds in the vicinity of the failure and no indication of any girth weld anomalies could be found.

In consideration of the bulge identified in the field, Baker Hughes also reviewed the raw caliper data in the vicinity of the failure and identified a possible wrinkle (with an approximate peak to trough height of  (OD) immediately upstream of GWD 13520 (the location of the bulge identified in the field). A screenshot of the MFL4 caliper data is shown in Figure 7.

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The difference in the caliper signal from the 2018 inspection when compared to the 2013 inspection was that there was an inward and outward geometry movement in the caliper data in addition to a minor signal response in the MFL sensor data indicative of mechanical sensor movement, which could indicate a possible deformation, though which was not considered to meet all criteria such that it would be characterized and reported as a wrinkle.

4.3.4 2020 NDT Global Eclipse Inspection

There were no reported features within the cut-out extents from the 2020 Eclipse inspection. Additionally, a manual review of the Eclipse raw data was conducted by NDT within the failure extents, though no axial cracking features or other features of interest were identified at the failure location. Note that due to the orientation of the failure feature, this indication does not fall within the specification of this

inspection, as the purpose of the inspection was to detect axial crack-like flaws rather than circumferentially oriented flaws.

4.4 2013 & 2018 IMU Review

The circumferential orientation of the failure feature warranted a review of the IMU data between the 2013 and 2018 inspections to better understand if any pipe movement had occurred between the two inspections. Baker Hughes calculated the change in strain from each of the IMU data sets.

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Based upon Baker Hughes' bending strain and pipeline movement assessment at the failure location, no reportable indications of bending strain or pipeline movement were identified.

5 Subsequent ILI Review of Affected Segment

The circumferential orientation of the failure feature points to a longitudinal stress driving the failure. Bends, and more specifically elbows, concentrate longitudinal stress, which from a preliminary investigation appears to be the case with this failure.

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Based upon the findings from historical ILI which are outlined in section 4, two subsequent analyses were conducted in order to review for elbows exhibiting similar characteristics and associated geometry features, summarized below.

5.1 ID Restrictions (IDRs) at Elbows

All elbows within the affected segment have been manually reviewed in the raw caliper data from the 2013 GEMINI and 2018 MFL4 ILI by Baker Hughes to confirm whether or not any of the associated elbows also have ID restrictions similar to the failure site. As a result of this review, it was confirmed that the failure elbow is distinct with regard to the magnitude of the associated ID restriction.

Redacted by TC Energy No other elbows within the affected segment have ID restrictions more severe than that which was reported at the failure elbow, with all other elbows having ID restrictions ranging between Redacted by TC Energy

Note that as per the 2007 edition of TES-FITG-LD-US *Specification for High Yield Carbon steel Buttwelding Fittings* (the version of the specification in effect during construction), the minimum allowable ID restriction is Redacted by TC Energy. There are Redacted by TC Energy elbows within the Affected Segment that have an IDR less than this Redacted by TC Energy. A summary of the elbows in question and any identified ID restrictions seen in the 2013 or 2018 inspections are shown in Table 3. The elbow associated with the failure is highlighted in red.

Table 3: Results of Manual Caliper Data Review for IDRs Associated with Elbows within the Affected Segment

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5.2 Wrinkles or Bulges at Elbows

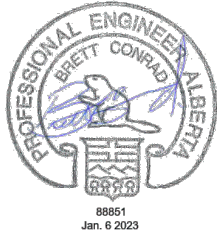
Based upon the bulge which was identified in-ditch in proximity of the failure elbow, and which was visible and characterized as a possible wrinkle within the 2018 MFL4 ILI data, Baker Hughes conducted a manual review of the raw 2013 GEMINI and 2018 MFL4 caliper data at all elbows within the affected segment looking for geometry indications which may be indicative of a bulge or possible wrinkle. Based upon the review conducted by Baker Hughes, there are no other elbows on the affected segment which are associated with similar geometry features having characteristics as a possible wrinkle.

6 Summary

Based on the review of available ILI data, it was identified that the **Redacted by TC Energy** **Redacted by TC Energy**, as well as indications of a possible **Redacted by TC Energy** identified in-ditch are the most notable characteristics to be evaluated in further detail when assessing for other ILI features with similar characteristics. Accordingly, a manual review of the 2013 and 2018 caliper data was undertaken in order to quantify the associated inner diameter restriction magnitudes at all elbows on the affected segment. As a result of this analysis, no other elbows within the affected segment have ID restrictions more severe than that which was reported at the failure elbow, with all other elbows have ID

restrictions ranging between **Redacted by TC Energy**. An additional review of the caliper data was conducted in order to review for geometry indications which may be indicative of a bulge or possible wrinkle. Based upon the review conducted by Baker Hughes, there are no other elbows on the affected segment which are associated with similar geometry features having characteristics of a possible wrinkle. Based upon this assessment, no other ILI features on the affected segment are considered to exhibit similar characteristics to the failure location.

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08 January 2023

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