Application No: A.18-11-010
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Witness: M.J. Rosenfeld

Application of Southern California Gas Company (U 904 G) and San Diego Gas & Electric Company (U 902 G) for Review of Costs Incurred in Executing Pipeline Safety Enhancement Plan	Application 18-11-010

CHAPTER XII

REBUTTAL TESTIMONY OF

MICHAEL J. ROSENFELD

(IN-LINE INSPECTION)

ON BEHALF OF

SOUTHERN CALIFORNIA GAS COMPANY (U 904 G)

AND

SAN DIEGO GAS & ELECTRIC COMPANY (U 902 G)

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

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REBUTTAL TESTIMONY OF SOCALGAS AND SDG&E WITNESS MICHAEL J. ROSENFELD

I. INTRODUCTION

The following Rebuttal Testimony of Michael J. Rosenfeld, PE addresses the matter of Southern California Gas Company (SoCalGas) and San Diego Gas and Electric Company (SDG&E)'s Application for review of costs incurred in executing Pipeline Safety Enhancement Plan (PSEP) (A.18-11-010).

In 2017, a SoCalGas pipeline undergoing a hydrostatic pressure test failed at a pressure below the intended test pressure, although the pipeline had been previously assessed using in-line inspection (ILI).[1] This has raised questions from the Public Advocates Office (Cal Advocates) as to the adequacy of the utility's ILI program, and the need for regulatory oversight of future ILI work.[2] The purpose of my testimony is to provide background on ILI as an integrity assessment method, the different ILI tools available, limitiations of ILI for integrity management, and the role of ILI in managing and mitigating pipeline integrity threats. The potential occurrence of a hydrostatic test failure following an ILI assessment does not necessarily indicate an ineffective ILI program, as no single ILI technology is optimized for all conditions. Performing a hydrostatic test following an ILI assessment is consistent with regulatory expectations that more than one method may be necessary to assess a pipeline segment for the integrity threats that it may be susceptible to.

II. BACKGROUND INFORMATION ABOUT ILI

a. What is ILI?

ILI involves inspection of a pipeline from the inside by instrumented devices ("tools") that pass through the line. Conventionally, ILI tools are introduced in the pipeline by a piping assembly (the launcher) that inserts the tool without having to depressurize and open the pipeline. The tool is propelled by the flow of product in the pipeline some distance to another assembly (the receiver) that allows removal of the tool, also without a need to depressurize and open the pipeline. Some pipelines are constructed in a manner that prevent a conventional ILI

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[1] The Public Advocates Office Direct Testimony (Botros) at p. 6, lines 6-7.
[2] Ibid., lines 19-20.

tool to pass through it. Those lines can be internally inspected using unconventional tools, such as wireline tools which are pulled through the line by a cable, or crawler tools. However, the pipeline has to be taken out of service, depressurized, and opened in order to operate those devices. The discussion that follows will focus on conventional methods of ILI.

ILI tools rely on various sensing technologies to directly or indirectly detect and measure features of the pipeline. Such features are referred to as "anomalies" if they differ from plain, round pipe or expected pipeline features, but the term is nonjudgmental as to whether the feature is of interest or important in terms of the safety of the pipeline. The detected signal representing the anomaly is referred to as an "indication", which is also nonjudgmental as to the significance of the anomaly.

ILI can offer important benefits over the main alternative integrity assessment method, hydrostatic pressure testing. If a pipeline is capable of accommodating ILI tools, running a tool will usually be lower cost. However, if multiple tool technologies are needed to address all integrity threats, the cost benefit may be lost. ILI tools also may be capable of indicating conditions that are of long-term interest to integrity management that cannot be detected by a hydrostatic test. This potentially provides the operator with an opportunity to deal with time-dependent conditions at a manageable pace.

b. ILI Technologies

The ILI technologies are briefly described as follows: ILI tools consist of an array of sensors designed to detect certain conditions, a position sensor (odometer), a data collection or recording system, batteries, and data storage. Depending on the size and number of components, and the diameter of the pipeline, all components may be packaged into a single unit or they may occupy several individual segments connected together. Tools for small diameter pipe usually requires more segments for packaging all the necessary components than do tools for large diameter pipe. The tool is propelled by pressure acting on the backside of a polyurethane cup or cone at the leading end of the tool that pulls the tool assembly through the pipeline. The tool must have enough flexibility to negotiate bends in the pipeline and other physical features that could intrude into the pipeline such as changes in wall thickness and valves.

Tool technologies are categorized as geometric, magnetic, or ultrasonic.

i. Geometry Tools

The simplest geometry tools consists of a deformable soft metal circular plate that deforms if it encounters a large indentation. It does not record the location of the dent. It is mainly used following construction to confirm damage-free installation, but is useless for integrity management purposes. A more effective geometry tool is a "caliper" tool, which carries an array of movable fingers that deflect as the tool passes a deformation of the circular cross section such as an indentation, ovality, or a buckle. The tool records the caliper arm movement and the location. The signal can be processed to interpret the size and shape of the deformation.

A different type of geometry tool can be used for mapping the alignment of the pipeline. It uses an inertial measurement unit (IMU) to sense changes in the tool orientation and position as it travels through the line. The data from the IMU can be used to develop an as-built baseline alignment. Subsequent inspections performed (usually several years) later using the same tool type can be compared to the baseline to identify changes in pipe curvature or position that might indicate soil movement such as slope instability or subsidence affecting the pipeline.

ii. Magnetic Tools

Magnetic tools saturate a region of the pipe wall with a magnetic field between north and south poles. The strength and direction of the magnetic field is referred to as the magnetic flux. If there is a reduction in wall thickness, for example due to a corrosion pit, some of the magnetic flux is forced out of the pipe wall. A sensor on the tool placed near the inside pipe wall, between the magnetic poles, can detect the intensity and geometric pattern of the magnetic flux leakage as the tool passes the affected spot on the pipeline. Hence the tools are referred to as Magnetic Flux Leakage (MFL) tools.

MFL tools were developed to detect metal loss due to corrosion, however other conditions such as mechanical damage, changes in wall thickness, and changes in material properties can produce magnetic flux leakage signatures detectable by the tool. MFL tools do not directly measure wall thickness. They sense changes in wall thickness inferable from an analysis of the pattern and strength of the magnetic flux field that has leaked from the pipe wall. The signal analysis is analogous to a canoeist on a river estimating the size and depth of a submerged rock or log based on the ripples on the water surface.

The wall thickness gradient and pattern of metal loss (relative to the orientation of flux lines) have large effects on the MFL signal which can lead to mischaracterizing the metal loss or even failure to detect the condition. The standard orientation of magnetization is axial (along the longitudinal axis of the pipeline). A wide or circumferentially biased metal loss area will produce a prominent MFL signal because it breaks many flux lines, but a narrow, axially-oriented feature interrupts few if any flux lines, producing no signal. Tools with transversely or circumferentially oriented magnetic fields are capable of detecting axially aligned metal loss features, but are not effective for circumferentially oriented metal loss. One ILI service vendor offers an ILI tool with the magnetic field oriented at a 45 degree angle on the pipe in order to be sensitive to metal loss in both primary axes. However even that tool will not be very sensitive to metal loss aligned with the angled magnetic field. The MFL signal is also affected by the juxtaposition of individual pits within a cluster of pits. In some cases individual pits are apparent while in other cases, not.

Other factors can also reduce MFL tool sensitivity such as excessive tool speed, metal loss distributed over a widespread area of the pipe, very gradual wall thickness gradients, heavy wall thickness (greater than about 0.75 inch), or very short metal loss pits.

MFL tool capability for detecting and characterizing metal loss due to corrosion is relatively mature and reliable. It is the primary method for assessing a natural gas pipeline for corrosion, if the pipeline is capable of accommodating an ILI tool. However, MFL tools are not crack-detection tools and cannot reliably detect most manufacturing defects in electric-resistance-welded (ERW) or electric-flash-welded (EFW) seams, fatigue cracks, or environmental cracks. The circumferential MFL tool was developed to detect grooving corrosion of the ERW seam, which is the primary reason for selecting that tool type.

iii. Ultrasonic Tools

These are three varieties of ultrasonic technology (UT) tools: wall thickness (WT) tools, crack detection (CD) tools, and electromagnetic acoustic transducer (EMAT) tools. UTWT tools use a piezoelectric transducer to emit an ultrasonic signal aimed straight at the pipe wall. A liquid couplant transmits the acoustic energy to the pipe wall. A portion of the acoustic signal is reflected from the inside pipe surface, while a portion of the signal is transmitted through the pipe wall and reflected from the outside surface. The timing of the return signals is used to determine the metal thickness and whether any missing metal is on the pipe interior or the pipe exterior. In contrast with MFL, ultrasound is a direct thickness measurement. UTWT tools cannot detect cracks or seam defects because the radial orientation typical of crack-like defects prevents them from reflecting the acoustic signal.

UTCD tools send ultrasonic energy toward the pipe wall at an angle. If a crack-like flaw is present, the acoustic energy in the pipe wall is reflected back to the ultrasonic signal detector. The timing of the return signal is used to infer the dimensions and position of the reflector. Geometric features of the pipe that are not crack-like or that are not necessarily an integrity concern, for example a lamination or an undertrimmed upset in an ERW seam, can also produce acoustic reflections, resulting in false indications of defects.

UTWT and UTCD tools require a liquid couplant to transmit the acoustic energy to and from the pipe wall, so they are typically used in liquid pipelines where the pipeline product (e.g. crude oil, gasoline) serves as the couplant. UT tools cannot normally be used inside a natural gas pipeline which is a dry environment. Ultrasonic tools have been run through natural gas pipelines in a slug of liquid such as water or diesel fuel, but that is a significantly more involved project than conventional ILI and takes the pipeline out of service.

EMAT tools were developed to accomplish UTCD ILI within a natural gas pipeline. EMAT introduces a high-frequency magnetic pulse to the pipe wall. The magnetostrictive property of the pipe steel induces high-frequency acoustic energy within the pipe wall. A crack-like flaw will reflect the acoustic energy which is picked up by another EMAT sensor through a reverse of the signal-generating process. Operators of gas pipelines concerned with stress corrosion cracking sometimes run an EMAT tool. The capability for seam assessment is still being studied by the industry.

III. LIMITATIONS OF ILI

There are important limitations to ILI for integrity management, which are discussed below.

a. Not All Pipelines Can Be Assigned Using ILI

Not all pipelines are capable of being assessed using ILI tools because of how the pipelines were constructed or how the pipelines operate. This is particularly true with older natural gas pipelines. Features or conditions that can interfere with running ILI tools include small diameter, short length, changes in pipeline diameter, tight-radius or mitered bends, tees without bars across the opening, valves that do not fully open, girth welds fabricated using chill rings, lack of launcher and receiver facilities, low operating pressure, or low throughput. A pipeline can be modified to facilitate tool passage, but the modifications could require a significant capital outlay and installing the upgrades will require that the pipeline be taken out of service. From a cost-benefit standpoint, some pipelines are not good candidates for assessment using conventional ILI. Nonconventional ILI using wireline, robotic, or crawler tools is possible but all such alternatives come at higher cost and are less convenient.

b. No Single ILI Technology Can Detect All Conditions Of Potential Interest

As alluded to above, each ILI tool type is designed to be sensitive to certain flaw types, and may be unable to detect other flaw types. The operator will select the tool type that is appropriate for the main integrity threat of concern. Regulations (e.g. Title 49 Code of Federal Regulations (CFR) Part 192, Paragraphs 192.919(b) and 192.921(a)) and industry guidelines (American Society of Mechanical Engineers (ASME) B31.8S, Paragraph 6.1) specifically state that more than one assessment method or ILI tool type may be required to address integrity threats of concern. That could involve running more than one type of ILI tool, or it could involve running an ILI tool followed by a hydrostatic pressure test. The operator will try to select a strategy that balances concerns for particular integrity threats, feasibility, impact on operation, and cost. Poor ILI tool performance may cause the pipeline operator to change assessment strategy, either by running another ILI from a different vendor or based on different technology, or by prove-up hydrostatic pressure testing even though pressure testing was not originally planned.

c. ILI Tools Have Performance Limitations

Measurement systems inherently contain error. ILI tools are no exception. The error may be random or may include a bias affected by flaw size, tool speed, or other variables. ILI vendors publish performance standards. For example, axial MFL tools are commonly described as reporting depth of metal loss due to corrosion accurately within plus or minus 10% of the wall thickness 80% of the time. However, a rigorous statistical analysis will show that leaves a significant probability that a feature indicated to be acceptable based on reported dimensions is unacceptable based on a fitness for service criterion. The probability of such an error increases with defect severity. As a result, the regulations require that tool error be accounted for in establishing a response criterion.

Vendor performance claims are more complex than what is suggested above. For example, MFL vendors may report differing performance levels depending on the pattern, shape, or aspect ratio of the flaw. With crack detection, sizing accuracy is dependent on the actual defect size. All tools have a lower defect detection threshold. Many vendors will report a threshold flaw size corresponding to a 90% probability of detection. However, the size of flaw that is relevant from a fitness for service standpoint may differ from the stated threshold flaw and have a different probability of detection, which varies with flaw size. The performance claims are based on running a tool repeatedly through pipe containing artificial flaws to determine a statistical probability of detection, probability of correct indication, and probability of sizing accuracy. This provides repeatability for consistency in measuring performance. However actual tool performance may differ noticeably from the commercial claim because actual defects in a pipeline may exhibit more complexity than the test configurations, or measurement conditions may be nonideal. The situation is analogous to fuel mileage testing of automobiles, typically performed using standardized simulations of vehicle operating modes. The test conditions may bear little resemblance to actual conditions of usage, so all manufacturers make the disclaimer that "your mileage may vary."

The pipeline operator should validate the performance of each ILI tool run by comparing what is discovered in the field with what is reported by the ILI vendor. API Recommended Practice 1163 provides guidance for performing validation for axial MFL. The probability of errors can differ with pipe diameter and wall thickness. ILI tools for small pipe sizes cannot carry as many sensors as tools for larger diameter pipe. Since there is a fixed lower limit on sensor size, tools for small pipe usually have reduced performance when considering defect size normalized to the pipe size. With UTCD and EMAT tools, the probability of detection and probability of correct indication (of feature type) increases with pipe size.

IV. THE ROLE OF ILI IN MANAGING AND MITIGATING PIPELINE INTEGRITY THREATS

It is important to recognize that ILI is capable of assessing the pipeline for only certain integrity threats, typically metal loss due to external or internal corrosion, significant deformations of the pipe caused by external forces, some latent mechanical damage, and some seam defects and pipe body cracks (SCC). Capability depends on ILI tool technology, and no single technology is useful for all defect types. There are important integrity threats that cannot be managed effectively by ILI, mainly random events such as third-party damage, natural events, and operator error.

A successful ILI process removes defects of targeted dimensions before the next ILI assessment. Ideally, a defect management program should be both effective and efficient. Effectiveness is the operator's ability to target near-critical and critical defects. Efficiency is the operator's ability to focus resources optimally, meaning not spending undue effort investigating unimportant or noncritical features due to overly conservative indication. Both effectiveness and efficiency are affected by ILI tool performance; overly-conservative characterization could lead to inefficient programs (which wastes money), while poor detection or non-conservative characterization can lead to ineffective programs (which may leave unsafe conditions in the line). In many cases, ILI for seam defects or crack-like features is little more than a "thing finder", which leads the operator to investigate a joint of pipe that may contain features of concern. The expected tool performance should be considered in light of the capability and cost of alternative assessment methods, such as hydrostatic testing.

It may be useful to recognize that ILI is more than just a tool, it is a system. All elements of the system must work correctly within a narrow error band in order for a pipeline operator to make sound decisions to investigate an anomaly: the tool must be set up by the vendor correctly; the tool must not experience damage or failure during the inspection; the tool must not operate at excessive speed; the tool must sense and record the presence of the anomaly; the ILI vendor's software and human analysts must correctly interpret the signal in terms of the anomaly location, type, and size; the errors on location and size must fall within usable limits; the anomaly must be correctly described in the report; the operator must review and understand the report; the operator must correctly prioritize the anomaly in a response; and the tool accuracy must be validated by verification in the field. Error in any step may result in an inefficient or ineffective ILI program.

V. CONCLUSION

CalAdvocates' testimony refers to the occurrence of a 2017 failure in the utility's Line 2000-C during a hydrostatic pressure test after the pipeline had been assessed using ILI. The failure occurred at a flaw that was not identified by the ILI.[3] CalAdvocates suggests that

[3] Ibid., lines 17-19.

additional regulatory oversight is required to assure that the ILI program has adequate capabilities.[4]

In the case of Line 2000-C, the ILI was conventional MFL, which is an appropriate method for assessing the line for the primary integrity threats of corrosion and latent mechanical damage. The failure occurred in a manufacturing flaw in the submerged-arc welded seam. The MFL tool would not be expected to detect that condition. A hydrostatic pressure test conducted to a sufficiently high level could potentially reveal such flaws, and in fact did just that. The test was probably the highest pressure the pipe had ever experienced, and can be considered a success from the integrity management standpoint. The MFL inspection also made it possible for the utility to remediate corrosion or mechanical damage that could have led to test failures as well.

The occurrence of a hydrostatic test failure following an assessment performed by ILI does not necessarily indicate an ineffective ILI program. To the contrary, it is clear that the utility recognized that no single ILI technology is optimized for all conditions of possible concern. Moreover, performing a hydrostatic test after an MFL tool run is consistent with regulatory expectations that more than one assessment method may be necessary. The follow-on hydrostatic test may be viewed as prudent and in the interest of public safety recognizing that significant pipeline failures have occurred after ILI has been performed.

This concludes my prepared rebuttal testimony.

VI. QUALIFICATIONS

My name is Michael J. Rosenfeld. My business address is 102 West Main Street, #578, New Albany, Ohio 43054. I am Chief Engineer with RSI Pipeline Solutions, LLC.

RSI Pipeline Solutions, LLC. was founded in March 2019. In my current role with RSI, I perform work related to pipeline integrity management, fitness for service, training, and other engineering projects.

Prior to RSI, I was with Kiefner from 1991 until 2019. While at Kiefner, my work primarily related to pipeline integrity and fitness for service, including metallurgical and root cause failure investigations, stress analysis, fitness for service and remaining life evaluations, research on the effects of damage to pipelines, regulatory and codes compliance, and training. I

[4] The Public Advocates Office Direct Testimony (Botros) at p. 7, lines 1-5.

was President of Kiefner & Associates, Inc. from 2001 through 2011 when the company was acquired by Applus Global. Prior to joining Kiefner, I was employed by Battelle as a Research Engineer from 1985 until 1991, where I worked on various engineering and testing projects. Prior to joining Battelle, I was employed from 1981 until 1985 as a Principal Engineer at Impell Corporation performing stress analysis of piping systems and site structures of nuclear power plants.

I am involved in development of ASME pipeline standards. I am the ASME B31.8 Chair pro tempore, and also chair the B31.8 Design, Materials, and Construction Subgroup.

I received a Bachelor of Science in Mechanical Engineering from the University of Michigan in 1979 and a Master of Science in Mechanical Engineering from Carnegie-Mellon University in 1981. I am a registered Professional Engineer in the State of Ohio.

I have previously testified before the Commission.