Computational Pipeline Monitoring for Liquids

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Pipeline Segment

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, D.C. 20005, standards@api.org.

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Introduction

Computational Pipeline Monitoring (CPM) is a term that was developed by the API to refer to software-based, algorithmic monitoring tools that are used to enhance the abilities of a Pipeline Controller to recognize hydraulic anomalies on a pipeline. These anomalies may be indicative of a pipeline leak or commodity release. CPM systems are often generically called leak detection systems. However, pipeline leak detection can be accomplished by a variety of techniques such as: aerial/ground line patrol; third party reports; inspections by company staff; hydrocarbon detection sensors; SCADA monitoring of pipeline conditions by Pipeline Controllers; and software-based monitoring. To provide a clear reference, the term CPM was developed to specifically cover leak detection using software-based algorithmic tools. Simple monitoring tools such as observations of meter over-short reports, observations of pressure deviations and observation of flow rate deviations, without use of an inference engine and alert algorithm, although providing valuable information to the Controller, are not considered to be CPM systems because they do not meet the definition of CPM.

This is the first edition of API RP 1130 issued as a recommended practice. The first edition of API 1130 was published in 1995. The second edition was published in 2002. Between the first and second editions and now between the second and this RP, the users of this information (e.g. Pipeline Operators, system developers, system integrators and the regulators) have had an opportunity to use and evaluate the document. Their suggestions for improvements, correcting of inconsistencies and error elimination have been considered and incorporated in this latest edition.

All editions of this document have been written by Work Groups of the API Cybernetics Subcommittee. The purpose of the work was to develop an API recommended practice for CPM as it is used in the liquids pipeline industry. This update includes input from all committee members as well as a broad community of CPM system developers and system integrators.

The five-year cycle of re-writing and re-authorizing API RP 1130 is necessary under API standard rules and is especially important because the document is referenced in the federal pipeline safety regulations which are discussed in the following section.

Computational Pipeline Monitoring for Liquids

1 Scope

1.1 Purpose

This recommended practice focuses on the design, implementation, testing and operation of CPM systems that use an algorithmic approach to detect hydraulic anomalies in pipeline operating parameters. The primary purpose of these systems is to provide tools that assist Pipeline Controllers in detecting commodity releases that are within the sensitivity of the algorithm. It is intended that the CPM system would provide an alarm and display other related data to the Pipeline Controllers to aid in decision-making. The Pipeline Controllers would undertake an immediate investigation, confirm the reason for the alarm and initiate an operational response to the hydraulic anomaly when it represents an irregular operating condition or abnormal operating condition or a commodity release.

The purpose of this recommended practice is to assist the Pipeline Operator in identifying issues relevant to the selection, implementation, testing, and operation of a CPM system. It is intended that this document be used in conjunction with other API standards and applicable regulations.

1.2 Contents

This recommended practice includes definitions, source and reference documents, concepts of data acquisition, discussion of design and operation of a pipeline as related to CPM, field instrumentation for CPM purposes, alarm credibility, Pipeline Controller response, incident analysis, records retention, maintenance, system testing, training, considerations for setting alarm limits, trending and recommendations for data presentation. The relationship between the Pipeline Controller and the CPM system is also discussed.

1.3 Scope Limitations

This recommended practice is not all-inclusive. The reader must have an intimate knowledge of the pipeline system and may have to refer to other standards for background or additional information.

This recommended practice was written considering single phase, liquid pipelines. However many of the principles apply to liquid pipelines in intermittent slack line flow or liquid pipelines that may have permanent slack line flow. Slack line operation creates uncertainties in pressure and flow. For these operating conditions, the user of API RP 1130 will have to carefully consider what parts of API RP 1130 do and do not apply.

This recommended practice also may not apply to the special case of determining leaks during shut-in conditions that occur when the line is shutdown (sometimes called static conditions). For example, a Volume Balance CPM cannot evaluate volume loss if there is no flow through the meters during a line shutdown.

It is recognized that no one particular CPM methodology or technology may be applicable to all pipelines because each pipeline system is unique in design and operation. In addition, detectable limits are difficult to quantify because of the unique characteristics presented by each pipeline. Limits must be determined and validated on a system-by-system and perhaps a segment-by-segment basis.

CPM is intended to enhance human judgement when some type of intervention or shutdown of the affected pipeline segment(s) is warranted. Effective operation of a pipeline requires that the Pipeline Controllers be familiar with the pipeline and all the tools at their disposal. CPM can also enhance human judgement during decisions to activate remotely controlled valves and directing field staff to re-position hand operated valves on the pipeline.

This recommended practice complements but does not replace other procedures for monitoring the integrity of the line. CPM systems, as well as other commodity release detection techniques, have a detection threshold below which commodity release detection cannot be expected. Application of the information in this recommended practice will not

reduce the threshold at which a commodity release can be detected. For example, trained Pipeline Controllers analyzing SCADA-presented operating data can be effective at detecting certain sizes (i.e. larger) of commodity releases. Third party reports, pipeline patrols, and employee on-site examinations can also be effective procedures when used to verify the integrity of the pipeline within their range of applicability.

It is important to note that this recommended practice is in keeping with standard industry practice and commonly used technology; however, it is not intended to exclude other effective commodity release detection methods.

Annex A provides a discussion of CPM thresholds and other information related to understanding pipeline leaks and practical detection limits for commodity releases.

1.4 Transportation Systems

This recommended practice is written for liquid onshore or offshore trunkline systems but much of the content may be applicable to other piping systems such as selected gathering systems, production flow lines, marine vessel loading/unloading, and tank terminaling operations. CPM has typically been applied to steel pipeline systems but may be applied to pipelines constructed of other materials such as PVC, polyethylene, fiberglass, and concrete. The successful application of CPM may be limited by the characteristics of these other materials.

Pipeline systems vary widely in their physical characteristics including: diameter, length, pipe wall thickness, internal roughness coefficient, pipe composition, complexity of pipe networking, pipeline topology, pump station configuration, and instrumentation (quality, accuracy, placement). These same pipeline systems can also be categorized by operational factors such as: flow rate; magnitude and frequency of rate/pressure fluctuations; blending; batching; batch stripping schemes; product type; product fluid characteristics (viscosity, density, sonic velocity, bulk modulus, vapor pressure); pressure, temperature; and heat transfer.

1.5 Regulatory Considerations

Users of API RP 1130 should be familiar with the regulations that cover hazardous liquid pipelines. These regulations may apply at municipal, state or federal levels. For example, since the first edition of API 1130, the US Department of Transportation, Pipeline and Hazardous Materials Safety Administration have included a reference to API 1130 in 49 *CFR* Part 195. During the life of the second edition of API 1130, Federal regulations for leak detection were established for high consequence areas.

A Pipeline Operator should base their leak detection project decisions upon a structured qualitative and/or quantitative method for identifying and assessing risks. The CPM methodology selected should be evaluated against what characteristics of the pipeline are known and what is required by the methodology to provide acceptable results.

Listed below are direct regulation references to CPM and leak detection within 49 *CFR* Part 195. These are the principle references, but the list may not be all-inclusive. Since regulations are periodically updated, users of API RP 1130 should be aware that specific regulatory references may change or be supplemented in the future.

195.2	*Definitions, Computation Pipeline Monitoring*
195.134	*Design Requirements, CPM Leak Detection*
195.444	*Operation and Maintenance, CPM Leak Detection*
195.452(i)(1)	*Integrity Management, General Requirements*
195.452(i)(3)	*Integrity Management, Leak Detection*
195.452(i)(4)	*Emergency Flow Restricting Devices*

Within regulations, there may be a specific reference to CPM or leak detection. The reference may also be indirect as in the regulatory requirement for the closing of remote valves (or activation of flow restricting devices) where a CPM system may be used as one of the triggers for that activation, particularly in high consequence areas.

CPM systems may be employed when the requirement states:

— A Pipeline Operator must have a means to detect leaks on its pipeline system and to protect high consequence areas.

— The Pipeline Operator must evaluate the capability of its leak detection means and modify it as necessary to provide a sufficient level of protection (i.e. the CPM may be adjusted to account for the operational mode or characteristics of the pipeline segment including shut-in). Ideally, factors such as length and size of the pipeline, type of product carried, the pipeline's relationship to high consequence areas, the swiftness of leak detection, the location of nearest response personnel, the pipeline's leak history, and risk assessment results, must be considered.

This document provides guidance that will be helpful in addressing regulatory requirements but it does not claim to be all-inclusive in that regard. The Pipeline Operator should thoroughly understand the regulations and work with the regulators and their agents to satisfy all related requirements and maintain pipeline safety.

2 Applicable References

API RP 551, *Process Measurement Instrumentation*

API RP 1112, *Developing a Highway Emergency Response Plan for Incidents Involving Hazardous Materials*

API RP 1113, *Developing a Pipeline Supervisory Control Center*

API Publ 1149, *Pipeline Variable Uncertainties and Their Effects on Leak Detectability*

API Publ 1161, *Guidance Document for the Qualification of Liquid Pipeline Personnel*

API Std 1164, *Pipeline SCADA Security*

API RP 1165, *Recommended Practice for Pipeline SCADA Displays*

API *Manual of Petroleum Measurement Standards* (sections on metering, calibration and proving)

CSA CAN/CSA-Z662-03[1], *Oil and Gas Pipeline Systems, Annex E, Recommended Practice for Leak Detection*

US DOT 49 *CFR* (Code of Federal Regulations) Part 195[2]

NOTE API Publication 1155, *Evaluation Methodology for Software Based Leak Detection Systems* has been removed from the applicable references because it is being withdrawn by API. In particular, API Publ 1155 contained a pertinent excellent discussion of leak detection performance metrics. So this information is not lost, the pertinent sections of API Publ 1155 have been copied with minor modification into Annex C of this recommended practice.

[1]Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, L4W 5N6, Canada, www.csa.ca.
[2]US Department of Transportation, 400 7th Street, S.W., Washington, D.C. 20590, www.dot.gov.