Exceeding The Requirements

Of

Mandated Leak Detection Testing

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Abstract

Enbridge Pipelines Inc has implemented computational pipeline monitoring (CPM) systems to provide an additional method of leak detection on all 16 of their liquid hydrocarbon pipelines. These pipelines are located both in Canada and the United States where periodic testing of the CPM systems to determine their continuing effectiveness is mandated. Enbridge Pipelines Inc is developing a SCADA interfaced, transient simulation based, CPM test system to comply with this regulatory requirement.

In Canada, the National Energy Board, through the reference of CSA Z662 Appendix E, requires that "the leak detection system shall be tested annually to demonstrate its continued effectiveness". In the United States, the Federal Regulation Title 49, Volume 3, Part 195, through the reference of API 1130, requires that "CPM applications should be tested on a 5 year interval".

The Enbridge Pipelines Inc Material Balance System (MBS) is a real-time transient model based CPM system. The effectiveness of the MBS on one of the pipelines is verified yearly by fluid withdrawal testing. The effectiveness of the MBS on another pipeline was verified once by fluid withdrawal testing. While fluid withdrawal testing may be the definitive form of testing, cost, complexity, geographical limitations, and the possibility of an accidental product release limit the applicability of this method.

The use of API 1149 calculations to determine the maximum theoretical leak detectability (or minimum threshold) is detailed in the paper. The use of simulated fluid withdrawals in a SCADA interfaced trainer environment to test the leak detection capabilities of the MBS implementations and the verification of these tests with actual fluid withdrawal tests is discussed.

1. Background

Computational Pipeline Monitoring (CPM) systems (also called software based leak detection systems) use pipeline data to infer leaks on the pipeline and/or to alarm upon hydraulic anomalies that have the characteristics of a leak. These systems are in place to alert the Pipeline Controller so he/she can evaluate the cause and as necessary to shutdown the pipeline and minimize the size of a spill.

In the operation of hydrocarbon liquid pipelines, CPM systems are either mandated by legislation (e.g. in Canada) or must meet regulatory requirements when they are installed (e.g. the current situation in the United States). In the United States (US) the requirements for CPM systems are outlined in CFR 49 Part 195 section 195.444 and these in turn reference the American Pipeline Associations publication API 1130 "Computational Pipeline Monitoring. In Canada, the regulations are in The National Energy Board's Onshore Pipeline Regulations and those reference the Canadian Standards Association Z662 Oil and Gas Pipeline Systems standard and its Appendix E "Recommended Practice for Leak Detection Systems".

Enbridge has implemented CPM systems on almost all of its pipelines and have named the systems Material Balance Systems (MBS). All individual pipeline MBS are standardized to one software application, the AdvanticaStoner Leakfinder which is a real time transient model. The software is customized to each pipeline by Enbridge SCADA staff. This standardization to one particular application has a number of advantages, one of the primary advantages being ease of support and maintenance of the systems.

Enbridge has 16 pipelines, six of which are entirely in Canada, two entirely in the US and eight that extend across the international boundary so they are in both countries. For purposes of standardization, the MBS are designed to meet the regulatory requirements of both jurisdictions regardless of the location status of the pipeline.

2. The CPM Testing Issue

The particular aspect of operating a CPM system that is discussed in this paper is the need to performance test the CPM systems. The need for testing is not just a periodical test to meet regulatory requirements, but also it is necessary to performance test the systems during development, when they are modified and perhaps also on an ongoing basis for operational reasons. The various reasons for testing and re-testing are outlined particularly well in API 1130 Section 6.2, System Testing which is included in the Appendix A of this paper.

Because of the number of systems that Enbridge has in production, all the various reasons for testing the CPM systems are applicable.

2.1 Regulatory Testing. Canadian regulations require annual testing of CPM systems. In the US the testing frequency specified is 5 years. So this means that Enbridge must test most of the MBS systems annually (the shortest interval). This testing interval assumes that no changes have been made to a particular MBS system during the interval. In brief, the requirements of regulatory testing are:

- to evaluate the actual system performance
- to provide a baseline of achieved performance
- to determine that the CPM will alarm if a commodity release occurs

2.2 Testing During System Development. Once a CPM system is running, it may need to be tested a number of times during the continuing development as the system is 'tuned' to the sensitivity and alarm frequency that is acceptable to the users. Not only will the system be tested to see how it improves as it is optimized, but also the developer may utilize testing to determine what level of CPM performance is achievable during outages of individual sensors or groups of sensors. This establishes performance during less than ideal conditions.

2.3 Final Testing. After all the development is completed, the final CPM performance test is used to establish a baseline of system performance.

2.4 Re-Testing. There may be many reasons for re-testing a CPM system. Possibilities include:

- testing for operational changes such as after the operation of a line has been altered or when different types of or a different mix of fluids is in the line
- testing when a new version of the operating system or a new version of the CPM software is installed
- testing after maintenance of the software such as enhancement to a file that may have an impact on performance
- testing when additional sensors are added to the pipeline.

So testing is not only a 'capital expenditure' item related to initial development but also it is an ongoing operational cost.

3. Testing Options

There are a number of methods that can be used to test a CPM system. In this regard, the regulations are not prescriptive. They allow the pipeline operator to determine and use testing methods that are appropriate for the CPM system and the pipeline.

3.1 Methods. The methods which can be employed to test a CPM system are described below.

3.1.1 Fluid Withdrawal. This is the preferred method of testing a CPM system. It has the advantage of being the method that most closely simulates a leak. It does have a number of limitations which are:

- cost, as withdrawal tests are expensive (tanks or suction trucks, field staff….)
- there are limited locations where a withdrawal appurtenance or valve is available
- the withdrawal of the hazardous fluid has the potential for spillage
- on large pipelines (about 16" diameter and larger) the amount of fluid that must be withdrawn and the rate of withdrawal makes this type of testing impractical.

3.1.2 CPM Configuration Changes. This involves altering an input parameter (e.g. a meter reading from SCADA) or a CPM setting to create a hydraulic anomaly. The CPM thinks it 'sees' real information that would be similar to a leak. The purpose is to create a hydraulic anomaly, that has the characteristics of a leak. This method has the advantage of being relatively easy to do (therefore inexpensive) and there are many points in the data or configuration files that can be changed so a leak can be simulated at many locations. There is also no hazard associated with real fluid leaving the line. The disadvantage of this approach is that determining the correct values for numerous input parameters becomes increasingly difficult as the pipeline facilities and the CPM become more complex.

3.1.3 Field Data Alteration. Another method of simulating a leak involves altering an actual output from a field instrument, for example reducing a flow rate from a meter. The delivery event then become an effective 'leak'. This approach is inexpensive and certainly is somewhat indicative of a leak. The disadvantages of this approach are that there are usually a limited number of locations where a leak can be simulated and this method cannot be used to a leak somewhere on the mainline.

Also, for this example of altering a flow, since there is no pressure change when the flow rate is altered, the simulated leak is not truly hydraulically represented. In this case the change is strictly between the mainline facilities and the flow meter.

3.1.4 Other Means. This category covers all other possible methods to simulate a leak. An example could be creating a pressure spike by rapidly opening a valve and then closing it again, with a minimal loss of fluid. This attempts to create the characteristic pressure wave of a line break on a pipeline. There may be other methods that are applicable only to a specify CPM system.

3.2 The Enbridge MBS Test System. Enbridge was looking for a system that was accurate, minimized manpower requirements (and costs), and was easy to use. Since almost all the Enbridge lines are considered large, it would not be feasible to utilize withdrawal testing. Also, individually testing each of the 16 pipelines every year will be time consuming. Although the regulators may allow testing of one CPM application on just one pipeline as a representative test, there are sufficient differences between the 16 Enbridge pipelines that this is not considered to be a satisfactory approach.

The test method and the steps are outline below. This approach could be considered to be a sophisticated version of CPM configuration change but without the uncertainty disadvantage noted above.

Briefly, the Enbridge test system has three parts:

- calculate a theoretical detection threshold range
- create accurate MBS input data that will simulate a leak
- test the actual MBS using the MBS input data file

The Enbridge test system takes advantage of the facts that:

- Enbridge employs just one CPM system software
- the MBS and simulator trainer both use that same basic software and hydraulic engine
- line specific simulator-trainers are available for all the pipelines
- a calculation tool, based upon API 1149 “Pipeline Variable Uncertainties and Their Effect on Leak Detectability”, has been developed to calculate leak detection thresholds
- Enbridge staff developed the MBS so as developers they an intimate knowledge of the systems
- Enbridge has many years of withdrawal test data for one smaller line and some captured actual leak data that can be used to calibrate the test system.

This testing approach meets all the requirements of the regulators, it is inexpensive to use and re-use, it is quick and easy to use, it can simulate leaks at any location and of any size, it provides a tool that can be used to test all pipelines, it is easy to make changes and it is possible to test new configurations. The tool may prove to especially useful as the High Consequence Areas (HCA) must be covered by CPM systems. Details of the three parts of the test method are described below.

3.2.1 Calculating the Detection Limits. This is achieved by making use of the methods outlined in API 1149. API 1149 allows a user to determine theoretical detectable limits. If the calculation routines are entered into a spreadsheet, it is possible to run a number of calculations to consider different types of fluids, uncertainties in all the input parameters (e.g. batch location) and to consider the loss of data or greater data uncertainty. The detectable limits calculated then provide approximate leak sizes that can be used in the trainer scenario generation. In the real world, the leak sizes used in the simulations need to be larger than the theoretical limits calculated using the API 1149 method due to any CPM allowances for uncertainties such as differences between the model and the actual pipeline.

3.2.2 Creating the CPM Input Files. A transient hydraulic simulation tool that is interfaced to a copy of the SCADA system (that is, the simulation trainer tool which is used at Enbridge) is used to create accurate and realistic CPM input files. Leaks can be created at almost any location as is done for Pipeline Controller training. Scenarios can be easily created for any pipeline and for any possible operating condition. The SCADA system creates a MBS input file that is then used as input to the test copy of the MBS (the test copy is identical to the production MBS). The input data can use in real-time (i.e the test copy of the MBS can be directly connected to the simulation trainer) or the simulation trainer output can be a captured and archived for later use. In this project, it was decided to uses the create/capture/archive approach. In that way the input file would be available for re-run.

3.2.3 Testing the CPM. The CPM system uses the created CPM input file and the CPM results determine the CPM system performance. During the test system development phase, these results can be compared to results from actual withdrawal tests and previous leak data to calibrate and verify the test system.

4. Making It Work (Application Development)

The work to develop a viable CPM test system was set-up as a capital budget item with a two year duration. The expenditure justification included both the projected operating cost savings of using this method as compared to expensive withdrawal tests and as an alternative to less reliable non-withdrawal methods such as altering data inputs to simulate leaks. The following sections outline the steps in making this test method work.

4.1 Project Approach. Due to the size and complexity of this project, it was decided that the project should first apply the test methodology to one pipeline and use that as a prototype for other pipelines. This is not only because this project has a degree of risk of failure but for the bigger reason that the methods are complex and the various steps need to be well established so they can be efficiently and effectively applied to other pipelines. Enbridge's line 21, a 500 mile, 12 inch diameter, single fluid pipeline, was chosen to develop and test the prototype. Line 21 has many years of withdrawal tests of which all the data has been captured. So this withdrawal data can be used to verify the API 1149 calculations and to verify the test system performance. In fact, the line 21 withdrawal data was used as one source of verification of API 1149. The following is based upon the development effort of the line 21 prototype test system.

4.2 Calculating the Theoretical Thresholds. The methods and calculations of API 1149 were used to establish the leak detection limits for the pipeline. API 1149 provides a step-by-step process for calculating theoretical leak detection limits. Fortunately it is possible to place the calculations into a spreadsheet and this eliminates the rather cumbersome calculations and in particular the values in the look-up tables can also be estimated within the spreadsheet. Enbridge is on its third generation of API 1149 calculation spreadsheet. This makes it relatively simple to vary parameters and establish a range of detectable limits. The spreadsheet contains four worksheets :

- Input Data
- Results
- Calculation
- Fluids

4.2.1 Input Data. The Input Data worksheet allows the user to enter :

- Flow rate, pressure, temperature & batch interface location uncertainties

- Station flow rate and pressure values
- Mainline linefill and temperature data

as shown below in Figure 1.

	Uncertainties				Station Data			Pipeline Data		
	Flow dQ (m3/h)	Pressure dPss (kPa)	Temperature dT (deg C)	Batch Interface (km)	INJ/DEL/ML Flow Rate (m3/h)	Suction Pressure (kPa)	Discharge Pressure (kPa)	Linefill	Temperature (deg C)	
NS	1	7	0		220		6500		15	NS
				0				NW		
XA		7	0				5200			XA
				0				NW		
XB		7	0				4500			XB
				0				NW		
XC		7	0				3900			XC

Figure 1 : Input Data Worksheet

4.2.2 Results. The Results worksheet presents the user with the calculation results in 3 different formats:

- Volume uncertainty and corresponding minimum leak detection time in a tabular format
- Leak detectability (% of reference flow) and leak volume for various calculation intervals in a tabular format
- Leak detectability (% of reference flow) and leak volume for various in a graphical format

	dVs	dVt nlpc	dVt lpc	dVt up	dVt low
Volume Uncertainty (m3)	0.47	16.90	3.91	6.01	0.47
Leak Detectability (min)	0.129	4.723	1.193	1.634	0.129
dVs : Steady state volume uncertainty					
dVt nlpc : Full line stop volume uncertainty with no line pack correction					
dVt lpc : Full line stop volume uncertainty with line pack correction based on batched fluid transient modeling					
dVt up : Upper limit of the volume uncertainty = dVs + 1.44(dVt lpc)					
dVt low : Lower limit of the volume uncertainty = dVs					

Figure 2 : Volume Uncertainty & Minimum Leak Detectability

- The dVs values are calculated with the pipeline flowing at the nominal steady state flow rate. This is the best possible theoretical leak detectabilty using a mass balance approach.
- The dVt nlpc values are calculated for with the pipeline during a full line stop (ie : mainline valve closure) which causes the largest possible transient conditions with no linepack correction. This is the worst possible theoretical leak detectectabilty using a meter based volume balance.
- The dVt lpc values are calculated for with the pipeline during a full line stop (ie : mainline valve closure) which causes the largest possible transient conditions with linepack correction based on a real-time batched fluid transient model. This is the best possible theoretical leak detectectabilty using a linepack corrected mass balance.
- The dVt up values are a realistic combination of the steady state and the best possible transient leak detectability values.
- The dVt low values are the same as the steady state values.

Time (min)	Upper Limit Ql/Qref	Lower Limit Ql/Qref	Upper Limit Volume	Lower Limit Volume
1.000	163.4	12.9	6.0	0.5
2.000	81.7	6.5	6.0	0.5
3.000	54.5	4.3	6.0	0.5
4.000	40.9	3.3	6.0	0.5
5.000	32.7	2.7	6.0	0.5

Figure 3 : Leak Detectability & Leak Volume

- The Upper Limit values are calculated using the dVt up values.
- The Lower Limit values are calculated using the dVt low values.
- Ql/Qref is the ratio of leak flow rate to nominal flow rate
- Time is the mass balance calculation interval

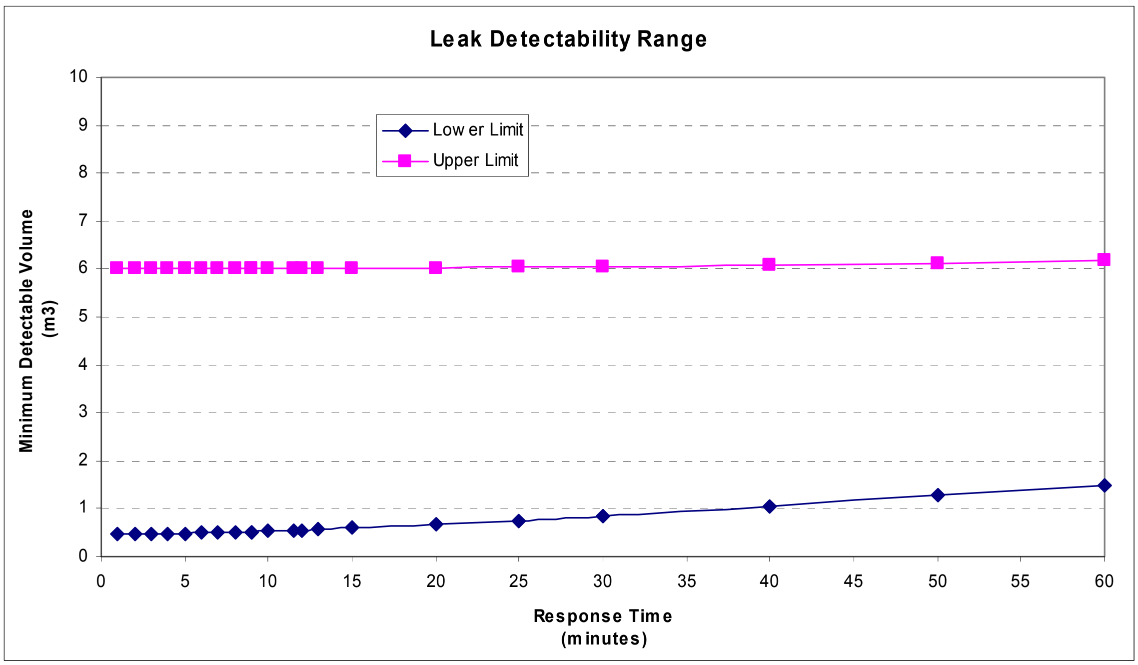

Figure 4 : Leak Volume Graph

- The Upper Limit values are calculated using the dVt up values.
- The Lower Limit values are calculated using the dVt low values.

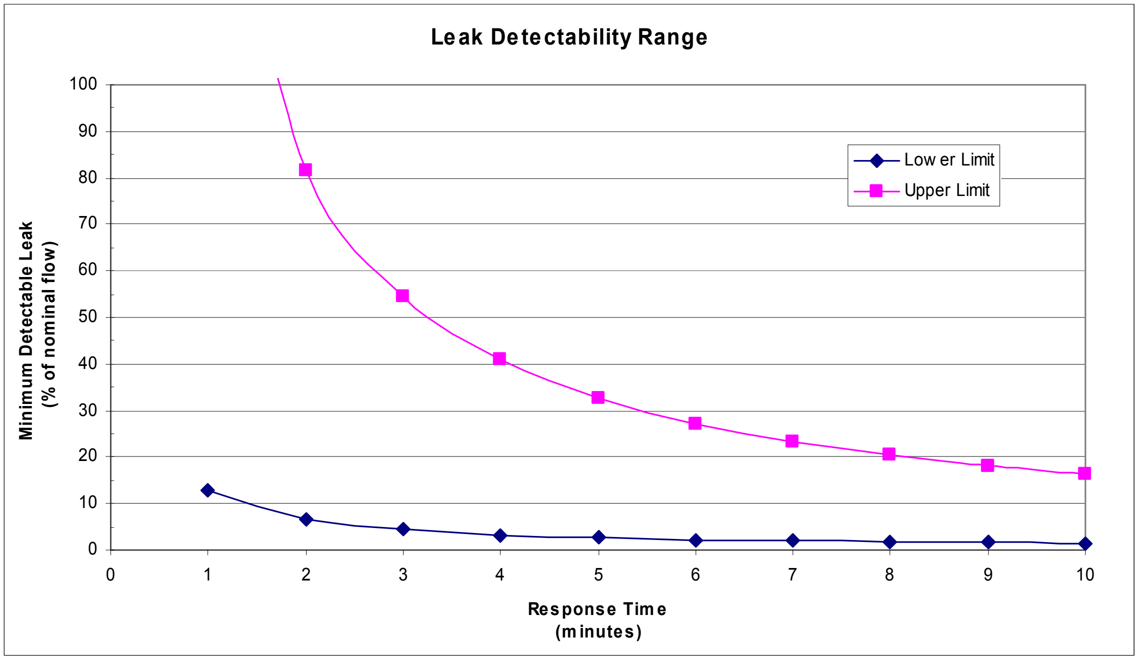

Figure 5 : Leak Rate Graph (0 – 10 minutes)

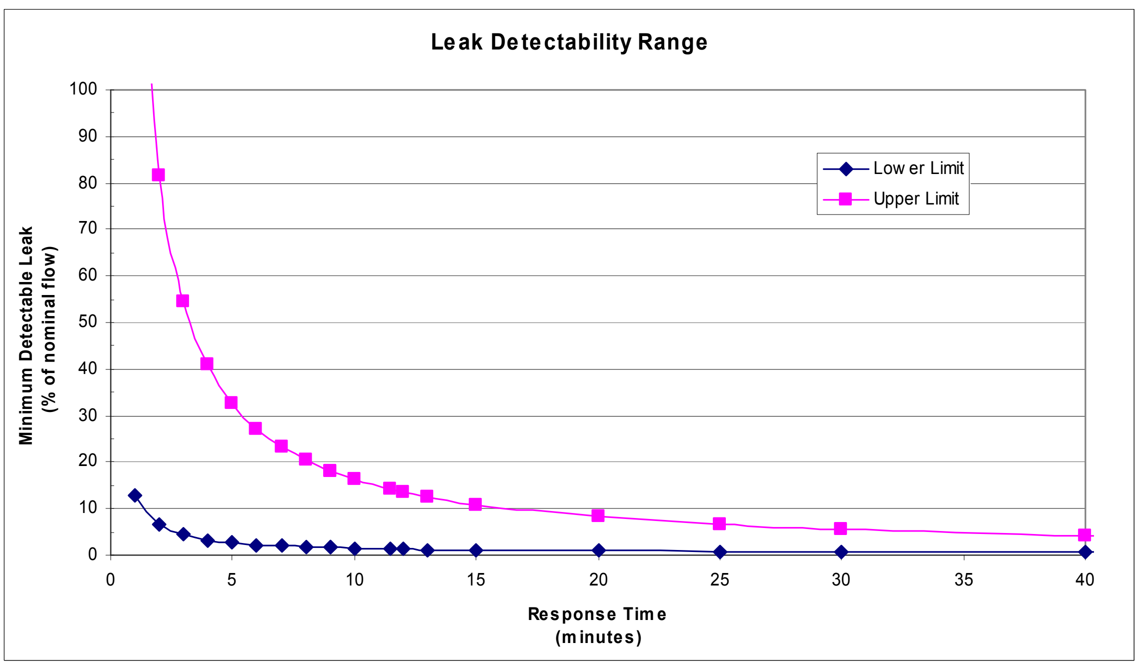

Figure 6 : Leak Rate Graph (0 – 40 minutes)

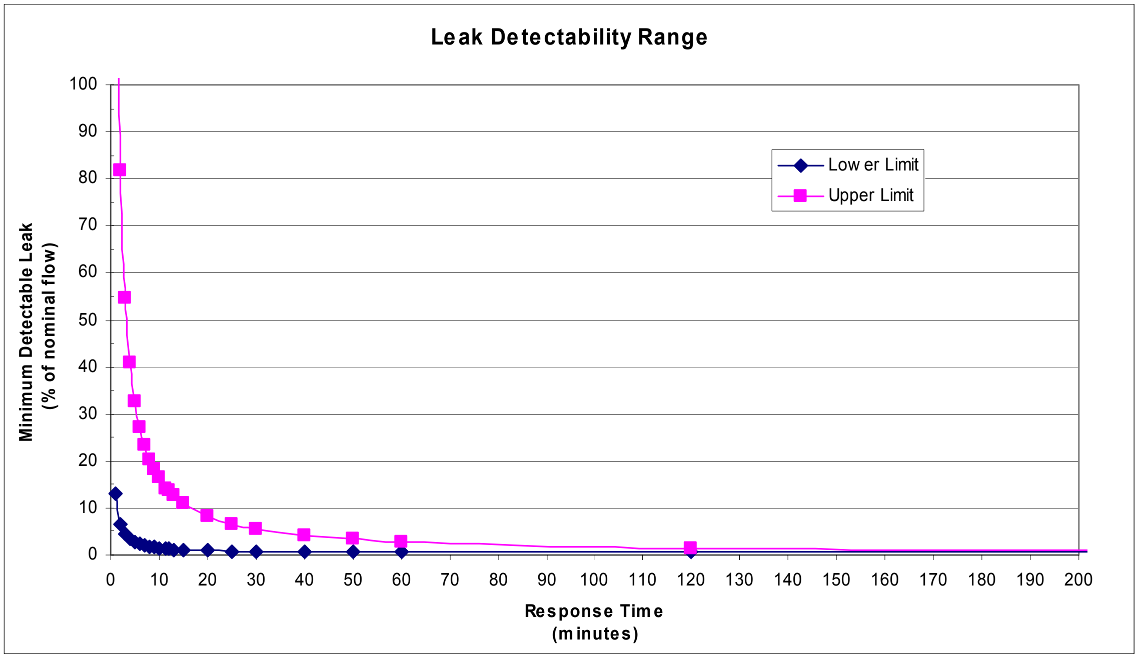

Figure 7 : Leak Rate Graph (0 – 200 minutes)

- The Upper Limit values are calculated using the dVt up values.
- The Lower Limit values are calculated using the dVt low values.

Leak rates lower than the Lower Limit values are theoretically impossible to distinguish from instrumentation uncertainty in a mass balance system at steady state. Leak rates lower than the Upper Limit values are theoretically impossible to distinguish from instrumentation uncertainty in a mass balance system during the largest transients.

4.2.3 Calculation. The Calculation worksheet contains:

- Pipeline description data
- Required constants
- Linefill data
- Intermediate calculated data such as sonic velocity, pressure and temperature
- Calculated API 1149 variables
- Volume uncertainty calculation

4.2.4 Fluids. The Fluids worksheet contains the required fluid properties for all of the possible batches in the pipeline.

Fluid Name	Base T (°C)	Base Den (kg/m³)	Bulk Mod (kPa)	Den T Mod (°C)	Base Den (° API)	Bulk Mod (psi)	Den T Mod (°F)
NW	15	822.5	1.30E+06	-1583	40.54	188549	-2849
HO	15	837.4	1.50E+06	-1190	37.48	217557	-2142
ISH	15	888.4	1.60E+06	-1200	27.78	232060	-2160
NCO	15	855.8	1.60E+06	-1200	33.84	232060	-2160
ZA	15	827.3	1.30E+06	-1200	39.54	188549	-2160

Figure 8 : Fluid Property Data

4.3 Considerations in Using API 1149. The calculation of the theoretical thresholds in this case (a simple and small diameter pipeline with one fluid) is relatively straight forward. The thresholds for the entire 500 mile line are calculated in one spreadsheet. But there may be instances where a pipeline will need to have the detection limits calculated for smaller portions than the entire line. This may be because the line uses differing diameter pipes or because there is a need to determine detection limits in a specific area, say for example an urban area (one type of HCA) where additional instrumentation has been installed to provide more inputs to the CPM and a more sensitive CPM.

Also, the spreadsheet calculates a minimum threshold (steady state operation) and a maximum threshold (transient operation). For the purposes of testing, at least initially, the lower value steady state thresholds may be the one to use for testing.

When creating the spreadsheet, the user will have to consider how best to represent the pipeline to determine the theoretical limits. It may be necessary to do two or even more separate calculations of parts of the pipeline. Enbridge has pipelines with variable diameter and varying flow rates along the pipe. These will need to be treated as individual pipeline sections and multiple worksheets inside the spreadsheet will need to be used for the data input and the display of the results.

4.4 Creating the MBS Input File (operating and leak data). The “equivalent to real world” pipeline data complete with a portion of data that contains the test leak is generated by a SCADA interfaced transient hydraulic simulation. The simulation model is based on one of the existing Enbridge Operator Trainer simulation models which are built for the specific pipeline to be tested. Some modification to the simulation trainer is necessary to provide all the required MBS data inputs. The simulation to produce a leak test file also needs more precise tuning than what would be needed for a Pipeline Controller trainer. In this case the simulation model needs to be tuned to produce data that closely matches actual operating data. Our specification is for data that is within:

- +/- 1% of pressure range at all pressure instrumentation sites
- +/- 2% of flow range at all flow metered stations

The modified trainer model is scanned by the trainer SCADA system and the required data is written to a circular binary data file which is archived the later read by the MBS application as shown below.

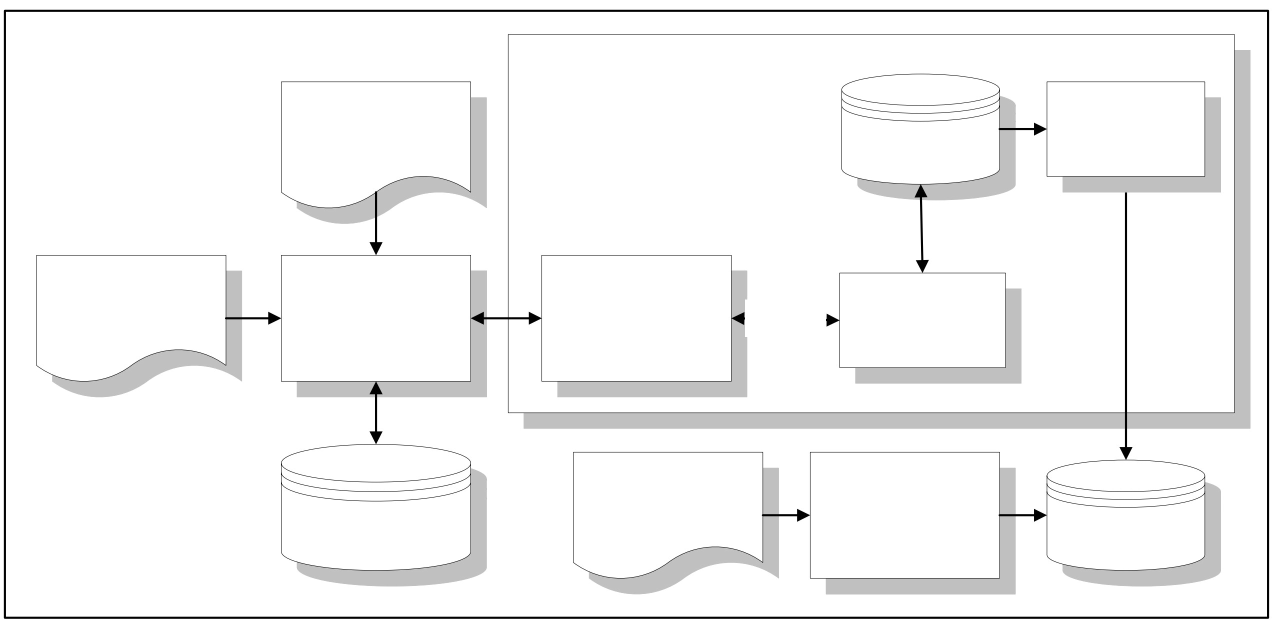

Figure 9: Process Chart

This data transfer can occur in real-time, to provide the most realistic test possible, or the data can be created and archived for future use.

4.5 Test Scenarios. The leak data generated by the modified trainer model will be based on a unique scenario that closely matches actual pipeline operating conditions. The production MBS input data files contain operating data for all hydraulically significant pipeline facilities such as :

- Injection, delivery, and mainline flow rates
- Mainline and station pressures and temperatures
- Injection and delivery density and batch identifiers
- Station pump status
- Mainline and station valve status
- Station pressure control setpoints

The modified trainer model will be configured to use and/or match these values for a period of time that is representative of both normal and abnormal operating conditions.

4.6 Evaluating the Input File Data. Testing a simulation based CPM using an input dataset that was produced by a simulation may seem like a risky approach (i.e uncertainties of simulation would render the final product meaningless) unless this method is somehow validated. Enbridge has extensive fluid withdrawal test data for the prototype pipeline and this will be used to verify the system performance. Also as Enbridge has many years experience with developing, maintaining and supporting the MBS, the staff have the knowledge and experience to design, implement, maintain and use this test approach.

One other item that requires careful consideration is at what locations on the pipeline the leak should occur. When the system is in production, it is not feasible to test a large number of locations on each pipeline every year. It will be necessary to select one or two locations. During prototype development numerous leak locations will be used. Data from these tests will be used to determine how the selection of a leak location impacts the ability of the CPM to identify and locate the leak. In production a number of factors will be considered in the leak test location. These will include: the area where the MBS is least sensitive (i.e. farthest from instruments and/or areas with less accurate instrumentation); environmental sensitivity; population density; elevation profile; fluid properties. In subsequent years' testing the location can be varied.

4.7 The MBS Testing. This is the 'easy' part of the work. It is nearly the same as running an archived data file from the actual pipeline. The procedures for that type of work are well established since that is a common work item in MBS system development and maintenance. The difference will be that the alarm details will need to be captured and evaluated.

4.8 Test Documentation. API 1130 has the most comprehensive list of the test documentation that should be retained. So our files will include that information for each test, in both electronic and hardcopy formats. The API 1130 section on Test records states the following

"*Records detailing the reasons for the tests, the test parameters and methodology and the test results should be recorded and retained for initial tests and for retests. These details of at least 2 previous tests should be retained. Details of any actual commodity release, if that event is considered as a retest should be retained at least as a part of the 2 previous tests.*

The pipeline company or operator policy will dictate the requirements for documentation of tests. Considerations for what information to include in the test records include:

- *Date, time and duration of the test*
- *Technical reasons for the test that documents the reasons the test is to be performed and why the methodology and particular parameters have been chosen.*
- *Method, location and description of the commodity withdrawal when used*
- *Operating conditions at the time of the test*
- *Details of any alarms generated during the test*

- *Analysis of the performance of the CPM system and, for unannounced tests the effectiveness of the response by operating personnel*
- *Documentation of corrective measures taken or mitigated as a result of the test*"

The MBS Test System documentation will consist of :

- Trainer and MBS model configuration files
- Trainer and MBS start status file
- Trainer scenario control file
- MBS input data file
- Trainer and MBS output files
- Trainer leak flow rate data
- MBS mass balance calculation output
- MBS alarm status
- MBS Test System Report

Of particular importance is retention of the test dataset, so it can be quickly located and easily re-run at any time.

4.9 Future Testing (re-running) It is proposed that the old or original test data file be re-run the following year to ensure the test is comparable to the previous year if no significant hydraulic changes have been made to the pipeline. The original data file can also be regenerated using a new 'leak' location. If significant hydraulic changes have been made to the pipeline, the trainer model will have to be modified to reflect these changes and retuned to match actual operating conditions prior to the creation of a new test data set.

5. Where It's At (Project Progress)

The MBS Test System project was launched in April of 2002. The planned completion date is April 2004. The project will provide API 1149 Spreadsheets and modified trainer model configurations for all 16 of Enbridge's transmission liquid hydrocarbon pipelines. This project has been divided into the following phases :

- Statement of Requirements (Complete)
- Prototype Design (Complete)
- Prototype Development (In-progress)
- Prototype Testing (pending)
- Detailed Design (pending)
- Development (pending)
- Testing (pending)
- User and Administrator Documentation (pending)

The prototype development phase of the project can be further divided into the following tasks :

- Trainer model modification (Complete)
- Trainer model schematic creation (Complete)
- MBS model schematic creation (Complete)
- API 1149 Spreadsheet creation (Complete)
- Trainer SCADA modification (In-progress)
- Modified Trainer model tuning (In-progress)

Far more than expected work on preparing the DDD (detailed design document) and additional work to get the simulation trainer configured has resulted in an approximate 4 month delay in project work. It is expected that the Prototype Testing will be complete by December 2002. Then after a careful review of what has been achieved, the project will continue to build test files and test the various MBS's. The particular pipelines to be tested will be determined based upon how long the MBS has been in place, type of products shipped, and consequences of a release on that pipeline.

6. Future Enhancements and Usage

It is envisioned that the test system will be enhanced with use and that it will find usage beyond testing MBS capabilities.

Enhancements to be considered will include:

- performing sensitivity analysis to determine where the CPM system could be strengthened to have lower detection limits
- allowing the input of real world situations such as instrument errors, communications outages, and slack line flow to be studied to see how they affect the MBS capabilities

Additional usage over and above using the system for new model tuning may include:

- determining CPM improvements
- using the outputs to quantify and justify capital improvements

7. Conclusions

The prototype development work is not yet completed, and so it is not possible to fully report on the success of this approach to leak testing, however, it was determined that this presentation and paper can provide value to the pipeline simulation community. Pipeline companies need to have methods to test their CPMs or software based leak detection systems. This approach offers an alternate that can meet or exceed regulatory and operational requirements.

8. References

American Petroleum Institute's API 1149 "Pipeline Variable Uncertainties and Their Effect on Leak Detectability"

American Petroleum Institute's API 1130 "Computational Pipeline Monitoring for Liquids Pipelines"

Canada's National Energy Board Onshore Pipeline Regulations 1999.

U.S. Department of Transportation CFR 40 Part 195

Canadian Standard's Association CSA Z662 Oil and Gas Pipeline Systems

APPENDIX

1. The wording of DOT CFR Part 195 Section 195.444

Sec. 195.444 CPM leak detection.

Each computational pipeline monitoring (CPM) leak detection system installed on a hazardous liquid pipeline transporting liquid in single phase (without gas in the liquid) must comply with API 1130 in operating, maintaining, testing, record keeping, and dispatcher training of the system.

[Amdt. 195-62, 63 FR 36376, July 6, 1998]

2. Excerpt from API 1130

6.2 SYSTEM TESTING

Testing of CPM systems evaluates actual system performance and provides a baseline of achieved performance. The CPM baseline may be established by testing, operating experience, offline modelling, or an API 1149, API 1155 or other theoretical analysis of the CPM/pipeline fit. This section outlines testing methods and intervals.

The primary purpose of testing is to determine that the CPM will alarm if a commodity release occurs. The purpose of tests could also to be make sure that data failure alarms and unusual operating condition alarms function as expected. The text that follows will not discuss CPM testing for other than commodity release alarms. The testing may also continue after the occurrence of the alarm to see also the transition from alarm state back to normal state.

Prior to testing, careful planning should be considered as to the reasons for the test and methods that will be employed and the process and procedures that will be followed. The test should be well managed to make sure it achieves the desired results.

Consideration should be given to the potential for a reduced level of pipeline monitoring during a CPM system test. The Pipeline Controllers should be alert to the possibility of an actual commodity release that could occur simultaneously with the CPM system test and that an actual commodity release may be disguised or misdiagnosed during the test interval.

6.2.1 Testing Methods

CPM systems should be tested to alarm state with actual or simulated commodity removal . The test method and testing parameters should be chosen to be representative of line operating conditions.

Possible methods of testing include but are not limited to:
- Removal of test quantities of commodity from the line
- Editing of CPM configuration parameters to simulate commodity loss (software simulations) or a desired hydraulic condition
- Altering an instrument output, for example a meter factor, to simulate a volume imbalance, or a pressure output to simulate a hydraulic anomaly which represents a leak.
- Other means that are capable of testing the performance of the CPM system.

The method used should be specific to the particular CPM application and pipeline system. CPM tests may be 'announced' or 'unannounced'. An announced test is started with the awareness of the Pipeline Controller and tests only the CPM system. An unannounced test is started without the knowledge of the Pipeline Controller and tests the CPM system as well as the response of the Pipeline Controller. Generally, unannounced tests are used only if the performance of the CPM system has been established by previous successful announced tests. When a series of tests are conducted, only the first test can be unannounced.

The location of the test may be varied from one test to the next so the CPM system experiences leak tests at various locations. This may increase the confidence in the capabilities of the CPM system Also the test may be performed at more than one withdrawal or simulated withdrawal rate so the time and leak rate response of the CPM can be evaluated over a range of possible leaks.

6.2.2 Initial Tests during CPM Commissioning

A new CPM system must be tested to verify that it has achieved the design or expected performance and to establish a baseline of performance. The reasons for testing a new CPM application are different than for retesting (which is outlined below). Throughout the installation and commissioning procedure, there may be a number of and a variety of tests. These tests would be to test the ability of the CPM system to function under varying operating conditions that are indicative of line operations . Initial tests may use simulated commodity releases. Consideration may be given to testing by actual removal of commodity from the pipeline for the final system test because the final test before acceptance will establish the baseline.

Subsequent CPM implementations on similar pipelines that employ the same CPM methodology may be able to use different initial test methods and may be able to take advantage of CPM work and testing on other pipelines.

Initial CPM tests may be rigorous and may be planned and executed using good engineering and technical judgement on issues such as test methods employed, commodity loss rates, and situations to be simulated.

6.2.3 Retesting

CPM retesting of applications will be necessary on a periodic basis to meet regulations, to confirm the continued effectiveness of the CPM, or to re-establish CPM performance after significant changes have been made to a existing CPM application or to the pipeline configuration. Retesting will be documented in test records.

CPM applications should be tested on a 5-year interval (or more frequently if significant changes have been made to the CPM or the pipeline segment or if there is a change in regulations that require re-testing) to confirm the CPM's continued effectiveness. It may not be necessary to test each pipeline system that uses the same CPM application, but consideration may be given to rotation of the tested pipeline and to varying the location of the test from one test to the next. The re-test may use the same method employed in the initial tests or may use another test method.

Operational use of a CPM system, for example successful detection of a commodity release, may be an acceptable substitute for periodic re-testing if it demonstrates continued effectiveness of the CPM. A successful identification of an actual commodity release, by an in-production CPM, shall be considered as sufficient for resetting of the 5 year re-testing interval.

Subsequent tests may not be as rigorous as the initial tests. If no changes have been made to the pipeline of the CPM during the re-test interval the re-test will be a confirmation test only.

6.2.4 Maintenance Testing

Maintenance testing is a type of CPM retesting but for a different purpose than outlined above. Maintenance testing may be performed on a much more frequent basis than retesting. There could be many reasons to perform maintenance testing on an operating CPM system. For example, throughout the life of the CPM system, it may be necessary to re-configure and retest the CPM software when: the pipeline system, SCADA system, CPM software or configuration changes; instrumentation changes; or any other changes occur to a degree that there may be a concern that the change will impact the performance of the CPM system. Amongst those may be testing following minor tuning changes, installation of a new software release, event re-run testing to examine CPM response to an unusual operating condition. The decision to perform maintenance testing will be based upon individual analysis of possible effect on performance and on a line by line basis. Maintenance testing may be included as a part of change management.

Maintenance testing may employ an actual commodity release data-set, a data-set from a leak test; or a test simulation. In these cases the persons responsible for the CPM will determine that method is best suited to maintenance test the CPM system.

The results of maintenance testing may not be recorded in test records. However, when the maintenance test is documented in accordance with 6.2.6, such maintenance tests may be considered a re-test and will set the start of a new testing interval.

6.2.5 CPM Systems Self Testing

Some CPM systems may be capable of running self diagnostics on a scheduled basis. Such diagnostics may monitor the health of the CPM system and may create CPM alarms. This may be a desirable system feature if the disruptive effect of these alarms on the Pipeline Controllers can be minimized.

CPM systems self tests do not meet the criteria for re-testing or maintenance testing.

6.2.6 Test Records

Records detailing the reasons for the tests, the test parameters and methodology and the test results should be recorded and retained for initial tests and for retests. These details of at least 2 previous tests should be retained. Details of any actual commodity release, if that event is considered as a retest should be retained at least as a part of the 2 previous tests.

The pipeline company or operator policy will dictate the requirements for documentation of tests Considerations for what information to include in the test records include:

- Date, time and duration of the test
- Technical reasons for the test that documents the reasons the test is to be performed and why the methodology and particular parameters have been chosen.
- Method, location and description of the commodity withdrawal when used
- Operating conditions at the time of the test
- Details of any alarms generated during the test

• Analysis of the performance of the CPM system and, for unannounced tests the effectiveness of the response by operating personnel
• Documentation of corrective measures taken or mitigated as a result of the test

3. Applicable Section from NEB's Onshore Pipeline Regulations

Pipeline Control System

37. A company shall develop and implement a pipeline control system that

(a) comprises the facilities and procedures used to control and monitor the operation of the pipeline;

(b) records historical pipeline operation data, messages and alarms for recall; and

(c) includes a leak detection system that, for oil pipelines, meets the requirements of CSA Z662 and reflects the level of complexity of the pipeline, the pipeline operation and the products transported.

Pipeline Control System and Safety Program Audits

55. (1) A company shall regularly conduct an audit of its

(a) pipeline control system developed under section 37;

(b) safety program developed under section 47; and

(c) environmental protection program developed under section 48.

(2) The documents prepared following the audit shall include

(a) any deficiencies noted; and

(b) any corrective action taken or planned to be taken.

4. Excerpt from CSA Z662

11.2.7 Leak Detection

Where appropriate, pipelines shall have leak detection systems. Leak detection devices and procedures, where used, shall be adequate for early detection of leaks. Line balance methods may be used.

Note: The adequacy of available leak detection systems for gas and multiphase pipelines may be limited.

10.2.6.2

Operating companies shall periodically review their leak detection methods to confirm their adequacy.

Note: A recommended practice for liquid hydrocarbon pipeline system leak detection is contained in Appendix E.

E4.3 Testing

The leak detection system shall be tested annually to demonstrate its continued effectiveness. Preferably, this should be done by the removal of liquid from the pipeline. Records detailing the results of each test should include

(a) date, time, and duration;
(b) method, location, and description of leak;
(c) operating conditions at time of test;
(d) details of any alarms triggered by the test; and
(e) analysis of the performance of the leak detection system and operating personnel during the test.