PROJECT 28: DRYWELL DESIGN IMPROVEMENT

ENME 535 Capstone Design Project 2015

Academic Advisor: Dr. Philip Egberts
Department of Mechanical and Manufacturing
University of Calgary

Project Sponsor: Mr. John Salazar, B.Eng, MBA, PMP
Project Manager
Young Pipeliners Association of Canada (YPAC)

Amy Zell – 10077026
Martin Burke – 10085069
Mohammad Kahlon – 10076484
Sheldon Kassa – 10076123
Spencer Kerber – 10077146
Tyler Hutchings – 10057611

Executive Summary

The current drywell design causes problems with H_2S probes freezing during the winter which puts avoidable stress on the connection tubing. This report describes and evaluates a range of possible design solutions. Three alternative solutions were designed and analyzed. By breaking down the customer requirements, five objectives were examined: energy consumption, ease of use and safety, installation, reliability and seasonality. Each of these objectives were weighted and ranked for each design to give the most optimal solution. By analyzing the objectives quantitatively and qualitatively by external research, calculations, and cost analysis, Design 3 was deemed the best solution to follow through on. With selecting a single design, the future of this project will focus solely on optimizing this solution.

Keywords

AER: Alberta Energy Regulators

ASME: The American Society of Mechanical Engineers

Ball Valve: A two-way valve that is opened and closed by a rotating or sliding stem with pressure imparted on a ball, which fits into a cup-shaped opening

Casing: A cover or shell that protects the pipe or tubing within

CEC: Canadian Electrical Code

Computer-Aided Design (CAD): The use of computer technology for design and design documentation, including 2D drawings and 3D modeling

CSA: Canadian Standards Association

Downstream: A term used for direction relating to pipelines; refers to the direction that the gas is flowing

Dry Gas: Natural gas containing mostly methane with little else; ideal for transmission via pipelines

Drywell (dry hole): A shaft/chamber constructed in the ground to contain pipeline equipment, allow access for maintenance, and assist drainage

Fuel-Gas Generator: An auxiliary power unit that uses available fuel gas/pipeline gas to generate enough power to run remote site instrumentation

H_2S: Hydrogen sulfide gas; a colorless gas that is poisonous, corrosive, flammable, and explosive

Hot Tapping: Method of making a connection to existing piping or pressure vessels without the interruption of emptying that section of pipe of vessel

Hydrates: A compound in which water molecules are chemically bound to another compound or element

Hydro Testing: A method for testing pipes and pressure vessels that make use of filling the vessel or pipe with water and pressurizing the vessel or pipe to a specified test pressure; this insures integrity of the vessel or pipe

Hyrdrovac: The process of hydro excavation; the only non-destructive method of digging; utilizes pressurized water and a vacuum system to quickly and safely expose underground infrastructure

In Line Inspection: (“Pigging”): The practice of using “pigs” to do maintenance operations (cleaning, leak detection, geometric information gathering); a “pig” device is inserted into a “pig launcher” which uses pipeline pressure build up to push the device through the pipeline until it is caught in a receiving trap or “pig catcher”

Low Bed: Trailer manufactured for the primary purpose of carrying heavy equipment on a flat-surfaced deck

Mainline: A pipeline that contains petroleum products from multiple suppliers

Natural Gas: Naturally occurring hydrocarbon gas mixture (containing a majority of methane among other lower carbons)

Project Advisor: University professor that provides engineering assistance and direction for the project and encourages our demonstration of engineering concepts in our design solution

Project Sponsor: Industry representative that provides the design project problem, objectives and expected deliverables

Solar Insolation: The amount of electromagnetic energy (solar radiation) incident on the surface of the earth

Sour Gas: Natural gas that contains H_2S

Teaching Assistant: Graduate or PhD student that is supervising and assisting our team for course requirements (design lab exercises, reports, etc.)

Tubing: Piping that is used to transport petroleum products from a producing area to processing

Upstream: A term used for direction relating to pipelines; refers to the opposite direction that the gas is flowing

Wet Gas: Natural gas containing mostly methane, but also containing higher carbon compounds and natural gas liquids (NGLs); can cause problems (corrosion, hydrates, etc.) during transmission via pipelines

YPAC (Young Pipeliners Association of Canada): An association of current and aspiring young professionals working in the pipeline industry in Canada; members come from many large and small pipeline companies in Alberta and Canada

Acknowledgments

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Introduction

Pipelines provide a service unparalleled by any other methods of transportation for natural gas and crude oil. The use of large diameter pipe acts as a highway to move these resources across the continent to high demand locations. Companies like TransCanada, Enbridge and Pembina Pipelines provide an efficient means of distribution. Pipelines successfully transport 420 million cubic meters of natural gas through the Canadian Energy Pipeline Associations Pipeline Network every day, with public safety as the top priority [1].

Pipeline operators ensure that risks to the public and environment are minimized by constant monitoring of the threats interacting with the pipeline and supporting infrastructure. These threats include: internal, external and stress corrosion cracking, manufacturing, fabrication/construction, equipment, human error, excavation damage, and outside weather and forces [2].

Pipelines are networked in a complex manner, resembling a spider web of inlets and outlets. A quality control group ensures gas quality that is brought on to the network is up to a standard agreed upon by both companies. To ensure this, random testing of the gas takes place. In the case of natural gas, special precautions are taken to guarantee no H_2S is present. H_2S is not allowed onto the network as it can corrode the pipe, unless the pipe is designed with particular materials selected. If companies are certain they will not bring on H_2S gas, pipelines are built to specifications of an H_2S-free standard as it is substantially less expensive [3].

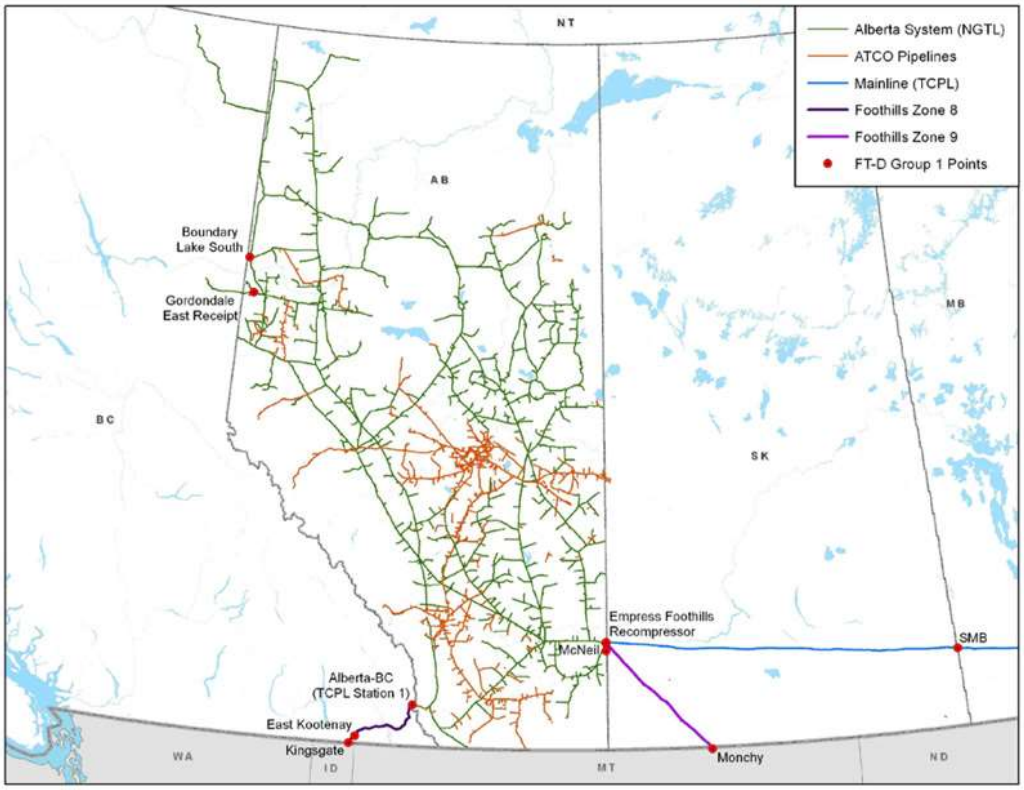

Figure 1: TransCanada's Alberta Natural Gas Transmission Line System is a natural gas system that is 24,828 km long that gathers natural gas for use within the province of Alberta

Gas quality is tested constantly and throughout the system. This ensures that H_2S concentration stays very low, hydrates are not forming, and foreign particulates are not damaging the inner diameter of pipe. When bringing companies online to the network, small facilities are built to immediately test the quality of gas. This allows for the gas be returned to producer instantly if the quality is lower than expected. These facilities make use of a drywell, a dug out hole in the soil that permits access of a probe to the pipeline. The probe then reroutes gas from the pipeline up to measurement equipment in the facilities.

The problem with current drywell design is temperature variation causes soil condition changes that negatively impact instrument piping and measurement probe. The objective of this project is to improve probe operability and decrease maintenance costs, and to provide an economic incentive to implement the design.7

Project Overview

Background

This project's goal is to improve upon the probing sites that are currently being used on gas pipelines. The purpose of these sites is to monitor the quality of the gas flowing through the pipeline at that given location. The quality of the gas can fall under two different categories, sweet gas and sour gas. Sweet gas in its natural state can be used with little purifying while sour gas contains an abundance of sulfur in its natural state (most often as H_2S) and is impractical to use without purifying [4]. Sour gas is therefore undesirable, so these probing sites are used to detect the presence of sour gas in the pipeline. If sour gas is detected at a site then it is coming from one of the gas refineries supplying the pipeline with natural gas upstream of the problem site but downstream of the previous site. The offending supplier can then be narrowed down further given which suppliers are currently feeding the pipeline. Once the supplier feeding the sour gas has been identified then the problem can be addressed.

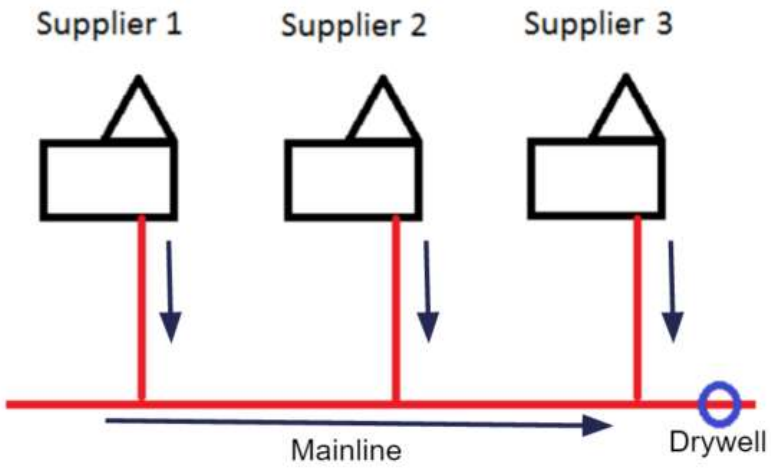

Figure 2: Illustration of supplier pipelines leading to the mainline

The main feature of these probing sites is the probe itself. The probe is essentially a long metal tube that enters the pipeline and carries sample gas from the pipeline through instrumental tubing to an electrical shack in order to be inspected. The probe enters the pipeline with the aid of a ball valve. The ball valve sits atop the pipeline and allows the probe to enter and exit the pipeline without any gas leaking out. The ball valve must be manually opened and closed in order to remove the probe. This means that workers need to have access to the buried pipeline. This is done with the inclusion of a drywell. A drywell is another term for a dry hole in the ground. This hole goes down directly to the pipeline and is located over top the ball valve. To help prevent the dirt walls from caving in, a plastic case is placed around the hole, like a drum. The drum includes a lid in order to help keep the hole free of snow and rain. There is also a ventilation spout on the lid of the drywell in order to prevent the accumulation of gas inside the drywell in the event of a pipeline leak. This drywell contains the vertical probe, a ladder, and enough room for a person to enter. If the probe needs to be removed from the pipeline then workers will enter the drywell by climbing down the ladder and physically lifting out the probe, followed by manually closing the ball valve located at the bottom of the drywell. The probe needs to be removed before pipeline maintenance can occur. The probe enters the pipeline to about 40% of the pipeline diameter. The probe therefore interferes with any in-line inspection or pipeline testing operations (hydro testing).

The probing sites include a shack that houses all the electronic equipment that is needed to run the probe and inspect the sample gas. The shack is located a few meters away from the drywell and connects to the probe through instrumental tubing along a metal frame. The metal frame keeps the tubing supported and off of the ground. The shack is powered using a battery or a fuel gas generator that runs off gas taken from the pipeline with the assistance of a regulator to reduce the pressure.

Problem Statement

On the majority of large diameter pipelines, companies that own or operate pipelines make use of a probe to measure gas quality brought in to the pipeline network. This probe is designed to reroute natural gas from the pipeline to a measurement device testing for H_2S gas. The probe is intended to be removed during in-line inspections. A drywell is typically built to allow for access to the pipeline underground for maintenance of valves, flanges, or for probe removal. During spring and summer months it is very common for the drywell to fill with ground water, limiting access to the probe. During winter months, the collected water can freeze, increasing difficulty in accessibility. Additionally, the temperature fluctuation that takes place in Canada can cause large variations in soil condition, resulting in frost heaving. Frost heaving can cause the instrument piping connected to the measurement probe to buckle. Propagating vibrations from the gas flowing in the large diameter pipeline can also impact the integrity of the instrument piping. Consistent maintenance efforts are needed to mitigate the risk of instrumentation and measurement probe system failure. The problem for the project design team is to develop and improve on existing drywell design to allow for easier probe maintenance and removal.