

OPPORTUNISTIC COMPILATION OF ECDA, ILI AND HYDROSTATIC TESTING FOR SUCCESSFUL PIPELINE UPRATING: CASE STUDY

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ABSTRACT

Regulators require minimum federal safety standards for pressure uprating as described in 49 CFR Part 192 Subpart K. Pipeline uprating to a pressure that will produce a hoop stress of 30% or more of SMYS in steel pipelines require a series of documented integrity assessments to ensure the pressure uprating will not adversely affect the safe operation. The objective of this paper is to disseminate a process that operators can use to develop an effective integrity assessment guide for pressure uprating. This guide exceeds the requirements established in §192.555. The combination of External Corrosion Direct Assessment (ECDA), In-Line Inspection (ILI), and hydrostatic testing is used in conjunction to identify a variety of time dependent and time independent threats. A systematic approach for chronological implementation of assessment types for pressure uprating has been validated through a successful case study.

Key words: Pressure Uprating, Fitness-for-Service, Subpart K, ECDA, ILI, Hydrotest, Case Study

INTRODUCTION

The annual natural gas demand in the United States surpassed 31 trillion cubic feet in 2019. This is over a 500% increase from demand in the 1950's (5.7 trillion cubic feet) [1]. As gas demand continues to rise, pipeline operators have limited options to meet demand requirements. Pressure uprating is one option that can be leveraged for certain pipelines to meet the increased demand economically. The pipeline pressure is increased to create a larger pressure differential from one end to the other which in turn increases the flow rate of the natural gas.

Pipeline pressure is a critical operational variable that must be determined and continuously monitored by the pipeline operator to ensure the natural gas can safely travel appropriate distances and meet the market demand. Pipeline pressure is also heavily scrutinized by the Pipeline and Hazardous Materials Safety Administration (PHMSA) to ensure compliance with Title 49 Code of Federal Regulations (CFR) Part 192 – Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards.

The information disseminated throughout this paper is organized to provide a reasonable approach to ensure pipeline integrity is maintained during and after a pipeline pressure uprating event. As required in CFR 192 Subpart K, *“Each operator who uprates a segment of pipeline shall establish a written procedure that will ensure that each applicable requirement of this subpart is complied with”* this paper may be used as a starting point to establish an integrity procedure that meets or exceeds CFR 192 requirements [2]. A case study has been provided by using External Corrosion Direct Assessment (ECDA), in-line inspection (ILI) and hydrostatic pressure test to uprate a Class 1 1983, NPS 30-inch, Coal tar coated pipeline from 50% specified minimum yield strength (SMYS) to 72% SMYS.

PROGRAM OVERVIEW

This paper targets gas operating transmission pipelines that are regulated to the CFR 192 code. In Table 1 are pipeline integrity threats required to be evaluated for each transmission pipeline, and a few optional assessment methods used to identify, quantify, and/or address those threats. The combination of ECDA, axial magnetic flux leakage (MFL-A) ILI, and hydrostatic pressure testing will effectively address identified threats with the exception to equipment failures and incorrect operations for anecdotal events.

Table 1: Threat Identification by Assessment Method

Identified Threat		Assessment Method		
		ECDA	MFL-A In-Line Inspection	Pressure Test
Time Dependent Threats	External Corrosion	Yes	Yes	Yes
	Internal Corrosion	Possible	Yes	Yes
	Stress Corrosion Cracking	Possible	No	Yes*
Time Independent Threats	Mechanical Damage	Yes	Yes	Yes
	Incorrect Operations	N/A	N/A	Possible
	Weather & Outside Forces	Possible	Possible	Yes
	Thermal Expansion	N/A	Yes	Yes
Static or Resident Threats	Manufacturing Defects	No	Possible	Yes
	Welding & Fabrication	No	Possible	Yes
	Equipment Failures	N/A	N/A	N/A

N/A = Not Applicable; Possible = Case Specific

* Spike pressure test

The objective of a pipeline assessment program for a pressure uprating opportunity is to select a combination of assessment methods that will effectively identify and quantify all threats that pose a risk to the case specific pipeline. The assessment types and the order in which the assessments are implemented should be considered for program cost and effectiveness optimization.

For the case study involved in this paper, the execution process of assessment types was as follows: first ECDA, followed by MFL-A ILI, and then lastly, hydrostatic pressure test. The data presented herein follows the order in which the assessments were executed. Opportunities for project cost optimization and lessons learned are provided.

SITUATIONAL AWARENESS AND APPLICABILITY OF CFR 192 CODE

The reader should recognize this paper is focused on the integrity aspects of CFR 192 Subpart K; other uprating restrictions detailed in the CFR 192 code must also be considered before a pipeline pressure uprate is implemented. The application of integrity assessments such as ECDA, ILI, and pressure tests are referenced numerous times throughout the CFR 192 code. It is paramount the operator can recognize the requirements, metrics, exceptions, opportunities, stipulations, and intricacies within the details of the code to appropriately execute a pressure uprating and set oneself up for long-term integrity success. This paper cannot identify every situation or opportunity to strategically apply assessment methods due to the inherent complexities imbedded within the CFR 192 code. Instead, it is recommended to utilize Table 2 below as potential starting points to support the operator in a pressure uprating project. Anecdotal situational opportunities are incorporated into this paper when possible.

Table 2: CFR 192 Referenced Sections of Potential Interest for Pressure Upgrading

CFR Code Reference	Overview	Generalized Overview
Subpart K	Upgrading	Minimum requirements for pipeline upgrading
192.105	Design formula for steel pipe	Minimum design pressure requirements for steel pipe
192.107	Yield Strength for steel pipelines	Yield strength and pressure stipulations; conservative Grade A approach stipulation
192.205	Records	Requirements for record retention for pipeline and pipeline components
192.493	ILI Inspections	ILI performance requirements
192.506	Spike hydrostatic pressure test	Test requirements
192.555	General requirements	General requirements for a pressure upgrading
192.607	Material Property Verification	Tracible, verifiable and complete records; upgrading stipulations
192.611	Class Change	Confirmation or revision of MAOP
192.619	MAOP	Establishment of MAOP requirements
192.620	AMAOP	Alternative MAOP for Class 1, 2 or 3 segments
192.621	MAOP – Distribution	High pressure distribution systems
192.624	MAOP reconfirmation	Requires transmission pipelines to be reconfirmed for MAOP in HCAs and Class 3 or 4 locations. Mega Rule related, implemented July 1, 2020.
192.632	Engineering Critical Assessment	MAOP reconfirmation and pressure stipulations
192.712	Analysis of predicted failure pressure	Evaluation requirements for defects or anomalies identified on the pipeline
192.925	ECDA	ECDA minimum requirements
192.927	ICDA	ICDA minimum requirements
192.929	SCCDA	SCCDA minimum requirements

CASE STUDY: PIPELINE OVERVIEW

The pipeline evaluated for this case study is 3,880 feet long of 1983, 30-inch diameter, API 5L grade X52 or X60 pipe manufactured by numerous steel companies with varying wall thicknesses between 0.425" and 0.562". The pipeline originally operated with a maximum allowable operating pressure (MAOP) of 858 psig, equating to a range of 46% to 62% SMYS, depending on wall thickness and material strength combinations. The coating type is reported as Coal tar with double submerged arc welded (DSAW) long seam welds. The objective of this pressure upgrading project was to increase pressure to 1050 psig, equating to a maximum stress level of 72% SMYS.

Cathodic protection has been operation since installation in 1983. A review of the historical test point surveys determined data was available from 1996 through 2021 at four test point locations. Figure 1 provides the average On and Instant Off potentials for the four above grade appearances that were annually measured, and the rectifier current outputs for a similar timeframe. In 2016 the groundbed and rectifier were replaced. A drop in CP current output is noted in 2018 when the pipeline was metallurgically bonded with other transmission pipe to share CP current. The three additional rectifiers that began applying CP to this pipeline after the 2018 modification were not added to Figure 1 but produce a total