CIPL Cross Inlet Extension Project

Conversion of Service:

LP CIGGS to CIPL E 10

Basis of Design

Public Document

Revision History

Rev	Date	Description	Author	Review	Approval
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1.0 Abbreviations

AAC	Alaska Administrative Code
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
BBL	barrels
BPH	barrels per hour
CFR	Code of Federal Regulations
CIGGS	Cook Inlet Gas Gathering System
CIPL	Cross Inlet Pipeline
CP	Cathodic Protection
F	Fahrenheit
lbs	pounds
MAOP	Maximum Allowable Operating Pressure
MOP	Maximum Operating Pressure
mil	one thousandth of an inch
NACE	National Association of Corrosion Engineers
psi	pounds per square inch
psia	pounds per square inch atmospheric
psig	pounds per square inch gauge
SCADA	Supervisory Control and Data Acquisition
SDV	Shutdown Valve
USGS	United States Geological Survey

2.0 Project Overview

The Low Pressure (LP) CIGGS pipeline is an existing 10" nominal onshore pipeline that will be converted from natural gas service to crude oil service between Station O and the KPL Oil Facility (KPLO). This work is part of an overall project, called the CIPL Cross Inlet Extension Project, that modifies the oil and gas pipeline systems in the Cook Inlet region in order to eliminate the need for Drift River Terminal and overwater transportation of crude oil.

As part of the CIPL Cross Inlet Extension Project, the existing LP CIGGS pipeline between Station O and KPLO, currently in natural gas service, will be converted to crude oil service. After conversion to oil service, LP CIGGS segment will become part of the CIPL E 10 pipeline.

The CIPL E 10 pipeline will be composed of three sections in order to transport crude oil from the East Forelands facility to KPLO facility.

1. The first section is a new 10" buried pipeline that connects East Forelands facility to Station O facility. The basis of design for this new section is in a separate document for the CIPL E 10.
2. The second section is composed of the existing 10" LP CIGGS, converted from natural gas service to crude oil service, which connects Station O facility to the LP CIGGS/KPLO tie-in. This document is the basis of design for the conversion of service. Once it is converted to oil service, the LP CIGGS pipeline will be renamed the CIPL E 10.
3. The third section is a new 10" buried pipeline that connects the existing LP CIGGS to KPLO facility. The basis of design for this new section is in a separate document for the CIPL E 10.

Figure 1: Location of LP CIGGS in Nikiski, AK

2.1 System Design

The conversion of the existing LP CIGGS to the CIPL E 10 is required to provide a segment in the new pipeline system for crude oil produced on the West Side of Cook Inlet to be delivered to the Andeavor refinery without the use of barges. The existing LP CIGGS pipeline will be connected to new crude oil pipelines at Station O and at KPLO to complete the pipeline circuit for crude oil to flow from the west side production facilities to Andeavor.

The LP CIGGS pipeline is designed to flow crude oil from north (Station O) to south (KPLO). Surface facilities at Station O include a manual valve for isolation. Surface facilities at KPLO include shutdown valves, pig trap, metering and pressure control valves.

2.2 Pipeline Length

The section of existing LP CIGGS that will be converted to oil service from Station O to the KPLO/LP CIGGS Tie-in is 19,920 feet (3.77 mi) and has a volume of 11,383 cubic feet (85,457 gallons; 2,035 bbls) at standard pressure.

2.3 Pipeline Construction

The LP CIGGS pipeline was constructed in 1972 using 10-inch nominal, API 5L-X52, 0.250-inch wall, double submerged arc welded (ERW) pipe. The LP CIGGS was originally constructed to transport low pressure oil well gas from MGS and Granite Point Platforms to Collier Carbon and Chemical (now known as Agrium). The pipeline was used as a bi-directional gas transmission pipeline. The LP CIGGS pipeline is currently classified, per USDOT, as a Gas Transmission pipeline. The pipeline crosses Class 1, 2, and 3 locations, as defined by 49 CFR 192.5.

The pipeline materials purchase documents (MTR's, construction specifications) indicate the existing LP CIGGS pipeline material is 10.75" OD, 0.250" wall, Grade 5LX-52 ERW Line Pipe that conforms to API Specification for High Test Line Pipe, API Std 5LX 18th Edition, dated April 1971. Product Specification Levels (PSL) were not included in the API specifications in 1971 - they were added in the late 1990's after the specification was changed from 5LX to API 5L Specification for Line Pipe.

The pipe was supplied by Republic Steel. Table 1 compares the pipe MTR information to current PSL specifications.

Criteria	Existing Pipe MTR	API 5L PSL-2	API 5L PSL-1
Carbon % max	0.22	0.18	0.28
Manganese % max	0.96	1.40	1.40
Silicon % max	na	0.45	na
Phosphorus	0.011	0.025	0.03
Sulfur % max	0.040	0.015	0.03
Max Yield	70,360 psi	76,900 psi	na
Toughness	na	20 ft-lbs at design temp	na

Table 1: Existing Pipeline Material Specifications

Currently the LP CIGGS is not flowing gas, but does have approximately 20 psig of natural gas in the pipeline, and has been maintained to CFR 192 standards.

2.4 Pressure Test

The LP CIGGS pipeline was successfully hydrotested after construction on August 26, 1972. The test was performed for 24 hours with a minimum recorded pressure of approximately 2,200 psig.

The pipeline was pressure tested for an integrity assessment on October 16 and 17, 2015. The pipeline was pneumatically tested for 8 hours to a minimum pressure of 448 psig.

Prior to conversion to liquid service, the LP CIGGS (CIPL East 10) pipeline from Station O to the KPLO/LP CIGGS Tie-in will be hydrotested per CFR 195 and ASME B31.4 to at least 1,850 psig (1.25 x design pressure) for 8 hours to confirm mechanical integrity.

2.5 Pipeline Integrity History

There are no known records of any pipeline leaks on LP CIGGS pipeline. There are no known previous repairs on the LP CIGGS.

2.6 MOP Verification

Pending confirmation by hydrostatic testing, a MOP of 1,480 psig will be established.

2.7 Normal Operating Pressure

The pressure source of the pipeline is the GPTF booster pumps, which will be normally operated between 300 psig and 600 psig. Due to hydraulic pressure losses in the pipeline system, the pipeline will experience pressures less than the booster pump pressure range. The normal operating pressure will not exceed 600 psig.

Based on the CIPL pipeline system hydraulic calculations, the typical operating pressure at the design high flow range will be about 400 psig.

3.0 Jurisdiction and Criteria

The pipeline is used for transportation of crude oil, so falls under the Office of Public Safety regarding design criteria for evaluation of the existing pipeline for the new service condition.

The Office of Public Safety, references 49 CFR Part 195 – Transportation of Hazardous Liquids by Pipeline, revised as of October 1, 2011 for crude oil transmission pipelines.

CFR Part 195 references ASME B31.4 – Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids, October 2006, for design of pipelines subject to external loads. B31.4 has been updated since 2006, and this evaluation uses the 2012 Edition.

4.0 Pipe Properties

The pipeline is coated with enamel and wrapped. Pipeline joints are triple random. Pipeline properties are summarized in Table 2 below.

Item	Value	Notes
Grade	5L-X52 ERW	
Outside Diameter, Do	10.75”	
Inside Diameter, Di	10.25”	
Wall thickness, t	0.250”	
Area, A	8.2 in2	
Elastic Section Modulus, Z	21.2 in3	
Weight / foot (empty)	30.1 lb/ft	Includes 2.0 lb/ft coating
Weight / foot (full of oil)	61.2 lb/ft	Includes 31.1 lb/ft oil
Weight / foot (full of water)	65.9 lb/ft	Includes 35.8 lb/ft water
Outside Diameter (Coated)	11.0”	Includes coatings

Table 2: Pipeline Properties

5.0 Pipeline Design

5.1 Structural Pipeline Design

For conversion from natural gas to crude oil service, the existing LP CIGGS (CIPL East 10) pipeline has been evaluated using design criteria from 49 CFR 195 and ASME B31.4. The evaluation determined the existing pipeline will remain within allowable stress through the range of operating loads that are expected and prescribed by the codes. See Section 6.0 for the loading scenarios for the design of the pipeline.

5.2 Geotechnical

The pipeline is buried between Station O and KPLO/LP CIGGS Tie-in. Soils along the pipeline route are typically glacial deposits consisting of gravelly sand.

5.3 SCADA, Communications and Control System

The LP CIGGS (CIPL E 10) pipeline will be monitored and controlled through Hilcorp's existing SCADA system. The primary control and operations center for the pipeline is located at the Kenai Gas Field facility. The backup control room is located at KPL Junction.

The SCADA system will enable pipeline operators to efficiently and effectively supervise pipeline operations in real time. Data acquisition and storage will be provided, along with provision for report generation using historical data. Data retention and management will comply with applicable federal and state regulatory requirements. Additionally, some control functions will be provided through the system to allow for manual operational control and testing when necessary.

The SCADA system scan rate will be fast enough to minimize overpressure conditions, provide very responsive abnormal operation indications to controllers and detect small leaks within technology limitations.

The SCADA system will incorporate a real-time database and historian. The information on these databases will be used to generate operations reports and trends.

The SCADA system will send necessary information to a business database/historian. The information on this historian will be used to file reports to outside entities such as government regulators and provide information for business analysis.

The SCADA system will collect measurements and data along the pipeline, including flow rate through the pipeline, operational status, pressure, and temperature readings. This information may all be used to assess the status of the pipeline. The SCADA system will provide pipeline personnel with real-time information about equipment malfunctions, leaks, or any other unusual activity along the pipeline.

5.4 Operating Philosophy and Valve Configuration

Flow of crude oil is introduced into the LP CIGGS (CIPL E 10) through the pipeline booster pumps located at Granite Point Tank Farm (GPTF). The pipeline pressure downstream of the pumps and pig trap at GPTF is monitored by pressure transmitters located at GPTF and Kaloa Junction that have high (500 psig), high high (800 psig), low (80 psig) and low low (50 psig) alarms. A high high pressure condition results in a shutdown of the pipeline by closing automated shutdown valves located at East Forelands and KPL Junction, which isolates the CIPL East 10 pipeline segment.

5.5 Leak Detection Systems

The CIPL pipeline leak detection system will include two separate leak detection technologies consisting of a statistical mass balance leak detection system and a wave rarefaction model leak detection system.

5.5.1 Mass Balance

Atmos Pipe leak detection system is a statistical volume balance leak detection system that provides a very accurate method of detecting smaller leaks over a longer period of time or larger leaks over a short period of time. Operational experience at other Alaska oil pipelines using the Atmos Pipe system has verified it provides a highly reliable and accurate method of leak detection on crude oil pipelines in similar oil production service.

Flow Meters carefully monitor inlet and outlet flows of the pipeline system for comparison of these values. Differences would indicate possible leaks. A statistical mass balance leak detection computer modeling system ties into the SCADA system that monitors the pipeline flow and generates predictable flow patterns over time. Disturbances such as those caused by temperature variations or varying flow or operating pressure are measured and masked out as "noise."

5.5.2 Wave Refraction

Complementing this, Atmos Wave is suited to identify larger leaks in a shorter period of time and is also able to identify the leak location. The Atmos Wave Leak Detection System is based on the detection of the negative pressure waves associated with the onset of a leak or theft. These rarefaction waves propagate out from the location of the release in both directions and can be sensed by high performance pressure meters at the ends or along the pipeline. The basic principle is simple, and it is used to detect and locate very large leaks using normal pressure meters. Unfortunately, when this principle is applied to very small leaks, the sensors detect not only the leak but also the large number of pressure changes that are part of normal pipeline operations and this causes a large number of false alarms on this type of system.

Atmos Wave is the result of several years of research and development directed at producing pressure-based leak detection system that is based on state-of-the-art hardware and telecommunication technology. A thorough review of the performance problems of the traditional systems leads to the decision to develop a completely new approach. This new approach is extremely successful. It examines all aspects of the negative pressure wave front and its propagation through the entire pipeline length. Three comprehensive algorithms filter out noise, arrange the analog pressure data into a detailed 3-dimensional map that allows the system to differentiate true leak/theft events from the pressure changes caused by transient operation. Extensive performance evaluation and field trials have proven that Atmos Wave consistently differentiates opening and closing leak/theft signals during transients. These remarkable algorithms have been rigorously tested in operational pipelines with great success.

In combined mode, Atmos Pipe acts as the primary leak detection system aided by Atmos Wave. Both leak detection systems run independently of each other. If one system fails, the other system will continue leak detection. Atmos Wave provide the Atmos Pipe System with the ability to detect leaks more quickly and provide a more accurate leak location.

5.5.3 Control Room Monitoring

In addition, the Harvest Kenai Control Room is manned 24 hours per day and the operator on duty constantly monitors pipeline transfer operations via the SCADA system. In addition, the controller takes readings to compare the accumulated totals for CIPL and compares with what has been received at KPLO. These readings are recorded by the SCADA historian.

5.6 Corrosion Control and Monitoring

The LP CIGGS has a corrosion control system, provided by protective coatings and cathodic protection (CP). The pipeline coatings used are enamel and felt or enamel and glass fiber wrap. Cathodic protection is provided to the LP CIGGS pipeline by an impressed current cathodic protection system located at East Forelands. CP surveys and system maintenance are performed annually.

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6.0 Pipeline Loading Scenarios

Loads on the LP CIGGS pipeline include both pressure loading cases and other loading cases. Loads are combined as prescribed by code.

6.1 Pressure Load Scenarios

The pipeline will be subject to various pressure loading summarized as follows:

- Normal Operating Pressure: 400 psig (based on pipeline hydraulic calculations for design high flow range)
- Design Internal Pressure (Maximum Operating Pressure): 1,480 psig
- Hydrostatic Test Pressure: 1,850 psig (1.25 * Design Internal Pressure)

6.2 Other Loading Scenarios

The pipeline segments will be subject to non-pressure loading conditions, including:

6.2.1 Installation Load

Pipeline was installed by conventional trenching / cover methods. No unusual installation loads are included.

6.2.2 External Pressure Load

14 psia to 22 psia (surface to 10 feet maximum soil cover). External pressure loading is considered inconsequential, as the operating pressure of the pipeline is about 400 psig to 100 psig, depending on location. External pressure is ignored in the hoop stress calculations.

6.2.3 Thermal Loads

Thermal loads result from a change in temperature in the pipeline walls. This pipeline is buried and considered to be restrained. The stresses are evaluated for winter installation (0F) and summer installation (70F) and an operating temperature of 35F to cover the range of time allowed for construction. The oil in the pipeline is ground temperature as there is no heat added from process that effects the temperature of this pipeline.

6.2.4 Traffic Loads

Traffic Load (Operational Load): External pressure loading due to surface traffic over the pipeline. Pipeline is evaluated for traffic loading with no pavement and tandem axle configuration, based on API RP 1102, which is conservative. The pipeline has a minimum depth of bury of 4 ft.

6.2.5 Seismic Loads

The pipeline is located in Cook Inlet, an area of high seismicity. The pipeline route onshore does not cross any USGS mapped faults or folds. No specific seismic loads are applied to the pipeline for design.

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7.0 Design Results

The pipeline meets the 49 CFR 195 requirements for hoop stress, summarized in Table 3.

Location	P per CFR	$P_{Operating}$	P_{Design}	P_{Hydro}
All	1,741 psig	400 psig	1,480 psig	1,850 psig

Table 3: 49 CFR 195 Design Results

It is acceptable for P_{Hydro} to exceed P_{CFR} as P_{Hydro} is a test condition and does not exceed the pressure required to yield the pipe.

7.1 Calculation Results

The pipeline is evaluated using B31.4, Section 402. B31.4 calculations take into account hoop stress, longitudinal stress from thermal, pressure and bending loads, and torsion stress. Since the pipeline is buried and fully supported, the pipeline is considered restrained, and is not subjected to bending or torsion loads.

As-Installed Stress Evaluation:

The pipeline is fully supported and restrained by soil backfill. The onshore pipeline stress is summarized in Table 4 (winter install) and Table 5 (summer install).

Pipeline Pressure Condition	Internal Pressure	Hoop Stress	Thermal Stress	Longitudinal Stress	Combined Stress
Normal Operation	400 psig	8,600 psi	-7,540 psi	-3,538 psi	12,138 psi
Design (600# ANSI)	1,480 psig	31,820 psi	-7,540 psi	7,269 psi	28,880 psi
Hydrotest (1.25*Design)	1,850 psig	39,775 psi	-7,540 psi	10,971 psi	35,581 psi
ASME Allowable Stresses		37,440 psi	46,800 psi	46,800 psi	46,800 psi

Table 4: Onshore Stress Summary – 0F Install Temp, 40F Operating

Pipeline Pressure Condition	Internal Pressure	Hoop Stress	Thermal Stress	Longitudinal Stress	Combined Stress
Normal Operation	400 psig	8,600 psi	7,540 psi	11,542 psi	10,389 psi
Design (600# ANSI)	1,480 psig	31,820 psi	7,540 psi	22,349 psi	28,299 psi
Hydrotest (1.25*Design)	1,850 psig	39,775 psi	7,540 psi	26,051 psi	34,993 psi
ASME Allowable Stresses		37,440 psi	46,800 psi	46,800 psi	46,800 psi

Table 5: Onshore Stress Summary – 70F Install Temp, 30F Operating

The hoop, thermal, longitudinal, and combined stresses for the normal operating and design conditions are all well within allowable stresses for the pipeline.

Traffic Load Evaluation:

The traffic loading on the LP CIGGS pipeline pass the stress requirements of the API RP 1102 calculation. Cyclical, internal pressure and total effective stresses are all within allowable stress requirements.

7.2 Minimum Wall Thickness Summary

The LP CIGGS pipeline has wall thickness in excess of that required by code. A corrosion allowance is not required per CFR or ASME, however excess wall thickness provides some additional reserve strength to allow for some wall loss and still meet code. The exterior of the pipeline is coated and protected by cathodic protection, so external wall loss is risk is mitigated.

The minimum wall is based on the hoop stress due to the design pressure of 1,480 psig since longitudinal stresses and combined stresses are comparatively insignificant for the buried condition.

Pipeline Segment	Nominal Wall Thickness	Minimum Wall Thickness
LP CIGGS Pipeline	0.25”	0.21”

Table 6: Minimum Wall Thickness Summary

7.3 Design Summary

After the conversion of service from natural gas to crude oil, the LP CIGGS (CIPL E 10) pipeline will remain within allowable stresses defined in 49 CFR 195 and ASME B31.4 through the range of loads that are expected and prescribed by code.

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