The Measurement of Free Water in NGL

Inline Measurement for Control

The Application of Dynamic Imaging Technology to Measure Free Water Contamination in Natural Gas Liquids (NGL)

Ethan Schrodt

During the fractionation process of natural gas liquids (NGL's), the presence of free water can create major issues with the operation of various pieces of equipment while negatively impacting the quality of the products from the process. This leads to increased costs and decreased revenue. Filtration systems are typically installed to remove impurities, including water, from the incoming natural gas.

When these systems near the point that they need maintenance or when there are upsets to the normal process conditions, it is possible that some water makes it past the filters and goes downstream into the process. For this reason, it is critical to have a means of measuring the amount of free water entering into the process. This paper explores the use of CANTY's Inflow analyzer, a dynamic imaging technology, to detect and measure the concentration and droplet size distribution of free water in natural gas directly in the process line.

Contents

Introduction

Dynamic imaging involves flowing process material through an analyzer that takes microscopic images of the fluid and analyzes those images to detect the presence of “particles.” These particles could range from droplets to gas to solid materials. Since the acquired images are 2-dimensional and there is a morphological differences in the appearance of these types of materials, dynamic imaging analyzers are capable of simultaneously detecting, sizing, and measuring concentrations of all of these materials independently from one another.

As natural gas flows out of the filtration system before being processed further, it should be free of water contamination. There are times, however, when that filtration does not completely remove all of the contamination. This may be due to a variety of factors including filter maintenance and upset conditions to the process or raw natural gas coming in. When a CANTY Inflow is installed inline, the analyzer will be able to pick up on free water droplets at sizes as low as 1 - 2μm and concentrations down to 1ppm. When detected, the analyzer can output a signal indicating the size, count, and concentration of the droplets detected.

These outputs allow a control system to automate a response to prevent problems from occurring before they happen.

Overview of Water Measurements in NGL’s

Natural gas being fed into a fractionation process often has impurities, such as water. Filtration systems are put in place which are designed to remove these droplets so that they never make it downstream into the process. These filtration processes are not perfect, however, and can allow water through under certain conditions. That situation may result from incoming natural gas having an unusually high concentration of water in it beyond what the filtration was designed to remove. In this case, the filtration system may be working properly but just be unable to keep up with the amount of contamination, resulting in water slipping by. Alternatively, a filtration system may be approaching the point where consumable parts need to be replaced or maintenance needs to occur. When this happens, the system may not be running at its normal efficiency and, again, water may find its way into the fractionation process.

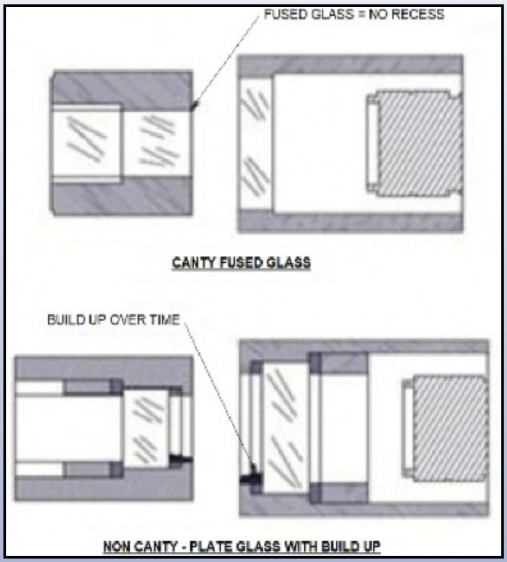
When free water does make it downstream of the filtration system, it can cause equipment to run less efficiently or even cause serious damage. This then results in product that is out of specification. The combination of these things leads to higher maintenance costs, lower throughput through the process, and decreased revenue.

It is clear that it is important to measure the amount of free water in the NGL entering the fractionation process, but it is also critical to make sure that the measurement is being done directly inline. If measurements are made by taking samples to a lab, there is a time delay between when the samples are taken to when the analysis is complete and data reported. Even worse, solubility of water in NGL changes substantially with temperature and pressure. By taking samples out of the line, both of these parameters are changing, making it difficult to impossible to know if the results are truly representative of what is going on inside of the process. There are not many technologies available to quantify the amount of water in NGL. Of those technologies, only CANTY's Inflow can be used to reliably measure it inline.

The Canty Inflow works on the premise of dynamic imaging. It is installed in line with process flowing directly through it. As particles or droplets are detected, the Inflow will quantify the size and concentration of the contamination and output these values as tags to a control system. Since the technology evaluates 2-dimensional images, the software can determine the morphological shape differences between solids, gas bubbles, and water droplets, allowing it to analyze each of them concurrently while reporting them independent of one another. This prevents false readings and provides visual verification of all measurements. The system can then be set up to alert personnel of the problem and even automatically begin measures to mitigate the situation.

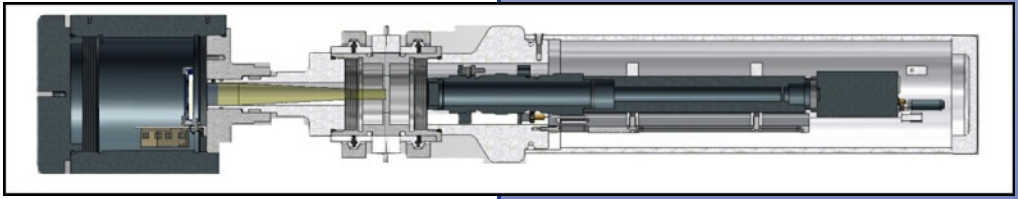
Inflow Hardware

The hardware involved in CANTY's Inflow includes 4 main key technologies: the flow cell, lighting, camera optics, and Vector Control Module (VCM).



The flow cell on an Inflow is designed to mount directly inline for pipe sizes under 3". For any line sizes 3" or greater, CANTY has developed their Short Loop Sampler which pushes a representative portion of process fluid up through the analyzer and returns it back to the process through a single connection on the pipe, keeping the analyzer directly online. Critically, the flow cell seals the light and camera from the process using CANTY's fused glass technology. This fused glass barrier, unique to CANTY, can sustain extremely high temperatures and pressures while still allowing for a view into the process. Unlike with other analyzers, this fusion of metal to glass creates a hermetic seal and does not utilize gaskets or O-rings at the glass interface that the camera and light look and shine through. That smooth surface doesn't leave any crevices and makes it difficult for contaminants to stick to or build up on the surface of the glass.

CANTY always says that there are three keys to a perfect image: lighting, lighting, and lighting. CANTY has been leading the industry and innovating in process lighting since the early 1970's and applies all of that knowledge to the Inflow analyzer. The LED light used is the brightest in the industry with a guaranteed lifetime of 5+ years of continuous operation. Unlike many other analyzers, the light in the Inflow back-lights the process, resulting in sharp, crisp images of each in-focus particle.



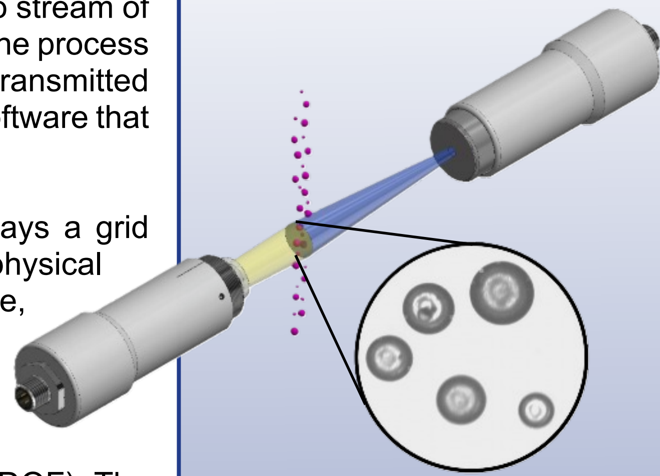
The camera optics used in each Inflow are high resolution gigabit Ethernet CCD's that undergo significant testing to ensure they will be robust for long-term use. Optics are always improving, so CANTY is constantly evaluating the latest and greatest cameras and lenses to provide the highest quality images without compromising on quality and reliability of the analyzer. Optics used in any given analyzer are picked according to the requirements of the application. The latest generation of optics used in the Inflow utilize a 4K resolution camera that can pick up on particles, bubbles, or droplets as small as 1μm.

Obtaining a high-quality image of a process is only half of the battle. The magic happens when that image is processed on CANTY's VCM. The VCM platform is a series of powerful processors that host the CantyVision software. These machines are configured with the analyzers at the factory prior to shipping to make obtaining an image plug-and-play out of the box. In an age of remote connections, the VCM's have the ability for users to allow CANTY personnel to remotely access the unit to provide support and help troubleshoot the analyzers. These units also provide the outputs to interface the data tags with a user's control system.

How Dynamic Imaging Works

Dynamic imaging makes use of image analysis on a video stream of microscopic images. CANTY's Inflow captures images of the process fluid and potential contaminants. These images are then transmitted back to a Vector Control Module (VCM) which hosts the software that performs the analysis.

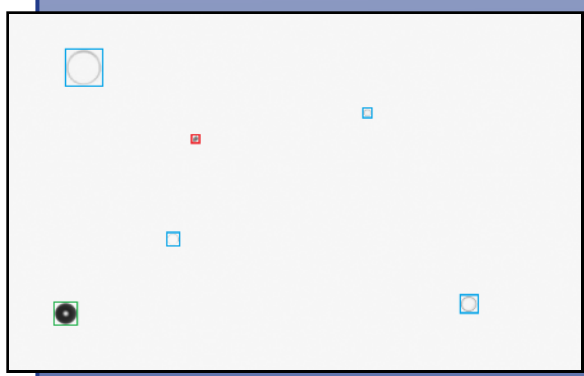
The analyzer is calibrated by installing a tool that displays a grid pattern on the camera. This grid is used to determine the physical distance that each pixel represents on the camera image, what CANTY refers to as the pixel scale factor (PSF). This is typically reported in μm/pixel. Knowing the PSF, the 2-dimensional area of each frame can be calculated.



The lens utilized in an Inflow has a known depth of field (DOF). The DOF is a measurement of the depth in which subjects, such as the droplets in a fluid, are in focus. This now allows CANTY to measure the volume of each image taken in which droplets are in focus.

On each image, the CantyVision software determines what might be a "particle" from what is the background fluid. At this stage, the "particle" could be anything - a solid, droplet, or bubble. After finding something that could be a particle, the software next makes a measurement that grades whether or not the particle is in focus. If it is in focus, then this particle is within the depth of field of the lens used. That means it should be included in the analysis. If a particle is not in focus, it is thrown out.

Each type of particle, solids, droplets, and bubbles, look morphologically different from one another. These differences are captured, numerically, in the various shape factors measured. The software is trained via AI to recognize the trends in these shape factors belonging to each type of particle. This is key because it allows CANTY to distinguish between different kinds of particles that were captured in the same analysis and quantify measurements for each class of particle differently.

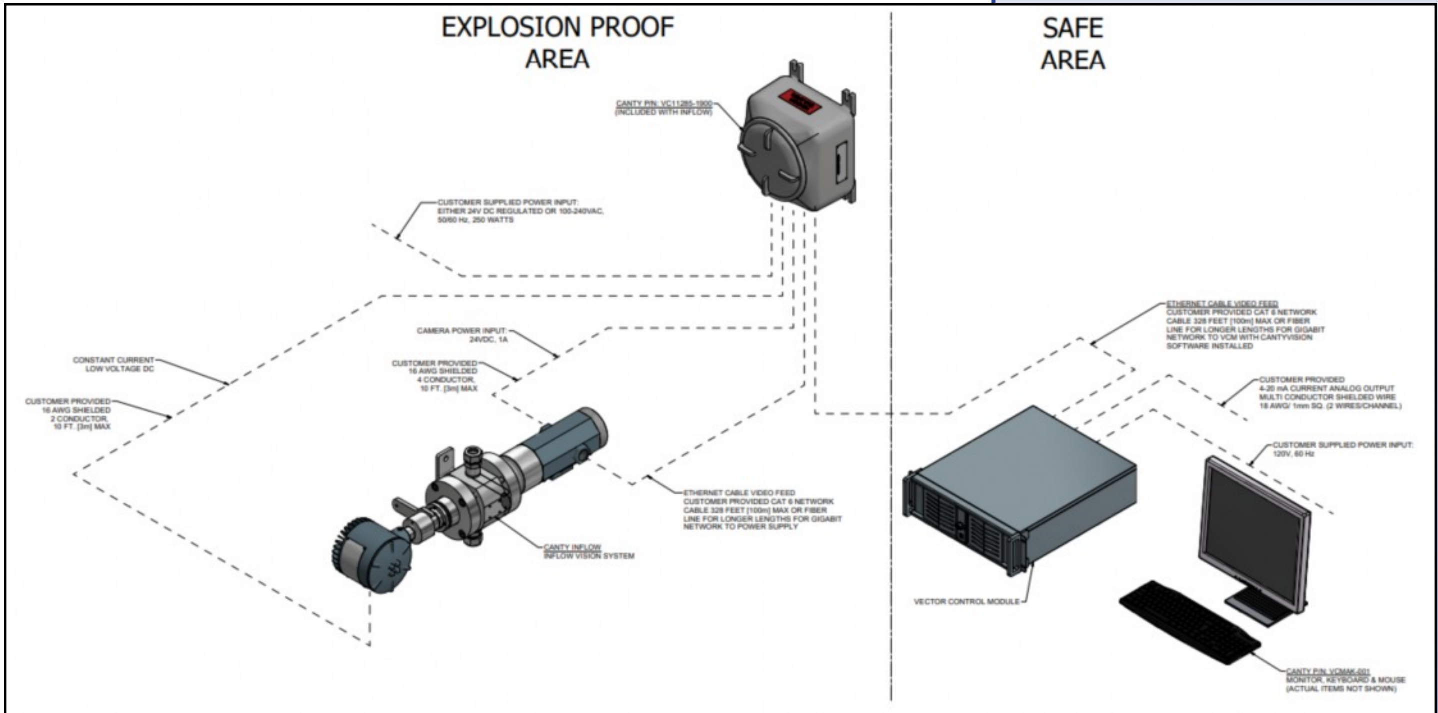


After a particle has been sorted into its correct class, the software calculates a volume of that particle based on its class. Since we already have the volume of each image being analyzed, the concentration of any given class of particle can now be calculated on a volumetric basis and can be converted into a mass concentration using the bulk density of the particle class in question.

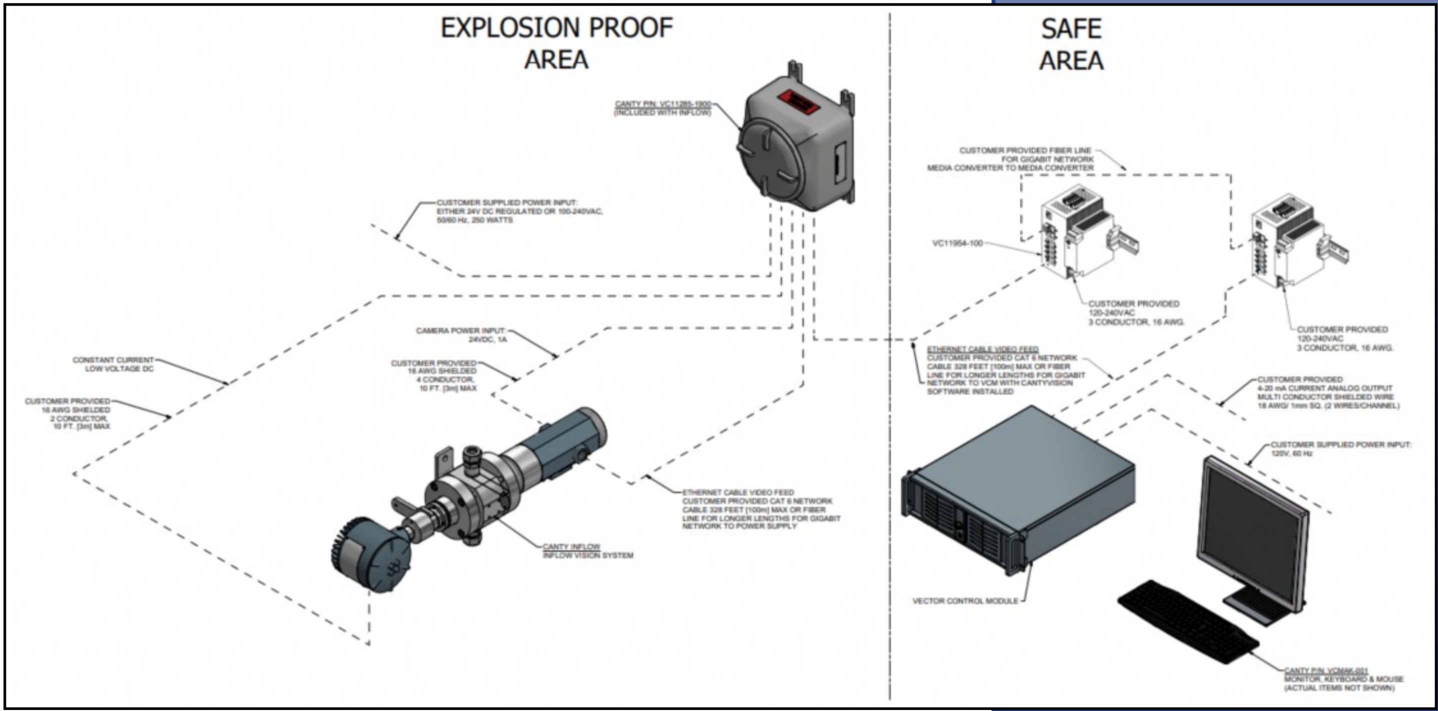
By averaging over hundreds of images, the Inflow is able to provide a representative concentration and particle size distribution for each particle class analyzed. Additionally, if there is ever skepticism about the reading, the images from the analyzer can be viewed live and/or saved as a recording for reference. This provides proof of a measurement and confidence in the analyzer that no other device provides.

Connectivity

Due to the amount of data being transmitted between the Inflow and VCM, CANTY requires the use of CAT6 Ethernet running from the analyzer to it’s power supply and from it’s power supply back to the VCM. A typical layout of the components can be seen here.



CAT6 Ethernet, however, has a distance limitation of 100m before there is signal loss that can interrupt analysis. In those situations, it is possible to convert the CAT6 Ethernet to fiber via CANTY’s media converters. Refer to document TA11950-1024. Using this method, it is possible to run a fiber line up to 10km between the analyzer’s power supply and then VCM. In this case, a typical layout of the components will look like the following.

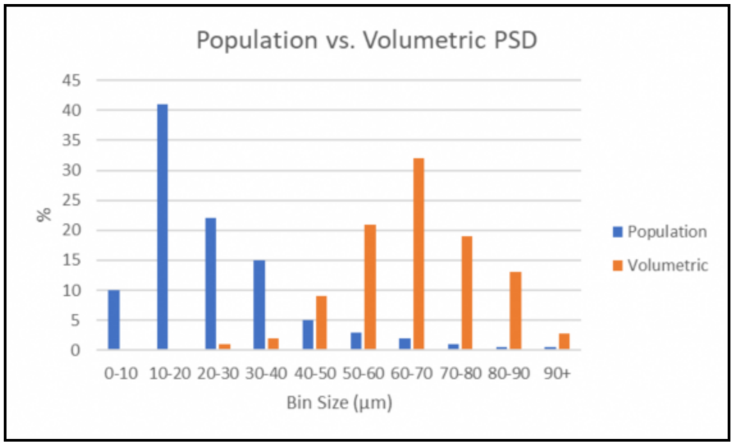


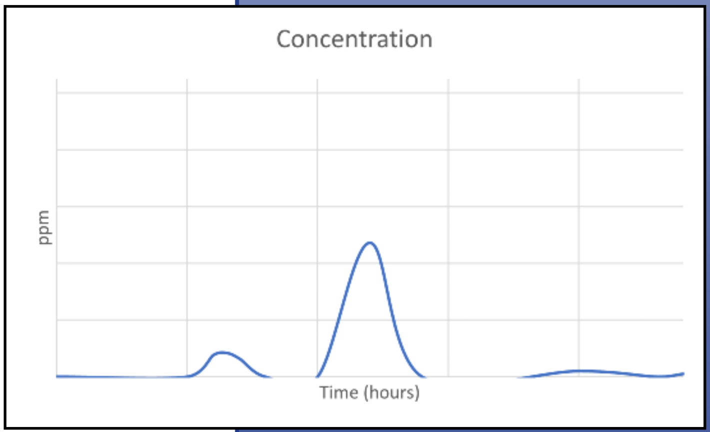
Data Outputs

When free water is measured, it is critical that as much information as possible is learned as quickly as possible. The Canty Inflow will provide:

- Concentration of free water, solids, and/or gas present in the NGL. This is directly measured by the analyzer as a volumetric concentration and can be converted into a mass concentration using density.
- Size distribution of the contaminants. The size distribution of the droplets may indicate why they are not being filtered out upstream and can guide how to separate it now that it has been detected.
- Count of contaminants seen per volume of process fluid. Combined with the size and concentration, this information will help give an idea of how the water is distributed in the NGL

These outputs are in addition to generic system health alarms that would indicate if there is a problem with the analyzer, such as camera temperature and communication signals. Each of these outputs can be trended over time in a data historian to monitor the change in concentration of the contaminants and provide historical context. To communicate between the analyzer and your control system, outputs including OPC UA, Modbus TCP/IP, Modbus RTU, and Analog (4-20mA) are available. Reference the VCM brochure, TA12100-1012, which outlines the available communication methods for each VCM.





Conclusion

CANTY's Inflow analyzer is an effective tool for the measurement of free water and other contaminants in NGL. It is installed directly inline, begins measuring particles and droplets at very small sizes and low concentrations, and has multiple outputs that can help inform an appropriate response to the situation. This will result in improved response times to water contamination, reduce down time and maintenance costs, and help to keep the end products within their specifications.

Get more information!
Website: https://www.jmcanty.com

North America
JM Canty, Inc.
6100 Donner Road
Buffalo, NY, United States
+1 (716) 625-4227
sales@jmcanty.com
techsupport@jmcanty.com

EU & International
JM Canty International, Ltd.
Ballycoolin Business Park
Blanchardstown
Dublin 15, D15 KV02, Ireland
+353 (1) 882-9621
+353 (1) 882-9622
Sales.ie@jmcanty.com
Techsupport.ie@jmcanty.com

Thailand Office
JM Canty Thailand Office
Phuket, Thailand
+66 83 9689548
Sales.ie@jmcanty.com
Techsupport.ie@jmcanty.com