API Separator

Monitoring and Control

Optimizing API Separator Performance Through Dynamic Imaging

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API separators are critical devices for water treatment in industries such as oil refineries and petrochemical plants. These separators remove oil and suspended solids from the water stream before it is further processed downstream. The outlets of the separator, which are for solids, water, and oil, as well as the baffle where oil flows above, need to be monitored in order to ensure a sufficient separation is occurring. Currently, the separator is monitored by observing flow behavior changes and taking samples to analyze the concentration of the outlets. These are tedious methods prone to errors and do not give a true representation of the performance of the separator, making it difficult for process optimization.

This paper explores the application of CANTY's dynamic imaging technology to monitor and optimize the performance of an API separator. CANTY's field deployable systems monitor various points of the separator in real time while providing visual verification to operators without having to step foot in the field. Using CANTY's software, detailed analysis of each of the inlet and outlet streams is given, providing quantitative data to indicate the separation efficiency. Furthermore, an interface camera system can be installed at the baffle to provide visuals of the water and oil interface. These systems can be utilized to make real-time adjustments to the process to optimize the separation in a produced water stream.

CANTY PROCESS TECHNOLOGY — VISION WITHOUT LIMITS

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Introduction

Produced water is water that is brought to the surface as a byproduct during drilling for oil and gas. The composition of produced water includes oil, solids, chemicals added during drilling, etc. Since the volume of produced water can be significant compared to the pure oil produced, it is critical to be able to manage this stream.

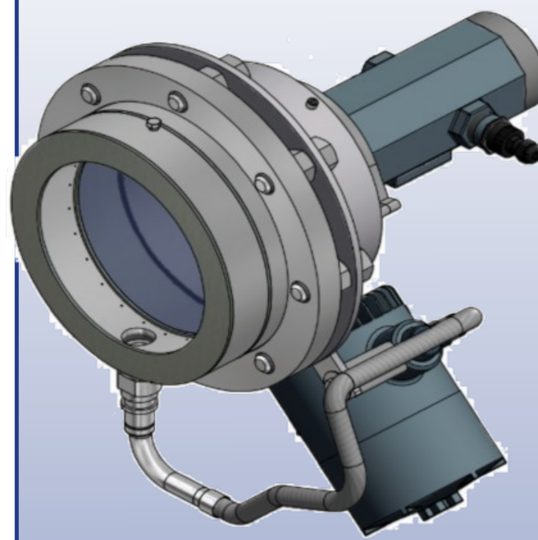
Produced water streams have a variety of ways to be discharged, with each way requiring the stream to be cleaned up from its oil and solid constituents. One option is to discharge the stream into surface water bodies such as rivers and oceans. To do this, the produced water stream needs to meet regulatory standards to minimize the environmental impact.

Another discharge option is the re-injection of produced water and seawater. Re-injection is used to maintain pressure in the well, which correlates to maintaining flow rate and stability within the well. Oil and solids can clog the reservoir and lead to damage of the well, meaning it is critical to be able to analyze the constituents of the produced water stream.

The application of imaging technology to measure the oil & TSS in water as well as the interface between oil and water requires both hardware that produces continuous, high quality images as well as software capable of analyzing those images. Taken together, these provide operators and engineers with reliable and unbiased data that can be used for process optimization.

Overview of API Separators

API separators are devices designed to remove oil and free solids from produced water and wastewater streams. The difference in densities between the solids, water, and oil cause them to separate into distinct phases. This works on the principle of Stokes law, which describes the settling or rising velocity of particles based on their density and size. Solids are the most dense and settle on the bottom of the vessel, where they can be discharged. Oil droplets, the least dense compared to solids and water, rise to the surface. The oil then flows over a baffle where it is separated from the water. To determine the separation efficiency, it is crucial to monitor the interface and the compositions of the outlet streams. These results can then be used to adjust certain process parameters such as flow rate and residence time to optimize the process.



Traditionally, there are many different ways to determine the separation efficiency within an API separator. One way is to monitor the position of the interface, which is commonly done through devices such as float level indicators, which feature a mechanism to transmit the floats position. However, these devices face problems with fouling that may lead to inaccurate readings. Also, the float may get stuck in the emulsion layer, again leading to an inaccurate reading. If a sight glass is present at the interface level on the vessel, operators will step into the field to look through it to verify the interface position. This is a subjective technique that is prone to human error. Furthermore, the operator would have to be constantly monitoring the interface level to see if any changes occur in order to adjust key process parameters in live time.

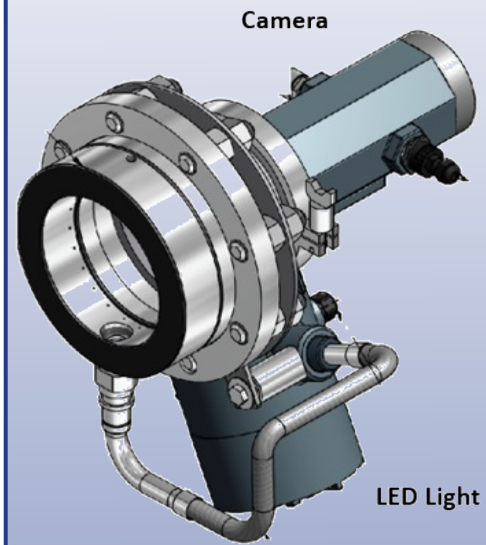
Another traditional method to evaluate the performance of an API separator is to take manual samples at different streams of the separator and analyze these for oil, water, and solids. For oil in water measurement, solvent extraction techniques are typically used. A solvent is used to dissolve the oil, which is then collected, where the solvent is then evaporated off to leave behind the oil for analysis. Total suspended solids are measured using gravimetric techniques, which include filtration, drying, weighing, and calculating the concentration of solids. Both of these methods are tedious, labor intensive, and prone to errors.

A better option for ensuring an efficient separation is to integrate CANTY's dynamic imaging technology. The interface camera can retrofit to an existing sight glass, and the Inflow analyzers can be installed directly in line. These systems include a light source, camera, and Vector Control Module (VCM). Real-time, high quality images are produced and analyzed via software. For the interface system, the position of the oil and water interface is output. For Inflows, the concentration of oil in water or water in oil is output, including droplet sizes, which have a major impact on the raising velocity. Results are reliable and repeatable, and a person can look at the video, either live or a recording, to provide visual verification of the system.

API Separators Camera Systems Hardware

The hardware involved in CANTY's Interface control systems include 3 main key technologies: the camera, lighting, and Vector Control Module (VCM).

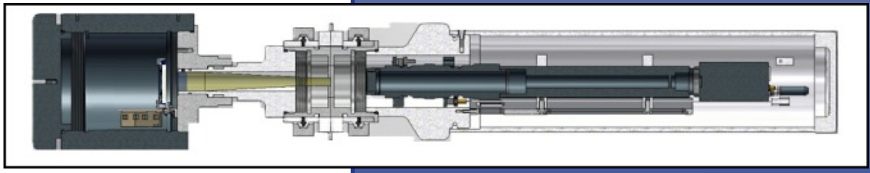
The cameras used in every CANTY system are high resolution gigabit Ethernet CCD's that undergo significant testing to ensure they will be robust for long-term use. Optics are always improving, so CANTY is constantly evaluating the latest and greatest cameras and lenses to provide the highest quality images without compromising on quality and reliability of the system. The housing that the camera is contained in is also critical to ensuring the longevity of the system. All cameras are housed in enclosures that are weatherproof and rugged, designed to last. One of the keys to this design is CANTY's fused glass technology, which serves as the protective glass barrier that the camera optics look at the process through. Fused glass is a technology unique to CANTY that provides larger, safer views into processes.



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 1970's and applies all of that knowledge in their interface control systems. The LED light used is the brightest in the industry with a guaranteed lifetime of 5 years. While not required for every interface control system where existing lighting may be sufficient, CANTY consistently finds that customers prefer to replace their existing light sources with CANTY lights both to optimize their image, but also because the lights are maintenance free and typically far exceed their guaranteed 5 year lifetime. In this specific application, 90 degree angled lighting is introduced to highlight the color differences between the phases.

Vector Control Module

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 camera systems 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 analyzers also provide the outputs to interface the data tags with a user's control system.



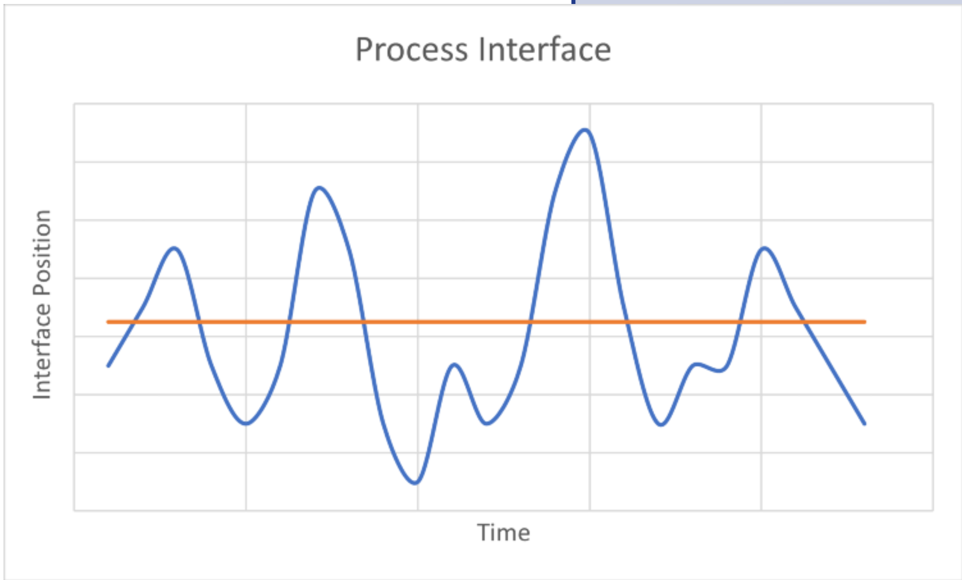
The hardware involved in CANTY's Inflow contains the three technologies of the interface system along with a flow cell. The flow cell is designed to mount directly inline for pipe sized under 3". For any sizes 3" or greater, CANTY has developed their short loop sampler which pushes a representative portion of process fluid up through the analyzer and returns it back into the process through a single connection on the pipe. The flow cell seals the light and camera from the process using the aforementioned fused glass technology.

How Dynamic Imaging Works

Dynamic imaging makes use of video images coming from CANTY's camera systems. The captured images are transmitted back to a Vector Control Module (VCM) which hosts the software that performs the analysis. The subsections below describe how image analysis works for both the interface camera system and Inflow, which can both be utilized on an API Separator.

Interface Camera System

For every image that comes into the VCM, the software looks through the image within an area of interest to identify where there is an interface using a combination of edge detection and pattern matching. While those algorithms work well for a majority of processes out of the box, users can also teach the software the types of interfaces that they want to track so that it can be trained for their specific application.

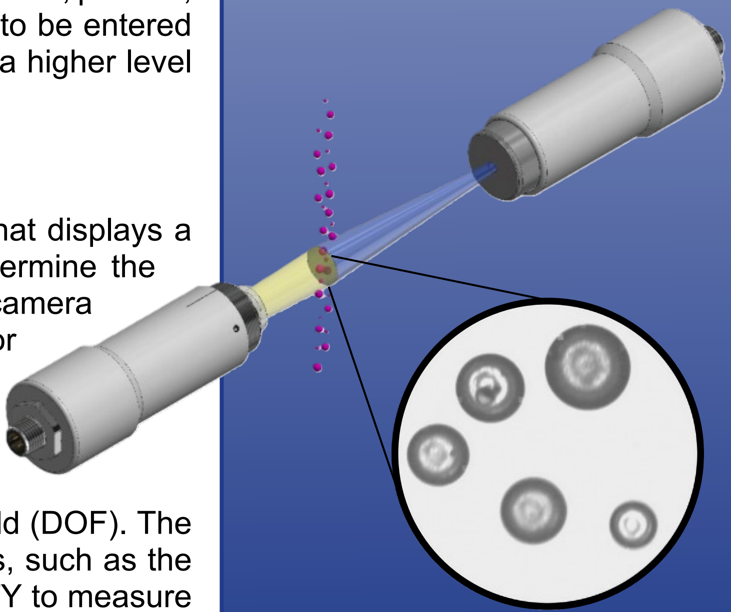


Once an interface has been detected, the software then calculates the position of that interface in pixels, converts it into a real-world value, and outputs that value via a number of different available control signals.

The calibration of the system is done based on the needs of the user. The raw measurements comes in as a position measured in pixels. Each pixel can be calibrated to reference a distance, volume, percent, etc… This requires a minimum of 2 calibration points to be entered into the software, though more are recommended for a higher level of accuracy.

Inflow Camera System

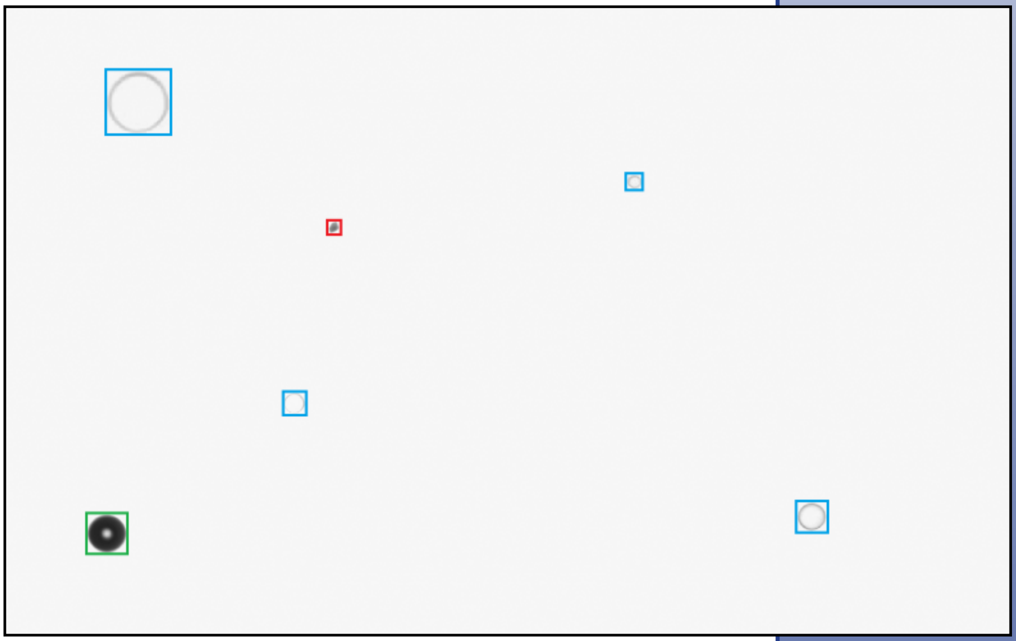
The Inflow analyzer is calibrated by installing a tool that displays a grid pattern on the camera. This grid is used to determine the physical distance that each pixel represents on the camera image, what CANTY refers to as the pixel scale factor (PSF). This is typically reported in μm/pixel. Knowing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

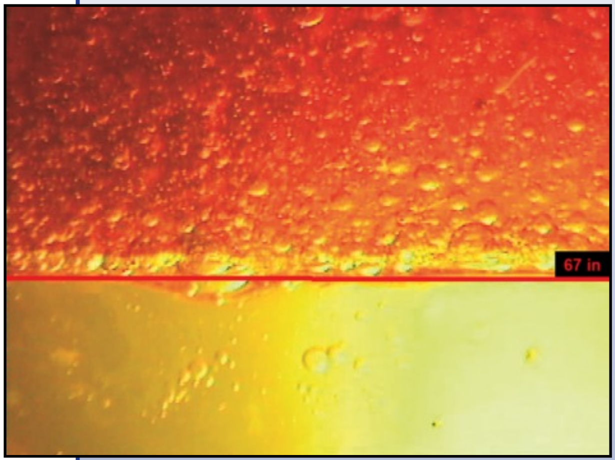
By averaging over hundreds of images, the Inflow is able to provide a representative concentration and particle size distribution for each particle class analyzed. Additionally, if there is ever skepticism about the reading, the images from the analyzer can be viewed live and/or saved as a recording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

Data Outputs

Outputs from the interface system include the following:

- Calibrated Interface Position/Volume/Percent

This is the main measurement that the system is making, typically output as a calibrated value.



Outputs of the Oil in Water Inflow systems will include the following (For water in oil, the opposite outputs):

- Concentration of oil, total suspended solids, and/or gas present in the water stream. 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 droplets and solids. The size of the droplets have a major impact on the raising velocity of oil droplets, leading to changes in separation efficiency
- Count of contaminants seen per volume of process fluid.
-

The troubleshooting outputs of both systems include:

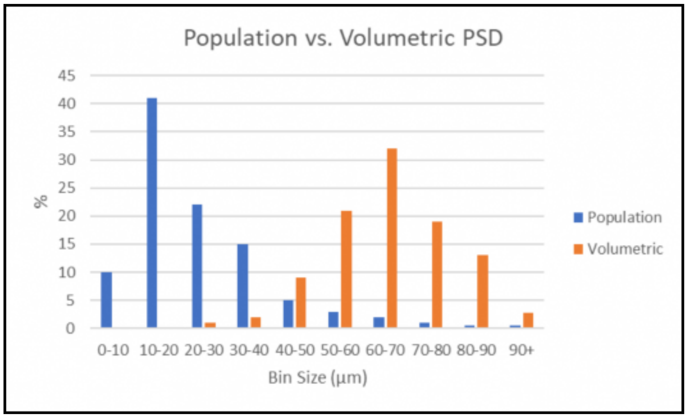
- Camera Temperature

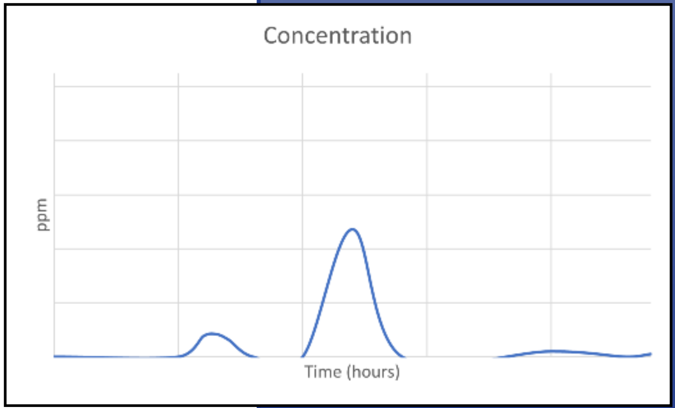
This is the onboard temperature of the camera. (Think of this as a computer CPU temperature, but for the camera electronic.)

- Camera Heartbeat

This is a boolean that indicates if the camera communication is interrupted, acting as a generic trouble alarm.

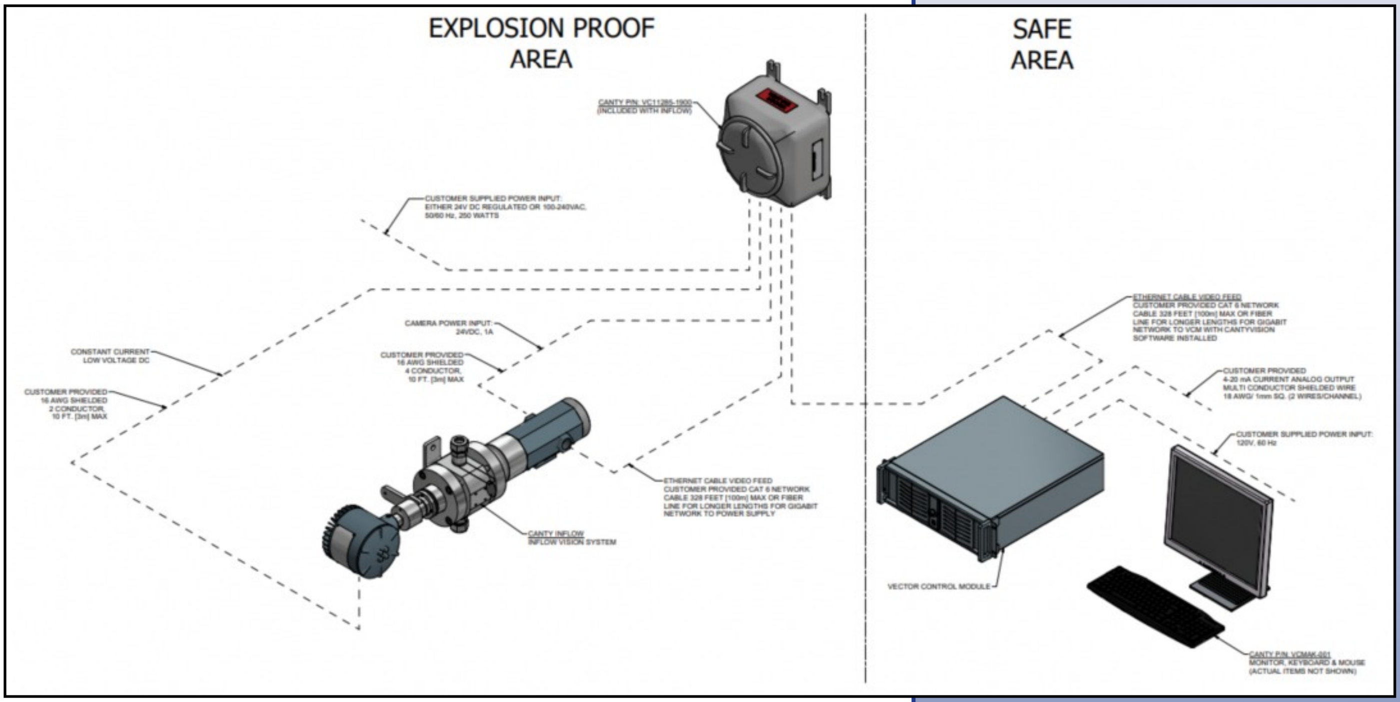
Each of these outputs can be trended over time in a data historian to monitor the process and provide historical context. To communicate between the analyzer and your control system, outputs including OPC UA, Modbus TCP/IP, Modbus RTU, and Analog (4-20mA) are available. Reference the VCM brochure, TA12100-1012, which outlines the available communication methods for each VCM.



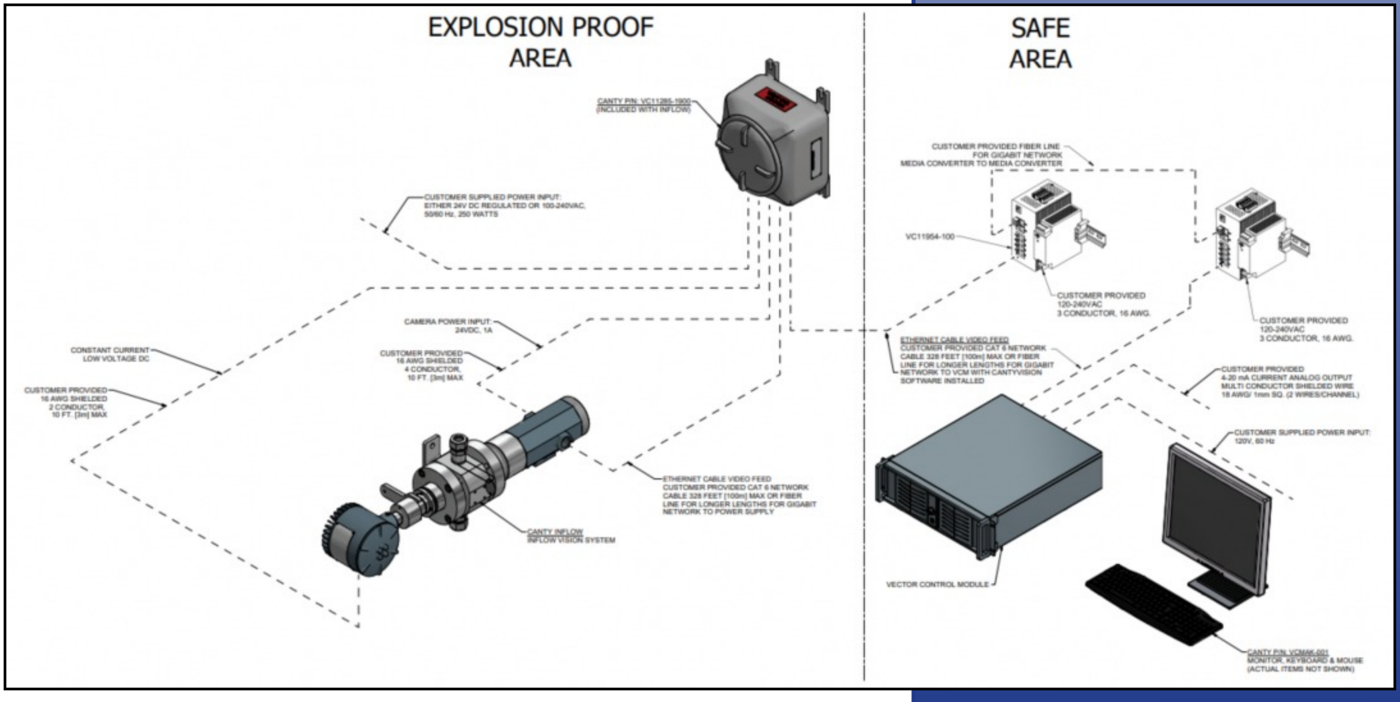


Connectivity

Due to the amount of data being transmitted between the analyzer 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 for an Inflow.

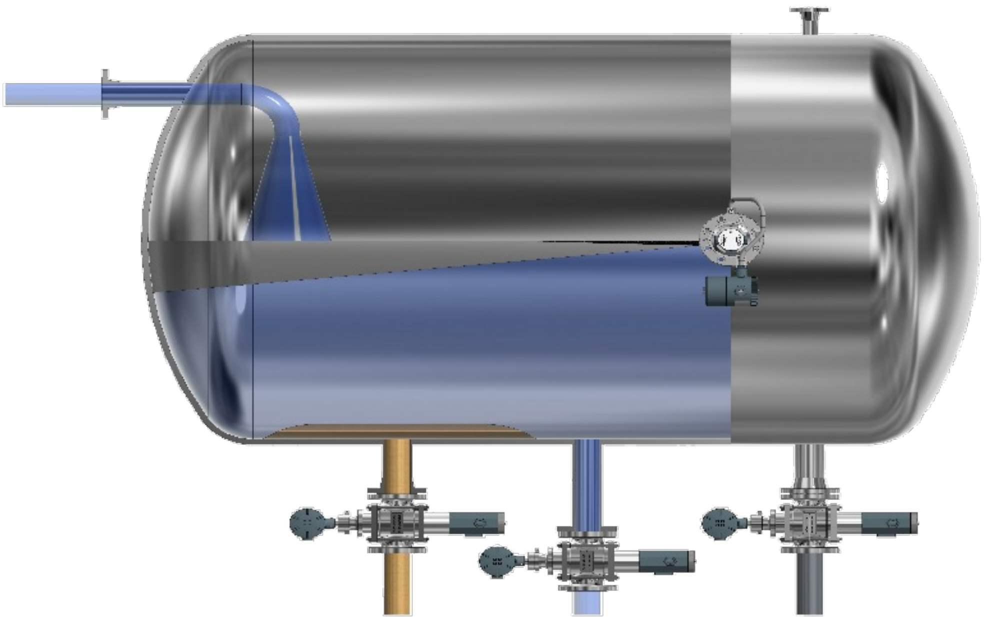


CAT6 Ethernet, however, has a distance limitation of 100m before there is signal loss that can interrupt analysis. In those situations, it is possible to convert the CAT6 Ethernet to fiber via CANTY's media converters. Refer to document TA11950-1024. Using this method, it is possible to run a fiber line 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.



Conclusion

CANTY's API Separator camera systems are a powerful way to ensure the separator is working as intended. Analyzers can mount at various points of the separator to monitor its performance and make necessary process adjustments to maximize its efficiency. The ability to analyze the outlet streams for oil and solids concentration as well as the oil and water interface level in real time provide many advantages over traditional methods to monitor the separator. This provides repeatable and reliable control that is backed by video that provides visual verification of all the measurements.



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