Panametrics
a Baker Hughes business

flare.IQ

Generation 2

Operation and Maintenance Manual

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panametrics.com

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Services

Panametrics provides customers with an experienced staff of customer support personnel ready to respond to technical inquiries, as well as other remote and on-site support needs. To complement our broad portfolio of industry-leading solutions, we offer several types of flexible and scalable support services including: Training, Product Repairs, Service Agreements and more.

Please visit https://www.bakerhughes.com/panametrics/panametrics-services for more details.

Typographical Conventions

Note: *These paragraphs provide information that provides a deeper understanding of the situation, but is not essential to the proper completion of the instructions.*

IMPORTANT: These paragraphs provide information that emphasizes instructions that are essential to proper setup of the equipment. Failure to follow these instructions carefully may cause unreliable performance.

CAUTION! This symbol indicates a risk of potential minor personal injury and/or severe damage to the equipment, unless these instructions are followed carefully.

WARNING! This symbol indicates a risk of potential serious personal injury, unless these instructions are followed carefully.

Safety Issues

WARNING! It is the responsibility of the user to make sure all local, county, state and national codes, regulations, rules and laws related to safety and safe operating conditions are met for each installation.

Attention European Customers!To meet CE Mark requirements for all units intended for use in the EU, all electrical cables must be installed as described in this manual.

Auxiliary Equipment

Local Safety Standards

The user must make sure that he operates all auxiliary equipment in accordance with local codes, standards, regulations, or laws applicable to safety.

Working Area

Auxiliary equipment may have both manual and automatic modes of operation. As equipment can move suddenly and without warning, do not enter the work cell of this equipment during automatic operation, and do not enter the work envelope of this equipment during manual operation. If you do, serious injury can result.

WARNING! Make sure that power to the auxiliary equipment is turned OFF and locked out before you perform maintenance procedures on this equipment.

Qualification of Personnel

Make sure that all personnel have manufacturer-approved training applicable to the auxiliary equipment.

Personal Safety Equipment

Make sure that operators and maintenance personnel have all safety equipment applicable to the auxiliary equipment. Examples include safety glasses, protective headgear, safety shoes, etc.

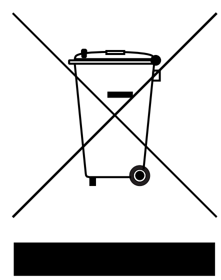
Unauthorized Operation

Make sure that unauthorized personnel cannot gain access to the operation of the equipment.

Environmental Compliance

Waste Electrical and Electronic Equipment (WEEE) Directive

Panametrics is an active participant in Europe's *Waste Electrical and Electronic Equipment* (WEEE) take-back initiative, directive 2012/19/EU.



The equipment that you bought has required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment.

In order to avoid the dissemination of those substances in our environment and to diminish the pressure on the natural resources, we encourage you to use the appropriate take-back systems. Those systems will reuse or recycle most of the materials of your end of life equipment in a sound way.

The crossed-out wheeled bin symbol invites you to use those systems.

If you need more information on the collection, reuse and recycling systems, please contact your local or regional waste administration.

Please visit www.bakerhughesds.com/health-safety-and-environment-hse for take-back instructions and more information about this initiative.

Chapter 1. General Information

Chapter 2. Hardware

Chapter 3. Software

Chapter 4. Installation & Maintenance

Chapter 1. General Information

1.1 Introduction

This manual contains information about the installation, operation, and maintenance of the flare.IQ Gen 2 hardware and software system. Proprietary flare control and in situ flare flow meter validation software is installed on a rack-mounted assembly of industrial embedded automation computers. flare.IQ also implements real-time flare combustion efficiency (CE) and destruction and removal efficiency (DRE) monitoring based on a parametric model derived from empirical data and computational fluid dynamics (CFD) calculations. Hence, the flare.IQ Gen 2 is a complete turnkey hardware and software flare control solution that enables regulatory compliance along with increased efficiency and reduced operating costs. The flare.IQ system offers three major features to monitor and control both assisted (downstream) and un-assisted (upstream) flaring - flare control (FC), digital verification (DV) and predictive emissions monitoring (PEMS).

1.2 Application

flare.IQ is an online control computer that receives inputs and sends outputs to the flare operator's Distributed Control System (DCS) via Modbus TCP to control an assisted flare's fuel gas and steam/air assist supply valves (see Figure 1). The software algorithm in flare.IQ uses the sound speed measured by an ultrasonic flow meter to calculate the molecular weight of the flare gas, and from the molecular weight, the Net Heating Value (NHV) is determined. Supplemental fuel gas demand and steam/air assist demand are then calculated based on current net heating values, hydrocarbon molecular weight and flare vent gas flow.

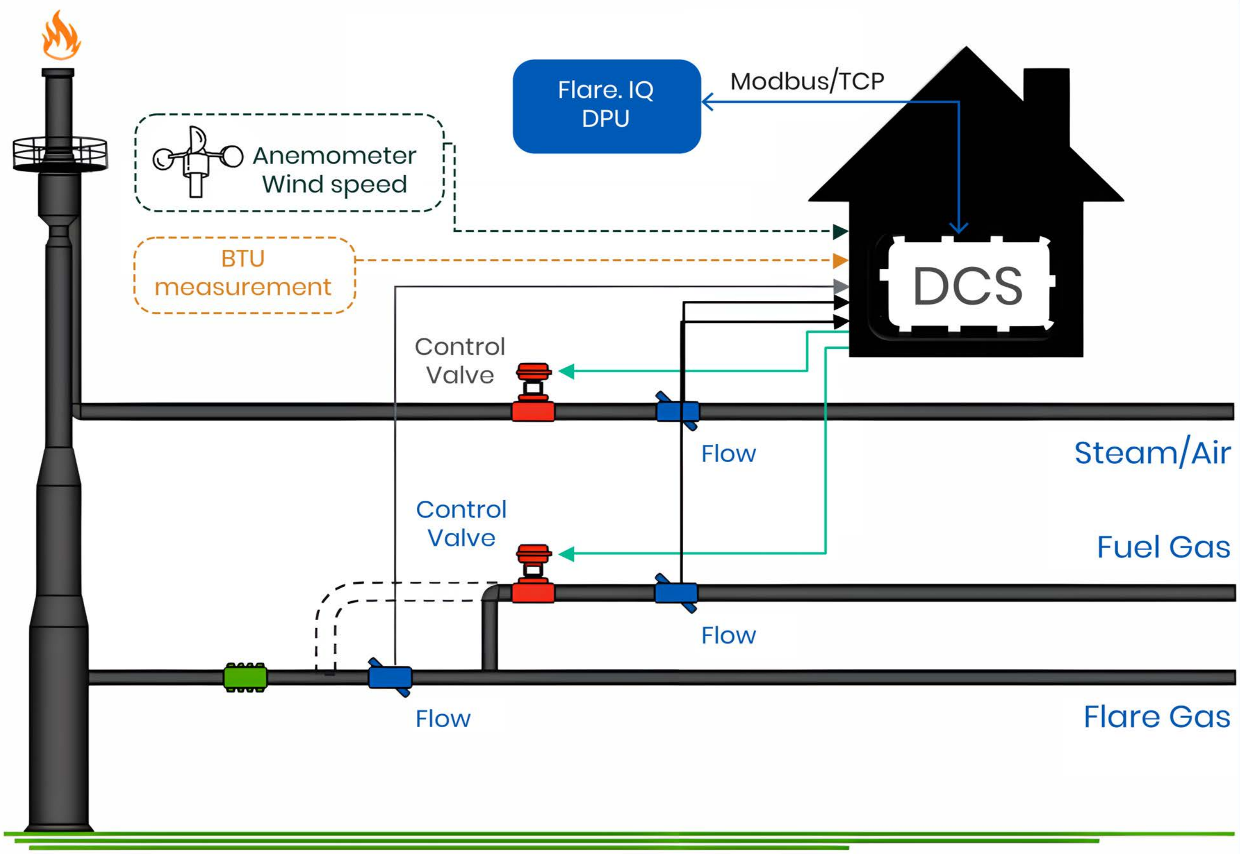


Figure 1: Schematic of flare.IQ-based control of flare assist (Steam/Air) and supplemental fuel

The flare.IQ is also capable of Digital Validation of an ultrasonic flow meter installed on the vent gas line either on a pre-determined schedule or on demand. This Digital Validation algorithm uses measured vs. calculated speed of sound based on an independent vent gas BTU and/or composition analyzer such as a Gas Chromatograph or Mass spectrometer. It also utilizes a variety of meter diagnostics such as signal strength, transit times, path length, and difference in channel velocities to validate the accuracy of the ultrasonic flow measurement.

The third and most recent feature of the flare.IQ system is in situ flare CE and DRE monitoring based on a parametric model derived from flare CE experimental data and CFD calculations. This PEMS feature can be deployed on both un-assisted upstream flares and assisted downstream flares to achieve maintenance-free, real-time monitoring of CE/DRE based on process and environmental conditions derived from flare flow and wind speed measurement.

1.3 Equipment Overview

The system hardware includes two 19" rack mounting sheet metal modules that house compact fanless Digital Processing Units (DPU), redundant power supplies, a pair of Ethernet switches and other power distribution equipment and cables. The top power distribution and networking module is shared with up to six DPU modules installed in the bottom module (Figure 2). A single DPU module is configured to control a single flare stack while a second DPU module loaded with identical firmware and settings provided for redundancy. However, a single DPU is adequate for digital verification of a single flare flow meter given the relatively low frequency of this procedure. Similarly, a single DPU is also adequate for CE/DRE monitoring of a single flare, assisted or non-assisted. The redundancy option might become necessary for flare PEMS as well in case flare.IQ becomes part of a fiscal measurement, custody transfer or carbon tax monitoring system in the future. For example, if a customer site has two flare stacks that need to be controlled, one power distribution and network (top) module and a bottom module with four (4) DPUs installed would be required. The power distribution and networking module weighs 8.65 lbs. (3.92 kg) and the bottom DPU module with the maximum number (6) of DPU's installed weighs 8.55 lbs. (3.88 kg).

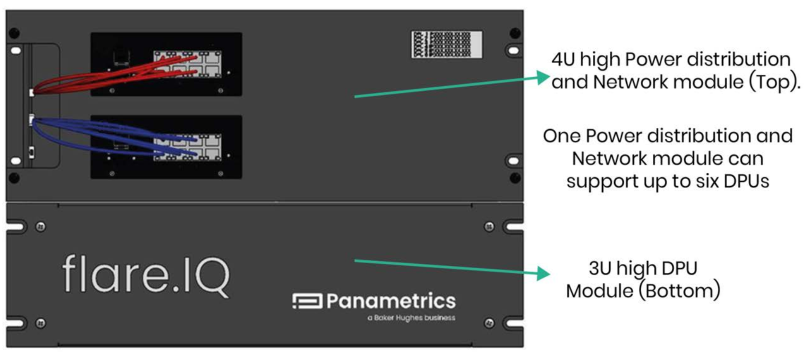


Figure 2: Front view of Rack mounted Control equipment

<u>WARNING!</u> A disconnect power switch is required to be installed within 30" (2.5 feet) of the rack-mounted panels.

<u>WARNING!</u> To ensure the safe operation of this unit, you must install and operate the flare.IQ as described in this user's manual. In addition, be sure to follow all applicable safety codes and regulations for installing electrical equipment in your area.

1.4 Equipment Installation

Users typically install the flare.IQ Gen 2 inside an industrial control room that may include a plant distributed control system (DCS), which controls multiple flare system components such as flare, purge and assist (steam/air) flow meters, valves, online BTU analyzers (e.g. gas chromatographs, calorimeters) and temperature and pressure regulators. It is intended for use in an office environment with adequate temperature and RH controls.

This section contains information and instructions for installing the flare.IQ Gen 2 in a plant (DCS) control room, while considering all the above factors. The flare.IQ Gen 2 system can also be installed on unassisted upstream flares with an ultrasonic flare flow meter and minimal additional control and measurement hardware. Chapter 4 describes in detail how to set up and connect the flare.IQ to the DCS. If you have questions about the installation procedures, contact our technical support department. See the rear cover of this manual for contact information.

Installation shall be in an enclosed rack that requires tool access.

You should discuss environmental and installation factors with a BH applications engineer or field service by the time you receive the hardware. The equipment provided should be suited to your application and installation site. The flare.IQ Gen 2 is available only in a 19" rack-mount version suitable for most indoor installations.

The power connections and power supplies are accessible from the backside of the rack mount panel as shown in Figure 3. The end user brings in a non-detachable power cord per the detailed specifications provided in Section 4.1.

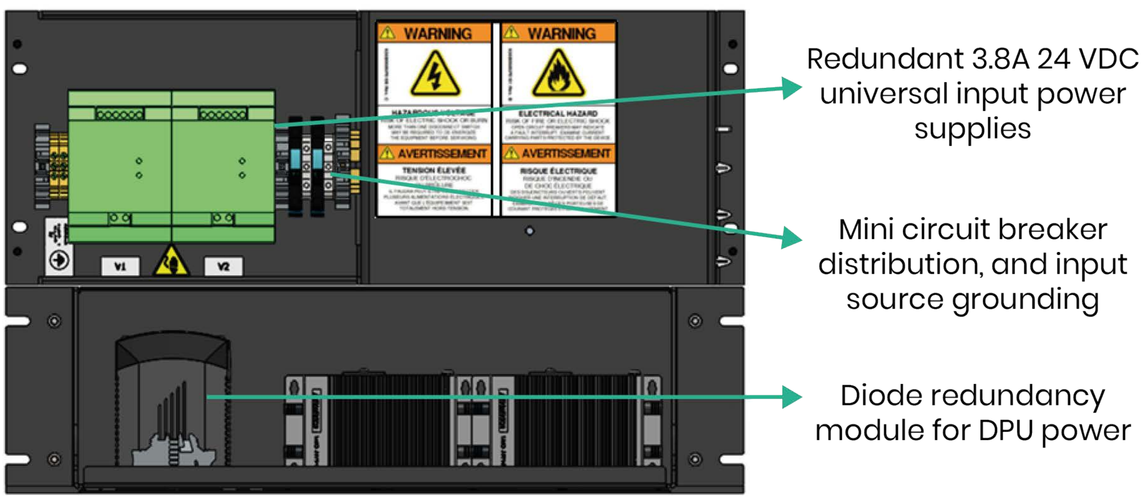


Figure 3: Rear view showing input power connections and power supplies

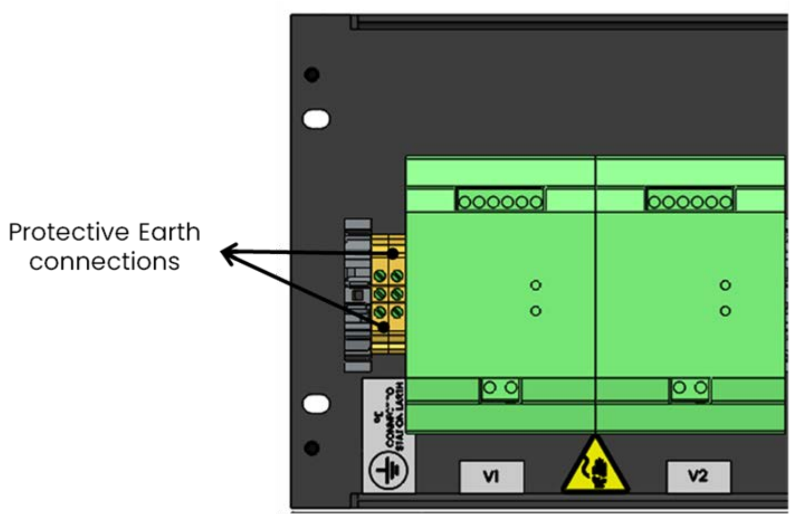


Figure 4: Rear view close-up of top module showing protective earth grounding

Protective Earth ground label

Electrical Shock warning label

System hazardous voltage warning label (English/French)

Figure 5: Description of warning symbol labels applied to the top module

Figure 5 provides a detailed explanation of all the warning symbols and labels applied to the flare.IQ Gen 2 hardware. In addition to following all installation and operation instructions in this User Manual, be sure to follow all applicable safety codes and regulations for installing electrical equipment in your area.

1.5 System Specifications

Installation

- 19" rack mountable (enclosed with tool access), 2 interconnected modules - top (4U) and bottom (3U).
- Flare Control software always comes with redundant DPUs (i.e., 2 DPUs/flare); Digital Verification or PEMS software by itself do not come with redundant DPUs unless combined with Flare Control.

Processor

- Intel Atom® E3815 Single Core 1.46GHz.

Memory

- Onboard 4GB DDR3L 1066 MHz.
- Onboard 32GB eMMC storage.

Connectivity

- One 10/100/1000 Mbps IEEE 802.3u (Ethernet) connection for Modbus TCP/IP.
- One 10/100/1000 Mbps IEEE 802.3u (Ethernet) connection for DPU configuration/monitoring.

Power

- AC configuration: Universal power supply adjusts automatically from 100 to 240 VAC, 50/60 Hz.
- Max power consumption 45 W.
- DC configuration: Not available.

Size / Dimensions

- Top module: 19.02" (483 mm) Width x 6.93" (176 mm) Height X 4.94" (126 mm) Depth
  - Weight = 8.65 lbs. (3.92 kg)
- Bottom Module: 19.02" (483 mm) Width x 5.22" (133 mm) Height X 8.05" (204.5 mm) Depth
  - Weight = 8.55 lbs. (3.88 kg) - with maximum number of DPU's (6) installed

Operating Temperature

- 0°C to +40°C (32°F to +140°F).

Storage Temperature

- -40°C to +70°C (-40°F to +158°F).

Relative Humidity

- 10% - 95% RH @ 25°C, non-condensing.

Maximum Operating Altitude

- 2000 m (6562 ft).

Overvoltage (Installation) Category

- II.

Pollution Degree

- 2.

Ingress Protection

- IP 10 (Protected from touch by hands greater than 50 mm; not protected from liquids).

Warm-up Time

- Meets specified accuracy within 5 minutes of turn-on.

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Chapter 2. Hardware

This section describes the three major components of the flare.IQ Gen 2 system hardware – the Digital Processing Unit (DPU), the network switch and the redundant 24 VDC power supply.

2.1 Main Processor (DPU) – Advantech UNO-2271G

2.1.1 Functional Description

The flare.IQ Gen 2 DPU is based on a highly ruggedized, fan-less, and modular industrial embedded computer. The Advantech UNO-2271G edge gateway shown in Figure 6 supports HDMI display, 2 x GbE LAN and 1 x USB 3.0 interfaces. It is equipped with an Intel® Atom™ processor, 4GB of DDR3L RAM and 32 GB of eMMC solid-state storage.

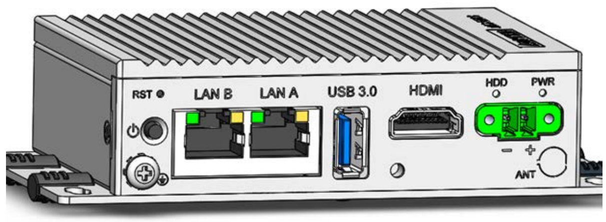

Figure 6: Advantech DPU Front View

The DPU offers the following features:

- Integrated design, single-board architecture, industrial-strength protective shell.
- Intel® Atom™ E3815/E3825 processor with 4GB DDR3L onboard memory.
- 2 x GbE, 1 x USB 3.0, 1 x HDMI.
- Compact fanless design.
- Rubber stopper design with internal reserved screws for 2nd layer assembly.
- 32GB eMMC non-volatile flash memory storage onboard.

2.1.2 Connections

LAN: Ethernet Connector

The DPU is equipped with two Gigabit LAN controllers that are fully compliant with IEEE 802.3u 10/100/1000 Base-T. The two Ethernet ports have standard RJ-45 jacks labeled LAN A and LAN B as shown in Figure 6.

Power Connector

The DPU features a Phoenix Contact connector that is compatible with 10–30 VDC input power shown in Figure 7 on page 7. The added inclusion of reversed wiring protection means reversing wiring of the ground and power lines will not damage the system. Following a forced shutdown, wait 4 seconds before powering on the system. The power connector must then be reconnected.

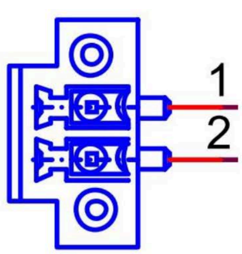

Table: Power Connector Pin Assignments		
Pin	Signal	Description
1	Power IN V+	+ 10 ~ 30 V DC
2	Power IN V(GND) -	

Figure 7: Phoenix Contact input power connector

USB Connector

A USB 3.0 type A connector that supports plug-and-play functionality is provided to enable service personnel to plug in a keyboard if required. The USB interface can be enabled/disabled in the system BIOS. A silicone rubber dust plug is provided to increase protection of the DPU during regular operation.

HDMI Connector

An HDMI type A connector is provided for the attachment of a monitor display for use by service personnel if required. A silicone rubber dust plug is provided for this port as well to protect the DPU during regular operation.

RTC Battery Specification

The DPU is equipped with a real-time clock (RTC) Battery to ensure that the BIOS and system clock settings are retained even when the power is disconnected.

- Type: Panasonic BR2032
- Output Voltage: 3 V, 195mA

Power Button/Power Management

The UNO-2271G system has been configured to automatically power on when DC power is applied. Pressing and holding the power button down for 10 seconds will power off the controller, if required.

Reset Button

If the DPU becomes unresponsive, gently press the "Reset" button with a paper clip to activate the hardware reset function.

LED Indication

A Power status LED is provided on the DPU front panel right above the Power connector. Also, each RJ45 Ethernet interface provides 2 LEDs for network connection status, i.e., the system's Link (green) and Active (green) status.

While designed for long-term availability, BH reserves the right to change the DPU hardware provided on flare.IQ Gen 2 with a suitable replacement as required.

2.2 Power Supply

2.2.1 Functional Description

The MINI POWER is a 24 VDC, 3.8 A supply, with a wide input voltage range (100 - 240 VAC). Two internal DC/DC converters convert supply power into an adjustable and regulated 24 V output voltage. Two MINI POWERs are connected in parallel (load sharing) to create a high reliability (redundant) supply. Reliable startup of heavy loads is ensured by a power reserve of up to 100%. MINI POWER also operates in applications where the static voltage dips or in transient power supply failures. Powerful capacitors ensure mains buffering of more than 20 ms at full load.

The mechanical structure and the housing of this Power Supply are largely determined by its compliance with safety regulations, and thus the possible installation location of the power supply unit. According to EN 60529, particular attention must be paid to shock protection, foreign body protection and water protection. These degrees of protection are listed in the IP (Ingress Protection) code. Generally, IP 20 protection is adequate for dry rooms and control cabinets.

This degree of protection ensures reliable protection from touching live components and prevents penetration of foreign particles with a diameter of more than 12.5 mm (0.5 in.). Protection against water is not provided. In this application, the power supply is installed in a rack-mounted control cabinet, which itself ensures the desired degree of protection.

For this power supply with class of protection I, protection against electric shock is not only based on the insulation rating. In addition, parts are connected to the protective conductor of the permanent installation in such a way that no voltage can remain even if the basic insulation fails. Hence, the system is always provided with a protective earth (PE) ground connection. These units are usually grounded using the PE connection on the AC input terminal. The power supply unit is electrically connected to the mounting DIN rail via the mounting rail adapter. PE connection via the terminal point is not required if the mounting rail is grounded.

2.3 Network Switch

2.3.1 Functional Description

Panametrics' industrial Ethernet 10/100 switches are designed specifically to meet the needs of real-time industrial control solutions. The Ethernet switch model used in this application is an 8-port 10/100 base T copper cables only, IS420ESWAH2A. To meet the requirements for speed and functionality, the following features are provided:

- 802.3, 802.3u, and 802.3x compatibility
- 10/100 base T copper with auto negotiation
- Full/half duplex auto-negotiation
- Two 100 base FX uplink ports
- HP-MDIX auto sensing
- LEDs for Link Presence, Activity and Duplex, and Speed per port (each LED has two colors)
- LED for Power
- Minimum 256 KB buffer with 4K media access control (MAC) addresses.

Flow Control (Pause)

The switch supports flow control between switches. It uses IEEE defined pause packets to receive and honor pause packets. The switch only sends the pause packets if it needs flow control on a port.

Connectors

The RJ-45 connectors support multiple insertions and removals with an estimated service life expectancy of 200 insertion/removal cycles.

Mounting

The two Ethernet switches labeled Ethernet #1 (Configure/Monitor) and Ethernet #2 (Flare control/to DCS) are mounted in the 4U top power distribution and networking module.

Power

Supports two redundant diode-OR'd power supply inputs of 18 to 36 V DC, < 0.5A (total).

Environment

Convection cooled when mounted vertically or horizontally. Coating is corrosion resistant with provisions made for grounding per IEC 60721-3-3 Class 3C2.

Diagnostics

The two status LED's indicate diagnostic information as show in Table 1 below.

Table 1: Network Switch Diagnostic Indicators

LED one	Flashes Green for activity at Full Duplex
	Flashes Yellow for activity at Half Duplex
LED two	Green = Link and 100 Mb
	Yellow = Link and 10 Mb
	No led lit = no link

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Chapter 3. Software

3.1 Overall Architecture

All flare.IQ software applications run on a real-time operating system (RTOS) for embedded devices. As described in the following section, all analog inputs from the flare flow meter, steam/air flow meter, and online analyzer are received from the DCS via Modbus/TCP. On startup, the RTOS automatically starts the flare.IQ core software, the embedded web server, and the Web Console application. The flare.IQ core is a component architecture of separate processes that perform the data acquisition and processing for flare control, meter validation, and emissions monitoring. It includes a dedicated Modbus/TCP server and components for verifying license status and user permissions.

The Web Console application is a browser-hosted interface that can be opened by a single authorized user connected to the flare.IQ via LAN A (Ethernet 1). It is used for configuring the flare.IQ during initial set-up and commissioning. As described below, it can be used to monitor the functionality of flare.IQ during operation, to upload software updates and license files, as well as to download meter validation reports and data logs.

3.2 Functional Description

3.2.1 Flare Control (FC)

As described in Section 1.2, flare.IQ can be used to calculate in real time the steam/air assist and supplemental fuel requirements for the efficient operation of downstream flares. The flare control software algorithm uses the speed of sound measured by BH's ultrasonic flare flow meter to estimate the molecular weight of the vent gas between updates from an optional online analyzer such as a Gas Chromatograph, Mass Spectrometer or Calorimeter. The calculated molecular weight, vent gas flow, and fuel flow are then used to estimate the net heating value of the vent gas (NHV_{vg}). The net heating value is used to control the supplemental fuel gas flow (i.e., fuel gas valve demand to the DCS). The steam/air assist demand is a function of the molecular weight of the hydrocarbons in the vent gas and the flare flow. The system also calculates the NHV in the combustion zone. The high-level process logic flow diagram is shown in Figure 8 below.

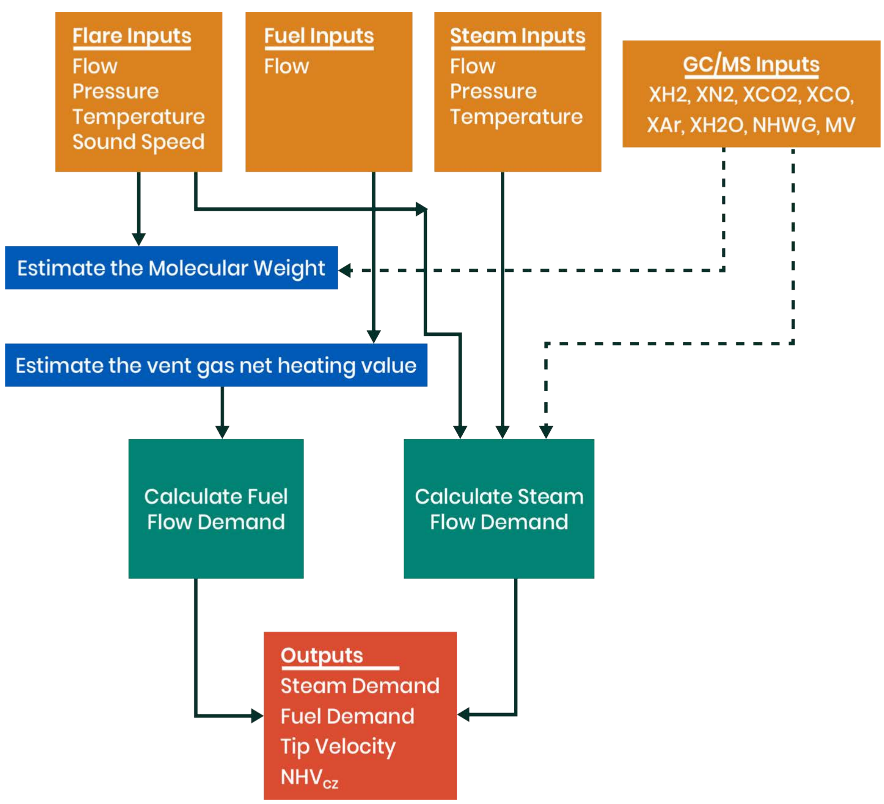


Figure 8: High-level flare control process logic flow

3.2.2 Flare Meter Digital Validation (DV)

Ultrasonic flare flow meters are widely used on oil & gas production assets, pipelines, and in refineries and petrochemical plants for flare operation and emission control. Regulatory compliance requires these flare flow meters to be validated periodically to meet their expected performance per the manufacturer's specifications. Typically, this requires a service engineer to travel to the meter installation site, conduct a visual and/or physical inspection of the meter hardware and components, access the electronics and/or transducers to collect performance/diagnostic data for a prescribed period. The service engineer then generates a Pass/Fail evaluation report for the meter after performing certain on-site tests and reviewing the diagnostic data.

A key new feature of the flare.IQ Gen 2 is digital verification, a new Software as a Service offering to realize this periodic meter validation in situ. This feature obviates the logistical complications of a service visit and plant/process interruption that may be required to access the meter. This feature has been implemented by building in the intelligence required to conduct digital verification of a flare meter in situ into the flare.IQ Gen 2 system without human intervention. The flare meter verification algorithm relies on a "reference" measurement of the vent gas composition, which could be done with an online analyzer such as a Gas Chromatograph or Mass Spectrometer where available. It also uses as input the flare pressure and temperature, flow meter data and diagnostics. The overall logic of the flow meter validation scheme is shown in Figure 9.

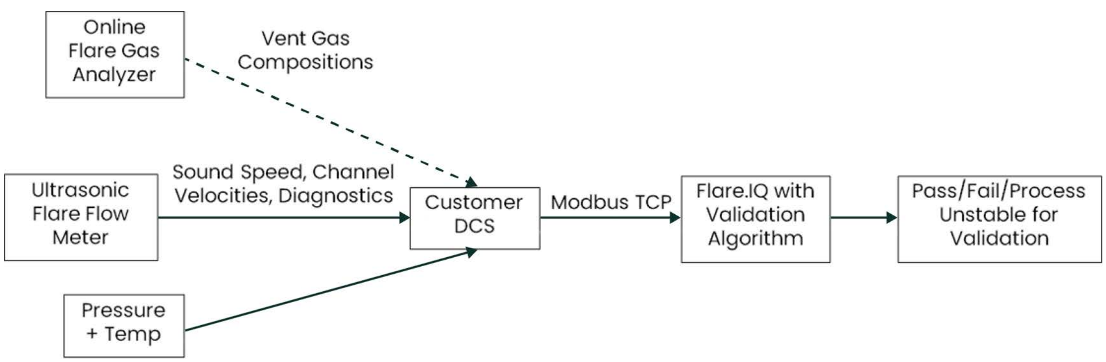


Figure 9: Digital Flare flow meter validation scheme

In case there is no online flare gas analyzer, a time-stamped sample can be analyzed off-line and used as a reference for vent gas composition. The main objective of the Digital Validation is to verify that the flare meter is functioning as designed without having to physically access its hardware. In order to efficiently collect and digitally analyze all relevant diagnostics, this DV feature requires a Modbus/TCP or RS485 connection between the flare flow meter and flare.IQ. Since the flare monitoring application is inherently noisy and variable, flow validation requires a stable flare process, which usually happens when there is no/low flaring event. In this case, vent gas flow rate is normally low, and flare gas compositions are relatively simple and constant.

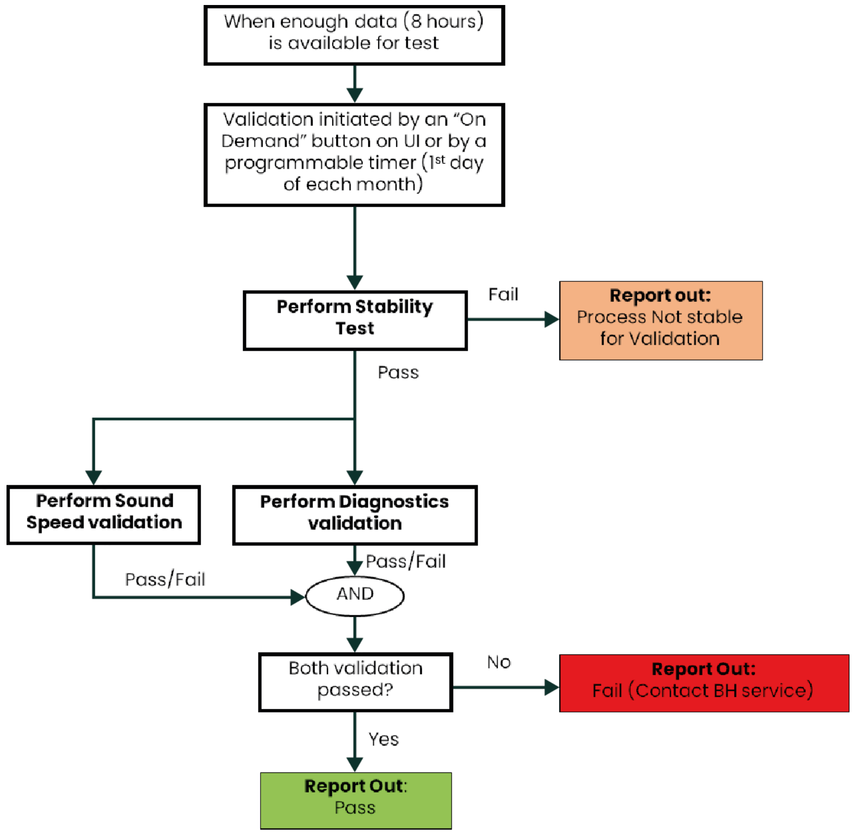


Figure 10: Flare flow meter validation logic

The high-level logic for the Panametrics flare flow meter performance validation is illustrated in Figure 10. flare.IQ uses a FIFO buffer to track meter performance and diagnostics data over the last 8 hours. This buffer's capacity is set to expect flare flow and diagnostic data **no faster than once every 5 seconds**. If an on-demand validation is initiated by the end user, flare.IQ will analyze the last 8-hour data and report a result as one of the following:

a. Pass

b. Fail

c. Process unstable for validation

If the validation is initiated on a pre-determined schedule, this validation will operate on an automated fashion on the last batch of 8-hour data available. At the end of each digital verification cycle, a summary meter validation report and the raw data (over the entire 8-hour block) used for generating the report are saved to the flash memory of the DPU in CSV format.

3.2.3 Combustion Efficiency and Predictive Emissions Monitoring (CE/PEMS)

A new feature that has been recently added to the flare.IQ Gen 2 software is the online calculation of flare combustion efficiency (CE), destruction and removal efficiency (DRE) and various gas emission values. This Predictive Emissions Monitoring System (PEMS) feature can be utilized for monitoring both unassisted (upstream) flares and steam/air assisted (downstream) flares independently of the Flare Control and Digital Validation features described above. As shown in Figure 11, a parametric model can utilize the vent gas NHV and flare operating conditions to calculate CO2, CO and VOC emissions.

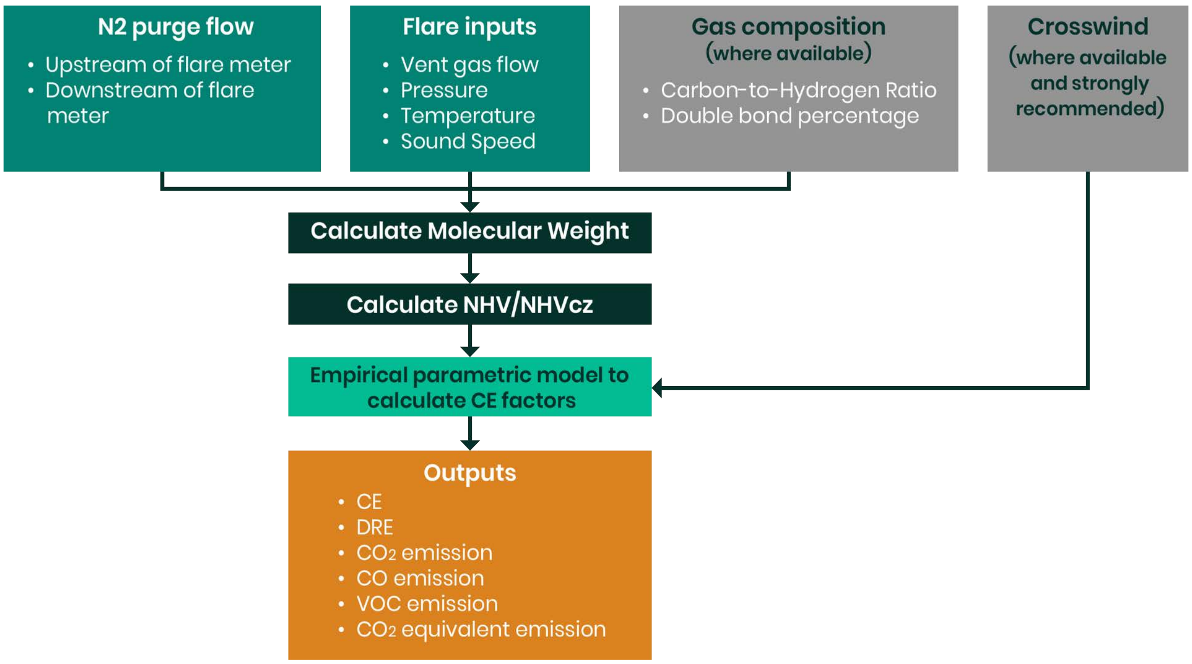


Figure 11: High-level schematic of flare CE, DRE and emissions calculations

flare.IQ implements in situ flare CE and DRE monitoring based on a parametric model derived from flare CE experimental data and computational fluid dynamics (CFD) calculations. At its core, it utilizes the calculation of molecular weight and Net Heating Value of the flare gas from the flare temperature, pressure and sound speed derived from the ultrasonic flow meter. This PEMS calculation can be customized for upstream and downstream flares to achieve real-time monitoring of CE/DRE based on process and environmental conditions derived from ultrasonic flare flow, assist/fuel flow and wind speed measurement.

3.3 Configuration

The Web Console application can be used to configure the flare.IQ during initial commissioning as well as to monitor performance of various components of the software such as flare control, digital verification and PEMS. This secure Web Console can be launched from a supported web browser running on a host PC connected to the Configure / Monitor (Ethernet 1) switch on the top module (see Figure 36 on page 44). From your web browser enter https://<ip address>/fiqWeb to launch the web console. If you leave off /fiqWeb, a default page will load that has a link to the Web Console page. The login screen of the Web Console application is shown in Figure 12 below.

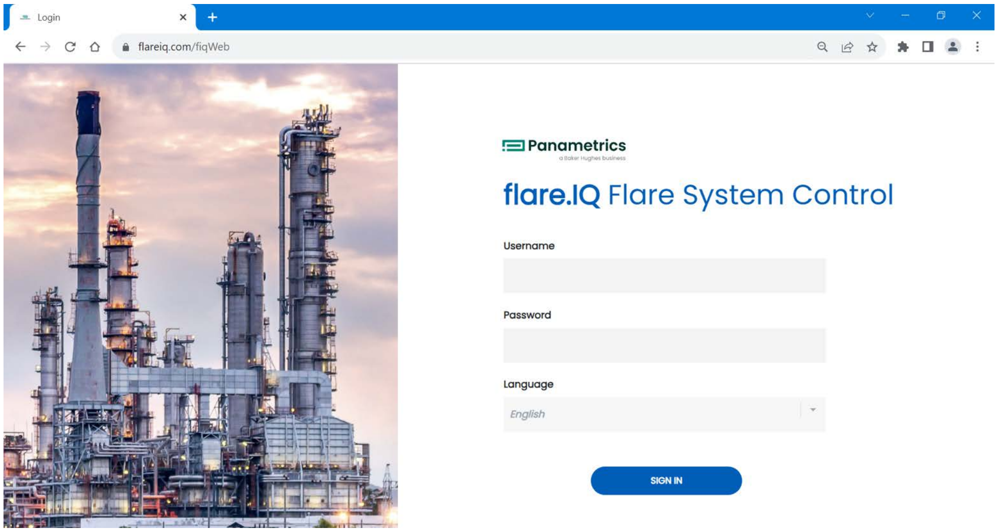


Figure 12: Log in screen of the Web Console application

The Web Console is designed to work with Chrome and Firefox browsers and is optimized for a screen resolution of 1280 x 1024. Upon initial log in with the default admin password, the user is led to the Service tab from where they can navigate to the Features tab shown in Figure 13 to upload appropriate software licenses.

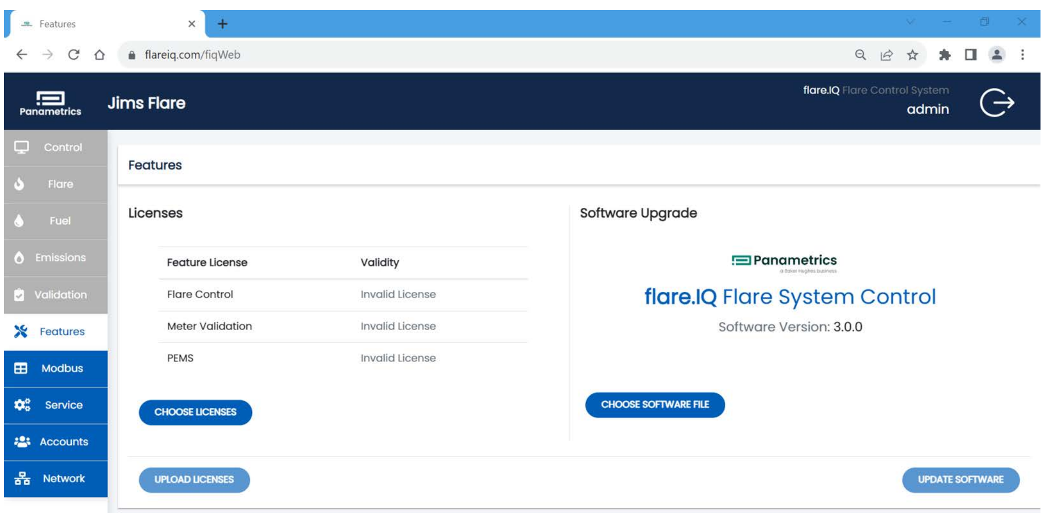


Figure 13: Web Console Service page upon initial login prior to installation of any valid licenses

Software license files that provide access to one or more of the three features listed on this page for a pre-determined duration can be obtained from your Panametrics Service Engineer. Please note these encrypted license files are tied to the specific DPU hardware on your flare.IQ Gen 2 system. These license files can be uploaded from the host PC connected to the flare.IQ by selecting the files using the "Choose Licenses" button and uploading them using the "Upload Licenses" button as shown in Figure 13.

When successfully uploaded, all menu items on the left side of the Web Console application will turn blue (live) on the Features page and the validity of each license will be indicated by showing the number of days each for which licensable service is valid (Figure 14). The color coding for the number of days remaining depends on the value, going from green (> 15 days, long duration) to yellow (0 - 14 days) to red (-1 to -30 days). After the 30-day grace period, the licensed component will stop functioning. Function will resume immediately after a new, valid license is installed.

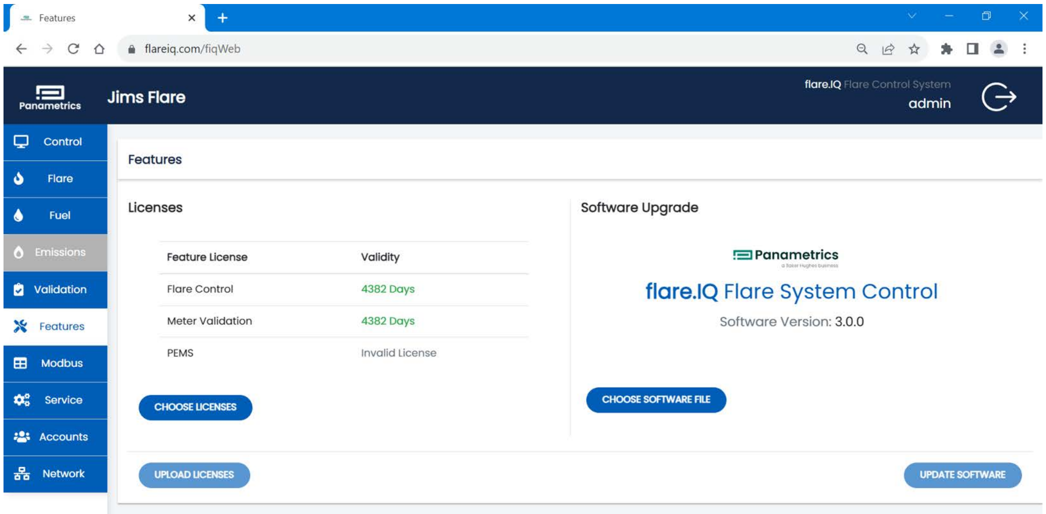


Figure 14: Web Console Features page after uploading software license information.

To update software, clicking the "Choose Software file" button opens up a file browser allowing the user to select a new Software Image file. Only a single file with ".tar.gz" or ".tgz" file extensions can be selected. A software update will reboot the DPU and will require the user to log back into the Web Console. Depending on the agreed terms and conditions, please note these software updates to correct for defects are provided free of charge. Any newly added product software features have to be purchased.

3.3.1 User Roles

There are 4 different types of User with different access levels as defined below

- Administrator: Administrators have full permissions and can access and modify all pages of the Web Console. Administrators can create new accounts on the system, including other administrators.
- Field Service: Field Service accounts have the highest level of access with the added ability to update software via the Features page and upload/download configuration files for Meter Validation on the Service page. Panametrics service personnel will typically create a Field Service account so they can access the system without requiring an Administrator to be present. They will, however, not be able to add, delete or modify other user accounts set up on the system by an Administrator.
- Operator: Operators can access and modify the Control, Flare, Fuel, Emissions, Validation, Features, Modbus and Service pages, so that they may observe and change the flare.IQ operating parameters as required. Operators do not have access to the Network configuration page. An Operator may change their own password on the Accounts page.
- Viewer: Viewers have read-only access to the Control page and may change their own password on the Accounts page.

Figure 15 shows how new users can be added by creating new accounts for them along with the Username and Password requirements. During the initial configuration, the Panametrics field service engineer will log in using their credentials but can help the Administrator set up other accounts as required.

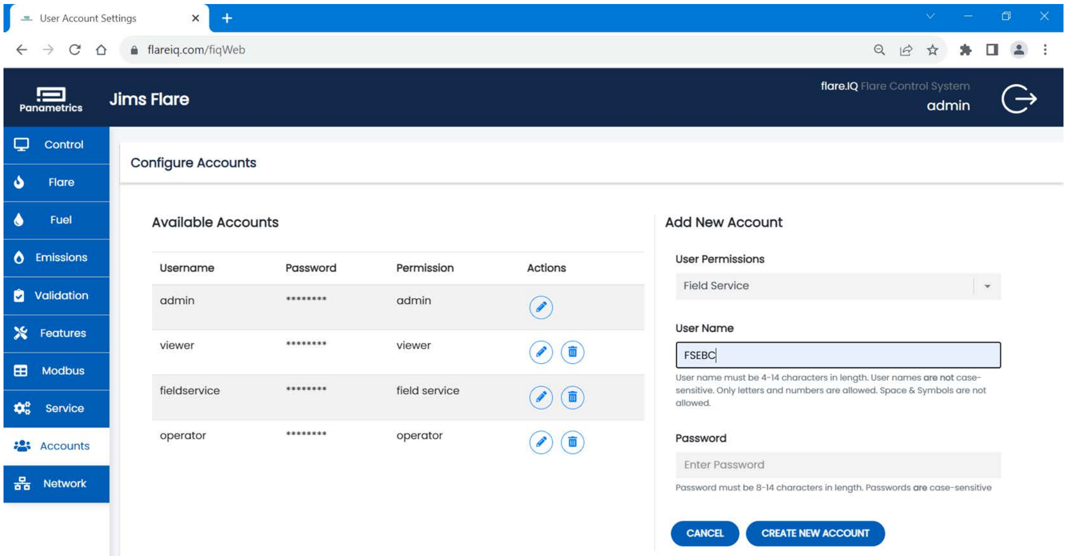


Figure 15: Web Console Accounts page showing procedure of setting up new accounts with different access levels.

3.3.2 Network Setup

There are two Ethernet switches on the top flare.IQ module, labeled Configure/Monitor (Ethernet 1) and LAN B Flare Control/DCS (Ethernet 2). The Web Console uses the LAN A (Ethernet 1) jack on each DPU. The Modbus TCP connection to the DCS is only supported on the LAN B (Ethernet 2) jack. DHCP is disabled. By default, the ports are at the following addresses:

- LAN A: IP address: 192.168.100.100, netmask 255.255.255.0, gateway = 192.168.100.1
- LAN B: IP address: 192.168.100.200, netmask 255.255.255.0, gateway = 192.168.100.1

Table 2: Factory set default IP addresses

DPU MODULE #	DPU Config IP Address	Modbus IP Address
1	192.168.100.100	192.168.100.200
2	192.168.100.101	192.168.100.201
3	192.168.100.102	192.168.100.202
4	192.168.100.103	192.168.100.203
5	192.168.100.104	192.168.100.204
6	192.168.100.105	192.168.100.205

Figure 16 shows the Network configuration page that can be navigated to after initial login. Any host PC should be set to a static IP address on the same subnet as the LAN A connections on all DPUs. As shown in Table 2, the DPU modules are addressed according to their mounted location (DPU 1 is assigned IP address 192.168.100.100).

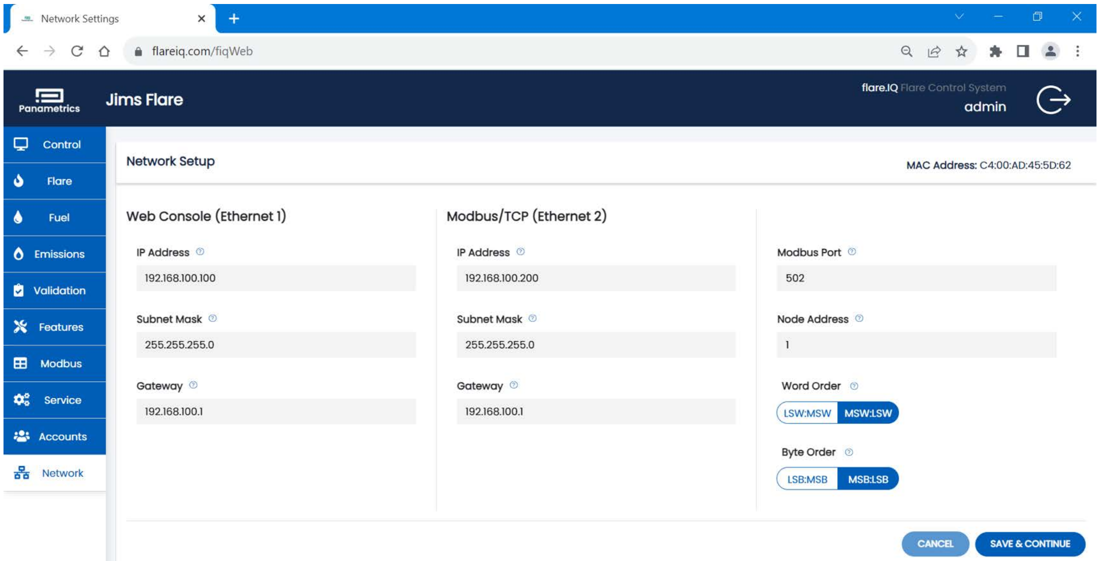


Figure 16: Network set-up page including IP address and Modbus Word/Byte order configuration.

This page also includes options for changing the Modbus/TCP configuration:

- Modbus/TCP server listen port (502 is the default)
- Modbus Node/Device address (1 is the default). Please note that the flare.IQ does not support address 0 (accept any address).
- Byte order (Most Significant Byte (MSB) first is the default). Please note that MSB order is per the Modbus standards.
- Word order (Most Significant Word (MSW) first is the default). Please note that word order is not formally defined by the Modbus standards.

A detailed description of the Modbus map required to set up the DCS Modbus master is shown in Section 3.4.2. Figure 17 shows the Service page of the Web Console which enables the following important system settings:

- Change Flare Name
- Choice of units of measure - SI (Metric) vs. English (Imperial)
- Ability to download installation specific Site File (text) that contains a record of ALL configuration settings available to the Web Console
- Ability to upload the configuration file required to set Pass/Fail criteria for digital meter verification (Field Service access only).
- Reset Totalizer (for Steam and Fuel totalizer features).

  1. When the flare control license is valid, the totalizer will be displaying message stating "Not applicable for units utilizing Flare Control".
  2. If only the DV or DV and PEMS both licenses are valid, the totalizer will show a message indicating a successful reset as "Totalizer has been reset successfully" after reset totalizer button is been clicked.
  3. If only the PEMS license is valid, the totalizer will be displaying a message stating "Not applicable for units utilizing Emissions".

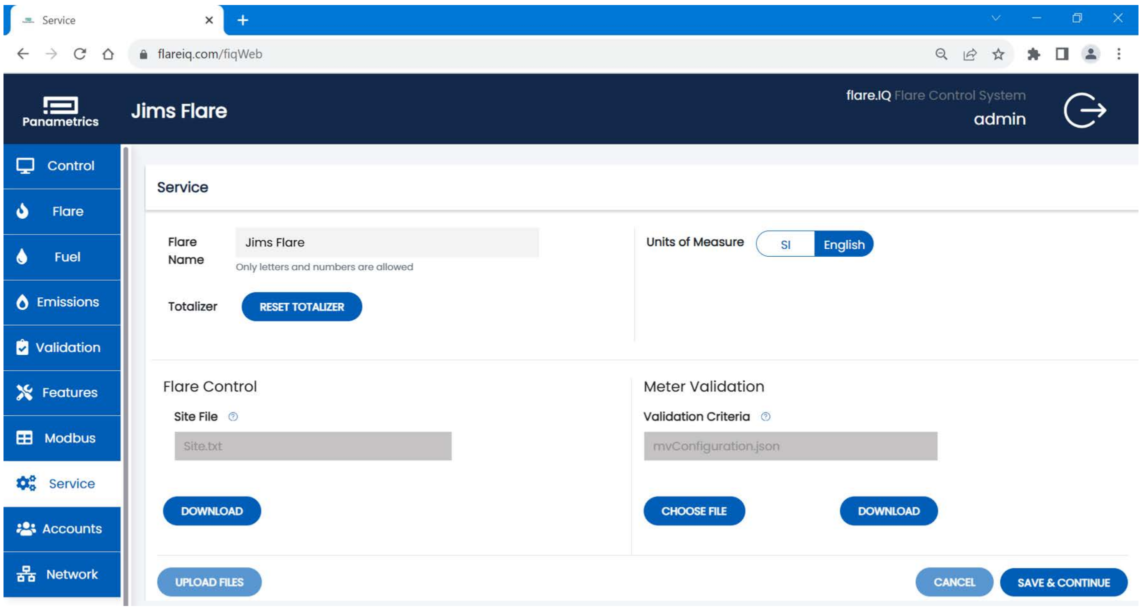


Figure 17: Service configuration page that enables uploading installation specific site files

3.3.3 Flare Configuration

The flare.IQ Gen 2 is capable of operating with a wide variety of flare installations such as steam or air assist, online gas chromatograph, mass spectrometer or calorimeter for BTU measurement, and multi-flare, single-stack installations. Depending on the specifics of each installation, the Web Console can be used to configure the flare.IQ Gen 2 during initial set-up. Figure 18 shows the flare configuration page for the steam assist option. All quantities are displayed in English units as listed in Table 11 on page 39.

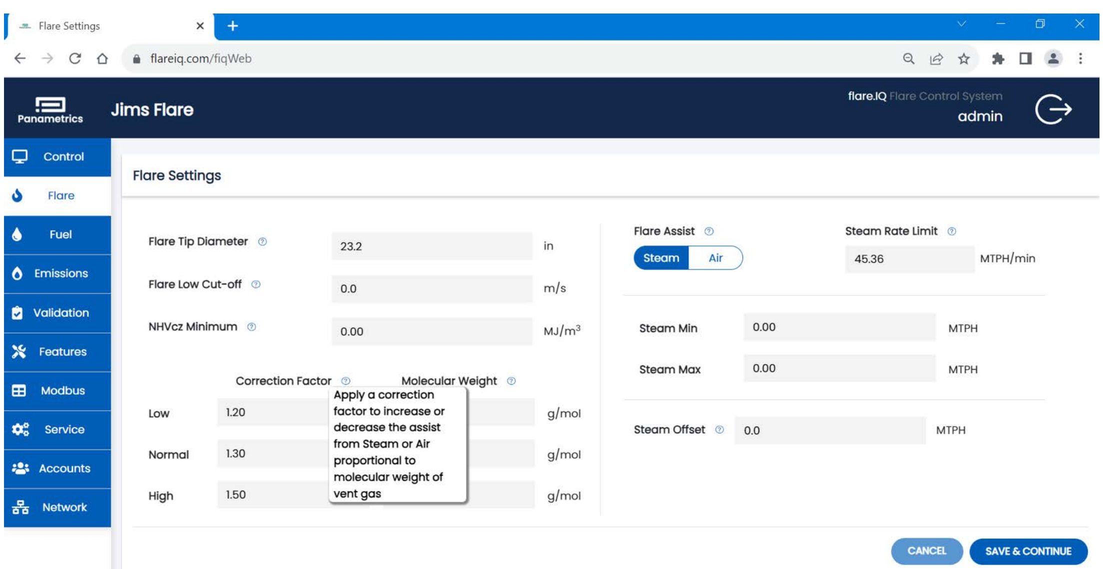


Figure 18: Flare Configuration page showing Tooltip example

All fields in the flare and fuel configuration pages utilize tooltips. Tooltips will indicate appropriate information about the item being hovered over. Some of the installation-specific parameters that apply to all types of flare installations available on the left side of flare configuration page are:

- Flare Tip Diameter
- Flare-to-steam ratio correction factor
- Choice of flare assist: Steam vs. Air
- Choice of Continuous velocity vs. 3-speed Air assist

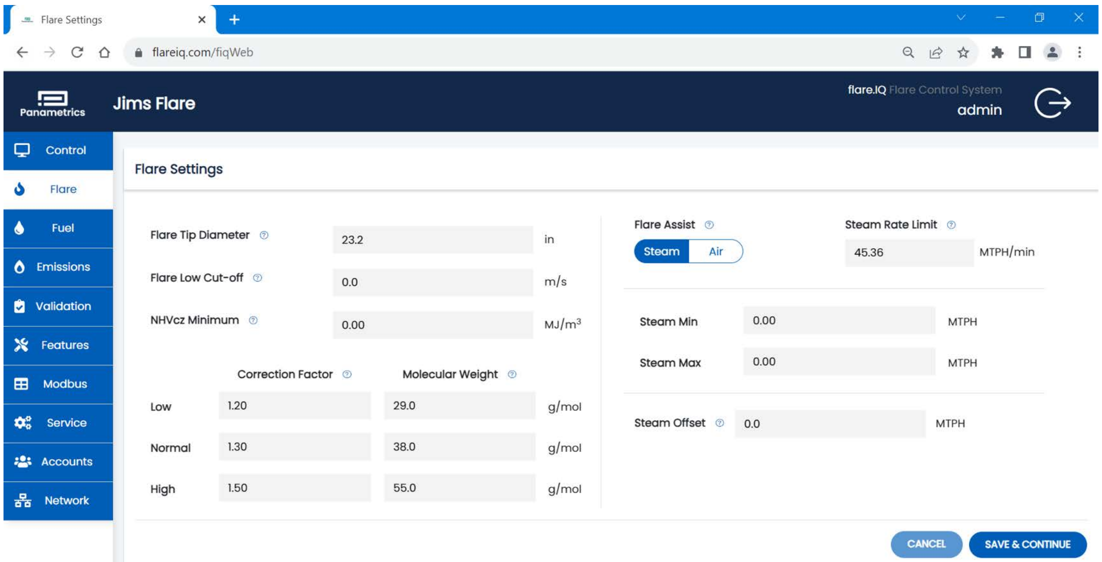


Figure 19: Flare settings for Steam assist

Figure 19 shows a typical Steam assist flare configuration page. Some installation specific parameters that may need to be fine-tuned for your installation can be set on this page including:

- Low Molecular Weight (MW) Correction Factor
- Normal MW Correction Factor
- High MW Correction Factor
- Low MW cut-off
- Normal MW cut-off
- High MW cut-off
- Minimum allowed steam flow
- Maximum allowed steam flow

Your Panametrics Field Service Engineer can provide in-depth instructions on the purpose of each configuration parameter and how to determine the correct values to enter.

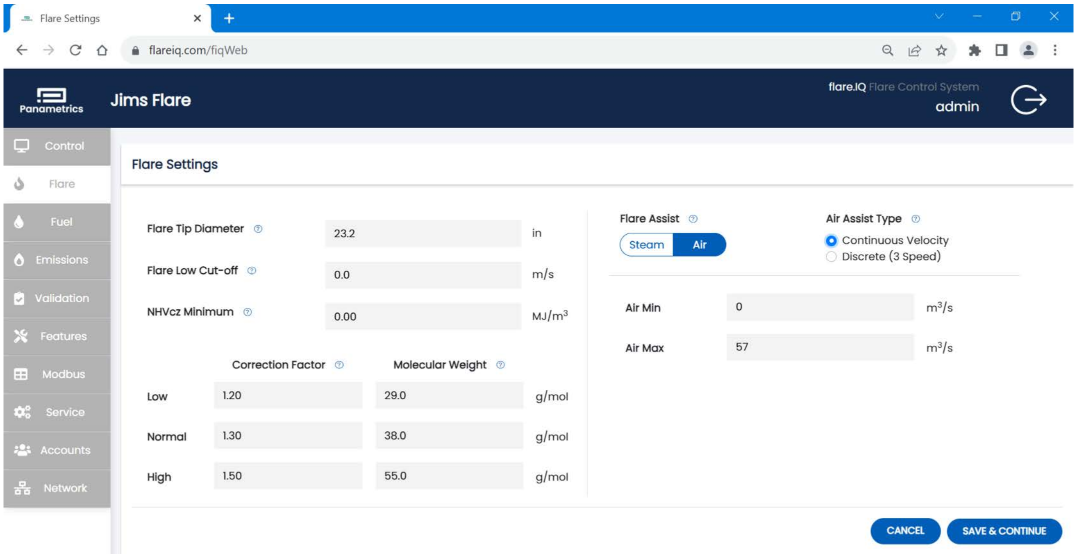


Figure 20: Flare settings for Air assist (continuous)

Figure 20 shows the Web Console settings for an Air assist flare configuration where the air flow can be varied continuously. While majority of these parameters are like those under the Steam assist settings, the only differences are the following:

- Minimum Air flow
- Maximum Air flow

This figure also shows as a representative example the state of the Web Console prior to clicking either "CANCEL" or "SAVE & CONTINUE" at the bottom. One of these must be clicked for any of the other tabs to be available. Figure 21 shows the Web Console settings for the discrete (3-speed) Air assist configuration with the following settings:

- Low Air flow
- Medium Air flow
- High Air flow

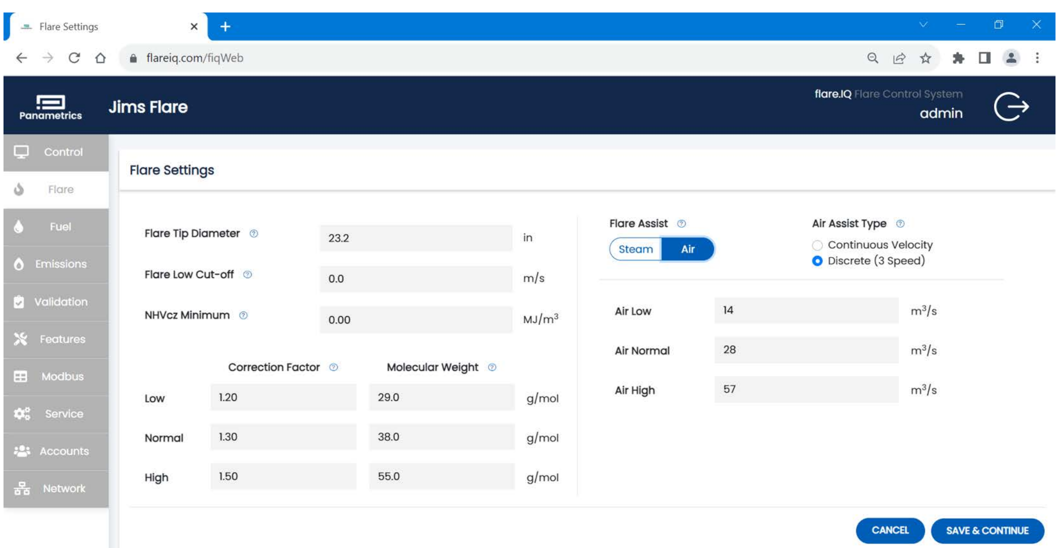


Figure 21: Flare settings for Air assist (discrete)

3.3.4 Fuel Configuration

As shown in Figure 22 this page enables setting the following flare (supplemental) fuel specific parameters:

- Choice of Flare Energy Content from - GC/Calorimeter.
- Analyzer Update Rate Minimum allowed fuel flow.
- Maximum allowed fuel flow.
- Lag time between fuel flow change and flare meter response.
- Action Threshold for changes in steam or fuel demand.
- Nominal fuel Net Heating Value (natural gas in this example).

The bottom left of the fuel page has two special configuration parameters:

4. Choice of NHV for H_2 between 275 BTU/SCF and 1212 BTU/SCF (apply EPA 1212 rule).
5. Choice of constant N_2 volumetric flow (i.e., N_2 mole fraction inversely proportional to total flare gas flow) or constant N_2 mole fraction.

In addition to tooltips, detailed information on the purpose of each of the above settings as they apply to your flare installation along with in-depth instructions on how to determine the correct values to enter can be obtained from your Panametrics Field Service Engineer.

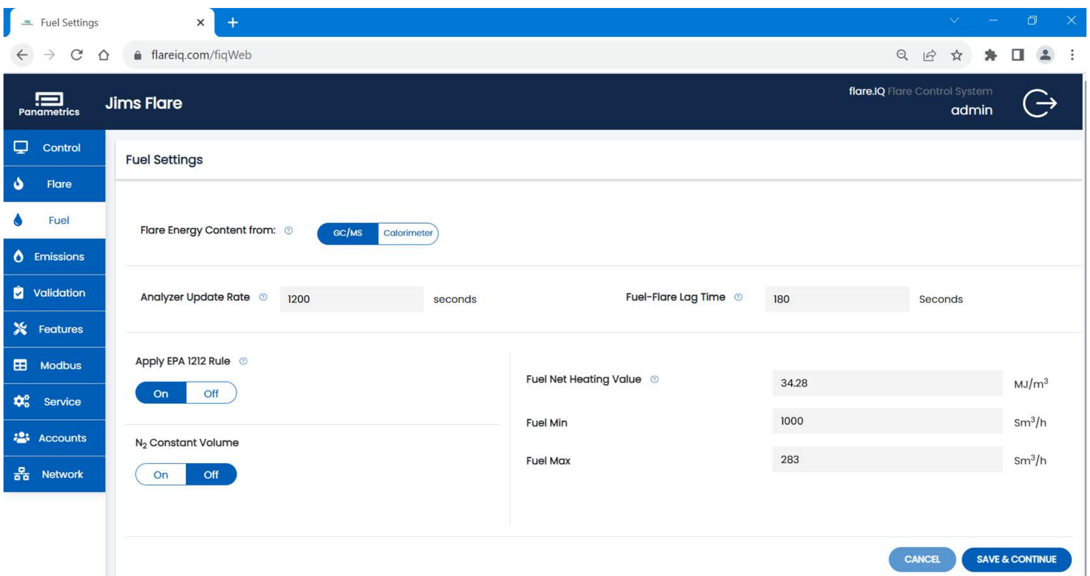


Figure 22: Fuel settings configuration page

3.3.5 Control Overview

After all configuration steps are complete, the Control Overview is displayed. This screen provides a real-time readout of essential data being sent to the flare.IQ, and the results the flare.IQ has calculated. Displayed data is organized in 'panes' as follows:

- The Heading Bar displays the configured flare name or tag, the Modbus connection status, and the user currently logged in. A running time display indicates updates of the data below.
- The System Readouts pane shows the Net Heating Value (NHV) actual. This is the calculated energy content at the flare tip, as determined by the gas composition and energy content derived from the vent/flare gas flowmeter measurements. $NHV_{current}$ must remain above a critical value of 270 BTU/SCF for EPA compliance under the MACT rules.
- This pane also shows the Fuel Demand and Steam or Air demand. These are the quantities of supplemental fuel and assist flow calculated by the flare.IQ for optimal operation. It is these values that the controlling DCS should use as setpoints for the fuel flow, steam flow, or air flow.

- The Flare pane displays the critical flare measurements as captured by the DCS and sent to the flare.IQ. Use this to verify that the data obtained from the flare flowmeter, temperature, and pressure sensors is being reliably transferred from the DCS to the flare.IQ.
- The Assist pane displays the amount of supplemental fuel, steam, or air being provided to the flare, as measured by additional flowmeters, or determined from control valve positions by the DCS.
- The Customer Analyzer Data pane displays the concentration of non-hydrocarbon components in the flare gas as determined by a Gas Chromatograph (GC), Mass Spectrometer (MS), or Calorimeter. If available, the NHV and Molecular weight of the vent gas as determined by these instruments is also displayed.
- The flare.IQ Calculations pane displays results calculated by the flare.IQ consisting of:
    - NHV of vent gas (NHV_{vg}) derived from the gas composition and sound speed data
    - Molecular Weight (MW) of the vent gas derived from the gas composition and sound speed data
    - NHV in the combustion zone (NHV_{CZ}) derived from the gas composition and sound speed data
    - Calculation of the flare gas velocity at the tip of the flare stack (V_{tip}).

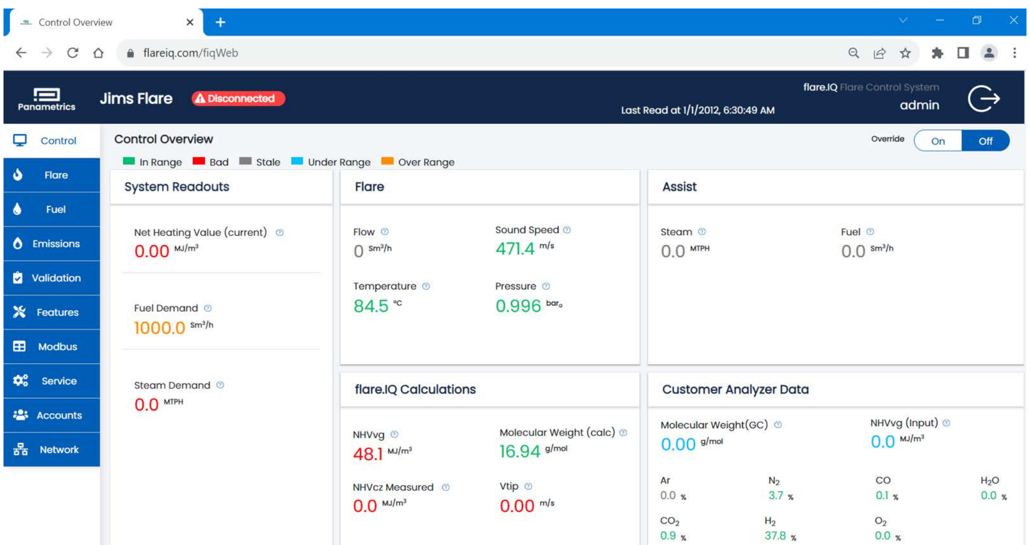
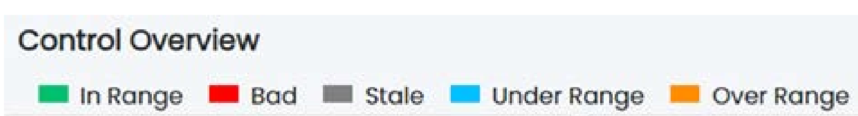


Figure 23: Control page with no Modbus connection

3.3.6 Data Status Color

The Control Overview screen uses color to provide additional information about the data displayed. The top of the display presents the following color key:



- Data displayed in **green** is determined by the flare.IQ to be valid, within programmed limits, and has been recently updated.
- Data displayed in **red** is determined to be invalid. This can be caused by the parameter never having been sent by the DCS or is the result of a failed calculation (for example, a divide by zero condition caused by another parameter being invalid).

- Data displayed in **gray** is determined to be 'stale'. The result is valid, but it is marked as stale because the parameter has not been recalculated or is the result of a calculation using another parameter that has not been updated by the DCS in a specified time period. Most parameters are considered stale if they have not been updated for 150 seconds (2.5 minutes). Gas composition data is considered stale if it has not been updated for the time specified as the GC/MS Update Rate on the Fuel Settings page.
- Data displayed in **blue** is determined by the flare.IQ to be below the low range limit determined for that parameter. This is usually an indication of an error in a parameter value supplied by the DCS.
- Data displayed in **orange** is determined by the flare.IQ to be above the high range limit determined for that parameter. This is usually an indication of an error in a parameter value supplied by the DCS.

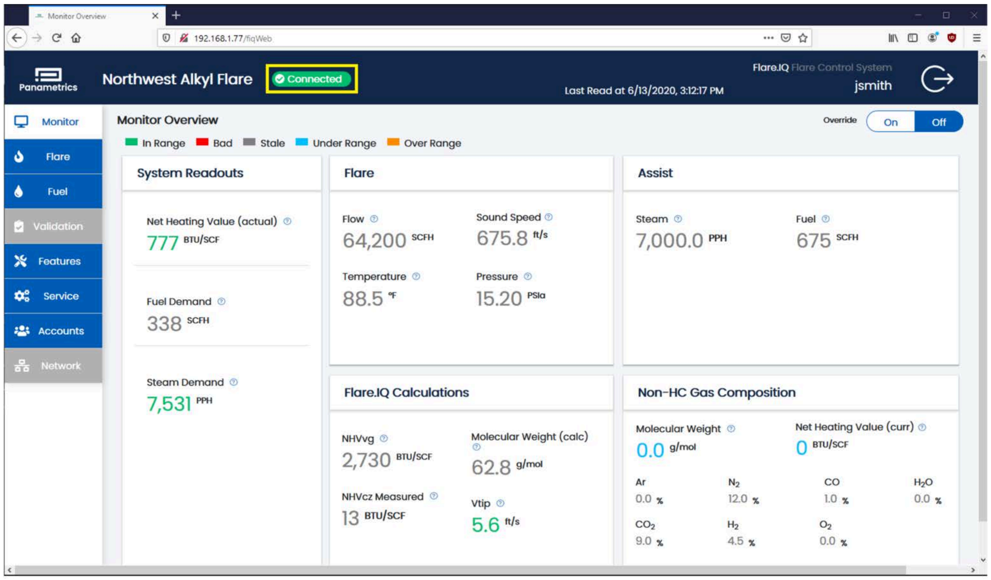


Figure 24: Control page with active Modbus connection

3.3.7 Modbus Connection Status

The status of the Modbus link between the DCS and the flare.IQ is displayed in the Heading Bar. Note that this is the network connection on LAN B. It is not an indication of communication status between the browser displaying the Web Console and the flare.IQ. Any issues with the network connection on LAN A will appear as an http error by the browser.

There are three Modbus connection states:

- Disconnected – The DCS or other Modbus master has not initiated a TCP session with the flare.IQ or has disconnected/closed the TCP session. A disconnect is assumed to have occurred if there is no traffic on the designated port for 30 seconds (Figure 23).
- Connected – The DCS has initiated a TCP session with the flare.IQ and is actively sending Modbus requests. This is the normal state of system operation (Figure 24).
- Time Out – The DCS has not disconnected/closed the TCP session with the flare.IQ but has not sent a Modbus request for more than 15 seconds (Figure 25).

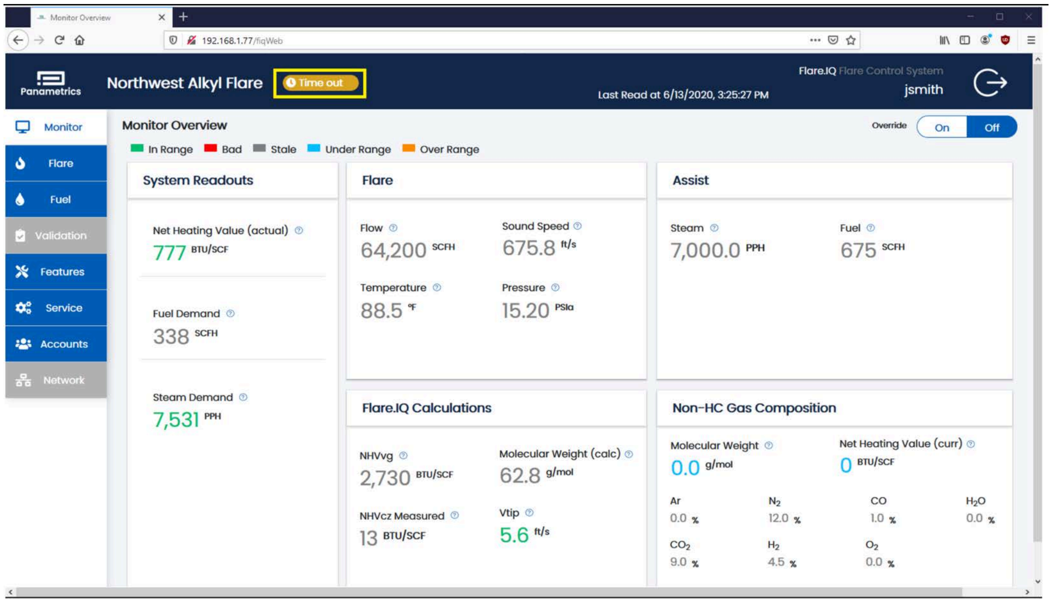


Figure 25: Control page under timeout conditions

3.3.8 Control Override

When logged in as an Administrator or Operator, an Override switch is displayed on the upper right of the Control page. Override mode is a troubleshooting and diagnostic tool for flare.IQ calculations page, overriding the data from the DCS.

When placed in Override, the Fuel and Assist setpoint calculations are determined by values entered by the Operator, **NOT** by the data Conprovided by the DCS. The DCS flare control must be placed in **MANUAL** mode before selecting Override. Automatic or 'cascade' control by the DCS **MUST** be disabled!

The flare.IQ will then calculate results based on the manual entries. This allows the effect of changing these parameters to be observed without having to otherwise disturb DCS operations or configuration. The changes in calculated values will continue to be read by the DCS. It is imperative that the DCS be placed in Manual mode before attempting to override any parameter. Otherwise the DCS would act on the changes in setpoint values, which are no longer valid. When Override is switched off, the flare.IQ will accept new data from the DCS as soon as it is provided via Modbus. When the calculated results have stabilized at the new values, the DCS may be returned to automatic/cascade control.

The parameters that can be manually entered in Override mode (by entering numerical value and pressing ENTER) are:

- Flare flow
- Flare sound speed
- Flare temperature
- Flare pressure
- Steam/Air assist flow
- Supplemental fuel flow
- Vent gas NHV
- Non-HC gas concentrations

These parameters will hold the last values written by the DCS before Override was switched on. The values can then be individually edited. It may take up to 10 seconds before the effect of a changed value is seen because the web page refresh rate is limited in Override mode.

Be sure to turn Override off to resume normal operation when testing is completed.

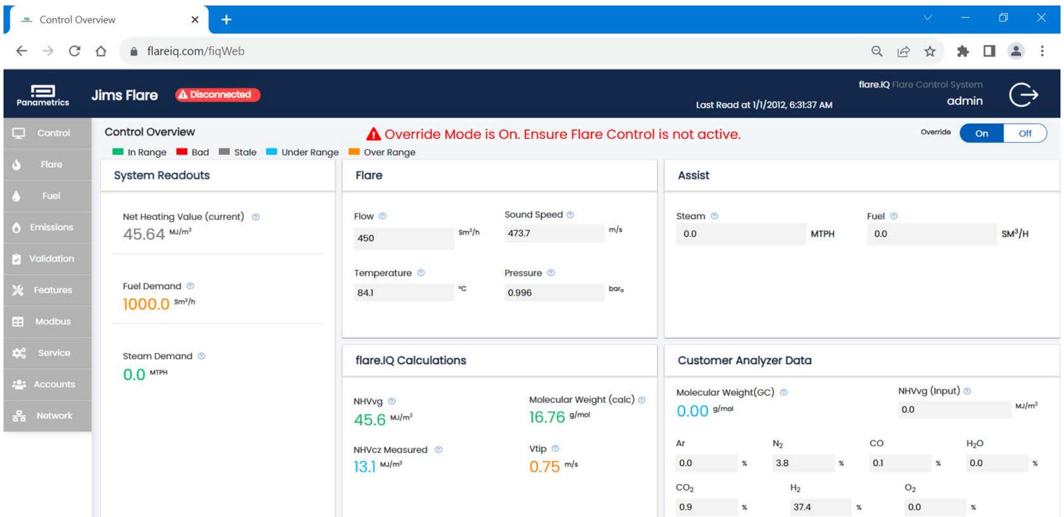


Figure 26: Control Page with Override Enabled.

3.3.9 Flare Meter Validation

The flare.IQ Gen 2 system is designed to operate at any GF868/XGF868i installation that employs a Modbus RTU or Modbus TCP connection between the Panametrics flare flow meter and the DCS. The DCS acts as the Modbus master reading diagnostic data from the GF868/XGF868i and writing them to flare.IQ Gen 2. The Gen 2 system is designed to operate on an independent Modbus TCP network without interrupting an existing installation of flare.IQ Gen 1 used for flare control. The basic logic of the digital meter verification feature is described in Section 3.2.2.

When enabled by a valid license, digital verification will be performed automatically on the 1st of every calendar month at 01:15 AM UTC. Figure 27 shows the validation page of the Web Console that enables an on-demand digital verification on a specific flare flow meter. Your Panametrics Field Service Engineer will ensure that the firmware and digital communication hardware of the flare flow meter (GF/XGF) is at the correct version and the units of measure (English/Metric) are set consistently between flare.IQ Gen2 and the flare flow meter. They will configure the digital verification feature at commissioning by uploading a site-specific meter configuration file via the Service page.

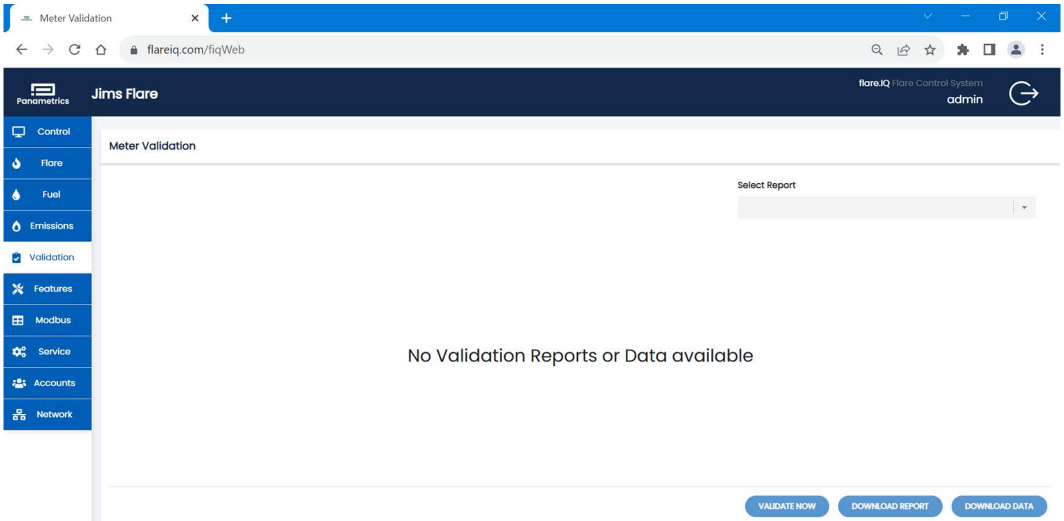


Figure 27: Validation page showing system is ready for on-demand digital verification.

As shown in Figure 10 on page 13, running digital verification requires a minimum amount of meter diagnostic data collected over an 8-hour time window. This ensures verification occurs only when stability criteria for all flow meter diagnostics are adequately satisfied. The "VALIDATE NOW" button on the validation page in Figure 27 will be enabled only when this condition is met. The maximum data interval for sending all GF/XGF Modbus data from the DCS to flare.IQ Gen2 is 3 minutes. Occasional communication dropouts that lead to data intervals greater than 3 minutes are acceptable. In case of loss of power to flare.IQ Gen 2, all validation data accumulated in the FIFO buffer is lost. Hence, an on-demand verification request will need to wait for 8 hours after power has been restored for the buffer to be refilled.

Figure 28 shows the results of a passing digital verification for a 2-channel flow meter. The date and time the last validation was completed (regardless of the result) are shown in the top right corner. The results of sound speed validation vis-à-vis an online gas analyzer are shown on top while the results of the diagnostics validation based on meter configuration-specific pass/fail criteria are listed in the bottom table.

These results can be downloaded in the tabular format displayed as a CSV (comma-separated value) file. This file is automatically named by the system using the date and time of the report and saved in a pre-selected directory on the DPU eMMC storage. Clicking the "DOWNLOAD DATA" button enables saving all the raw data used for generating this report as a CSV file, again at a preset location on the DPU eMMC storage for archival, or for downloading and sending to Panametrics service.

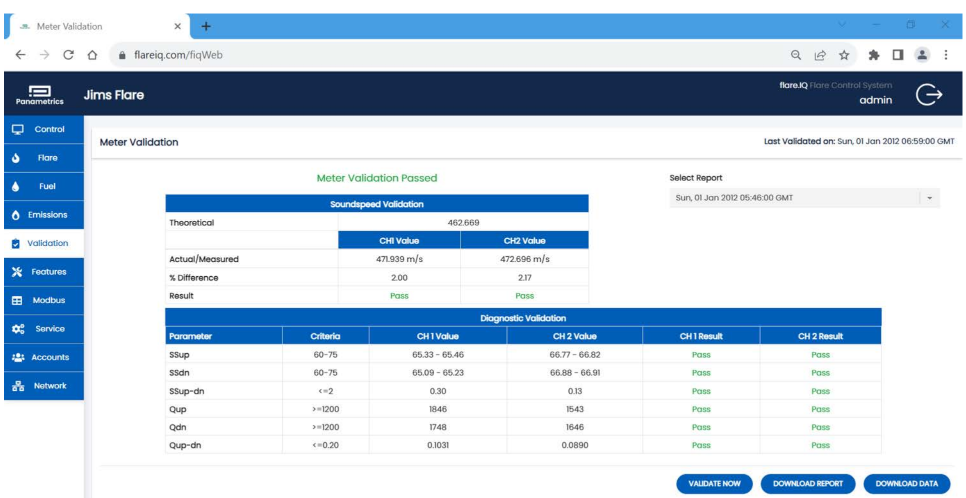


Figure 28: Validation page showing typical result for passing digital verification

There are two other possible outcomes of the digital verification process as described in Section 3.2.2 See “Flare Meter Digital Validation (DV)” on page 12. The former result is to be expected when either the Sound speed or the Diagnostics validation fail their installation-specific pass/fail criteria. The latter outcome is a result of analyzing all the data in the 8-hour block without being able to identify an adequately long block of "stable" data. In this case, the verification procedure can be repeated after waiting for a minimum of 30 minutes. In either case, you are advised to save both the report and raw data as separate CSV files and send them to Panametrics field service for further analysis.

Figure 29 shows the results of an unsuccessful meter validation where analysis of the 8-hour data block is unable to identify a sufficiently long period of stable data that can be used for verification. Again, these results can be downloaded as a CSV file for the report and/or for the raw data. Hence, after initial commissioning, the Validation page will display the results of the last digital verification “Flare Meter Digital Validation (DV)” on page 12 (preset or on-demand) along with a drop-down list of all available reports listed in reverse chronological order. The "VALIDATE NOW" button is available immediately after the analysis is complete and results report and data file have been generated.

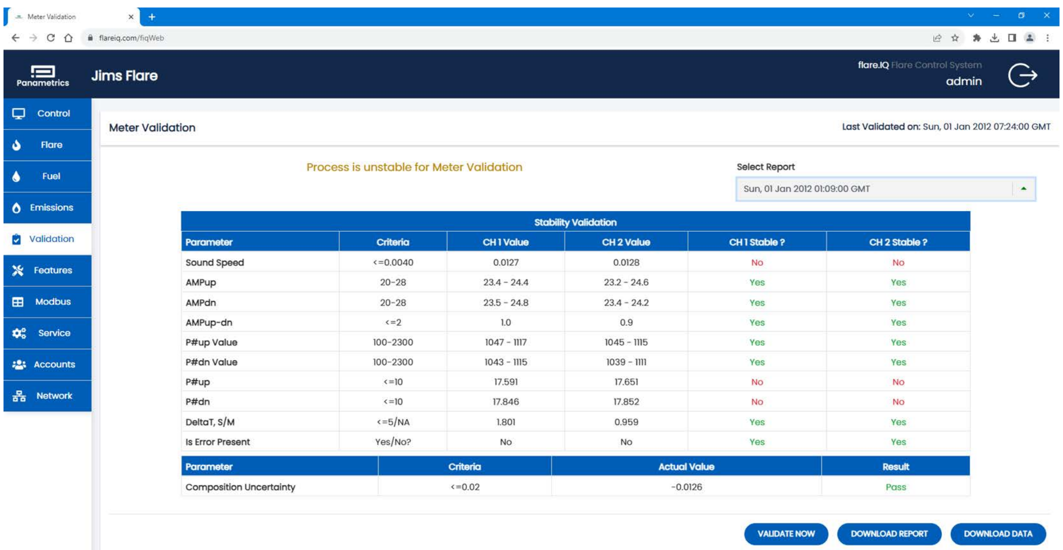


Figure 29: Validation page showing results of an unsuccessful digital verification due to process instability.

3.3.10 Emissions (CE/PEMS) - Normal and Override modes

This Emissions tab of the Web Console is enabled only when the PEMS feature is licensed. As shown in Figure 30, it provides a real-time readout of all CE/PEMS relevant data being sent to the flare.IQ including specific flare configuration information, and the outputs the flare.IQ has calculated. Displayed data is organized in 'panes' as follows:

- The Heading Bar displays the configured flare name or tag, the Modbus connection status, and the user currently logged in with a running time display indicating time stamps for the data values shown below.
- There are two selector slide bars on the top right - one to choose the flare assist type (Steam/ Air/ None) and the other to turn the Override mode On/Off.
- The Emissions pane on the left shows key PEMS outputs including:
    - Combustion Efficiency which measures the percentage of hydrocarbons in the flare gas that are completely combusted and converted into CO2 and H2O.
    - Destruction/Removal Efficiency which represents the fraction of hydrocarbons being removed or destroyed even if they are not completely combusted.
    - Volatile Organic Compound (VOC) emissions from the flare.
    - Carbon Monoxide (CO) emissions from the flare.
    - Carbon Dioxide (CO2) emissions from the flare.
    - Total CO2-Equivalent flare emissions based on Global Warming Potentials of all emissions components.

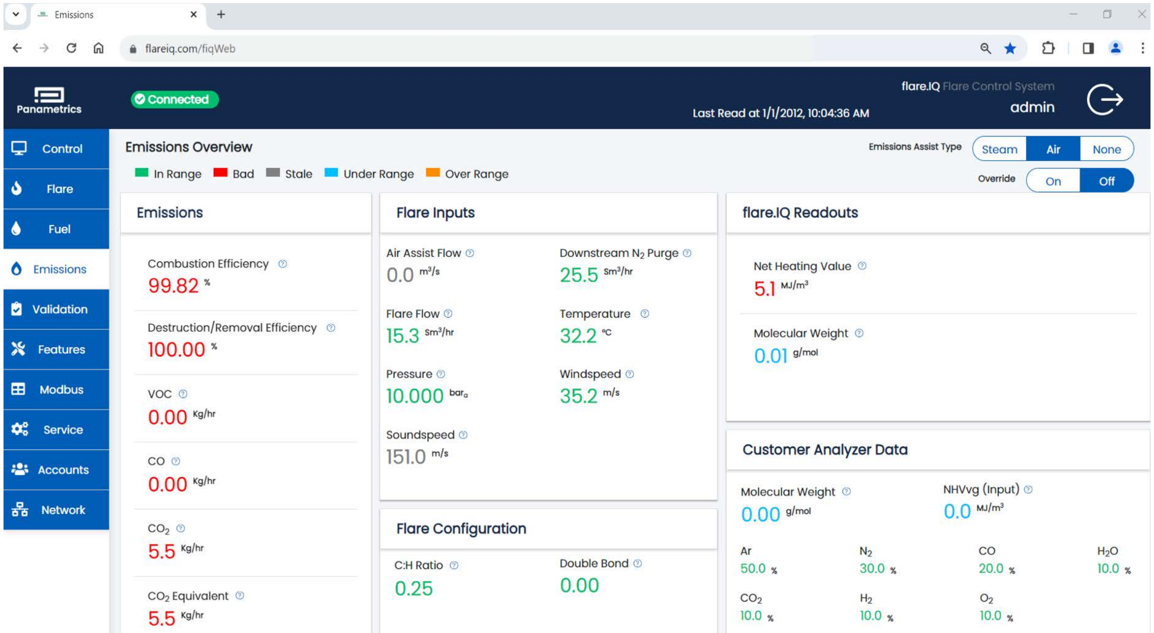


Figure 30: Emissions page without Modbus connection

- The Flare Inputs pane in the top center displays the critical flare measurements such as flare flow, assist flow, flare temp, pressure, etc. collected by the DCS and sent to the flare.IQ as Modbus inputs. This pane should be used to verify that the data obtained from the flare flowmeter, temperature, and pressure sensors are being reliably transferred from the DCS to the flare.IQ.
- The Flare Configuration pane in the bottom center displays two key flare gas parameters - the ratio of carbon to hydrogen atoms and the fraction of Double bond.
- The flare.IQ Readouts pane in the top right displays the Net Heating Value and Molecular Weight of the vent gas as calculated by flare.IQ.
- The Customer Analyzer Data pane in the bottom right displays the concentration of non-hydrocarbon components in the flare gas as determined online/offline by a Gas Chromatograph (GC) or Mass Spectrometer (MS). If available, the NHV and Molecular weight of the vent gas as determined by a BTU analyzer such as a Calorimeter is also displayed.

Similar to the Control page, when logged in as an Administrator or Operator, an Override switch is also available to a PEMS feature user on the Emissions page as shown in Figure 31 In this case, the override mode is meant to be used a troubleshooting and diagnostic tool for CE/PEMS calculations.

IMPORTANT: When placed in Override, all PEMS calculations are based on values entered by the Operator, NOT by the data from the DCS. Any DCS flare control must be placed in MANUAL mode before selecting Override. Automatic or 'cascade' control by the DCS MUST be disabled!

As described in Section 3.3.8, when the Emissions Override mode is switched on, the flare.IQ ignores Modbus data from the DCS for all input parameters shown on the Emissions page. These data values can then be entered manually by the Operator, overriding any data from the DCS. The flare.IQ will calculate CE/PEMS results based on these manual entries, which allows the user to observe the effect of changing these parameters without having to otherwise disturb DCS operations or configuration. The changes in calculated values will continue to be read by the DCS. It is imperative that the DCS be placed in Manual mode before attempting to override any parameter. Otherwise the DCS would act on the changes in flare control setpoint values, which are no longer valid. When Override is switched off, the flare.IQ will accept new data from the DCS as soon as it is provided via Modbus. When the calculated results have stabilized at the new values, the DCS may be returned to the automatic/ cascade control. The parameters that can be manually entered in the Emissions Override mode (by entering numerical value and pressing ENTER) are:

- Flare sound (box has to be clicked to initiate a new calculation)
- Flare flow
- Flare temperature
- Flare pressure
- Steam/Air assist flow
- Downstream N2 purge
- Wind speed
- C:H ratio in vent gas
- Double bond fraction
- Vent gas NHV
- Non-HC gas concentrations

These parameters will hold the last value written by the DCS before Override mode was switched on. The values can then be individually edited. It may take up to 10 seconds before the effect of a changed value is seen because the web page refresh rate is limited in the Override mode. One significant difference between the Override mode on the Emissions page (Figure 31) and that on the Control page (Figure 26) is any new calculation is triggered by providing a "new" value of the Sound speed. Hence, even if the value of Sound speed is not changed, none of the outputs will be recalculated until the Sound speed box is clicked.

IMPORTANT: Be sure to turn Override off to resume normal operation when testing is completed.

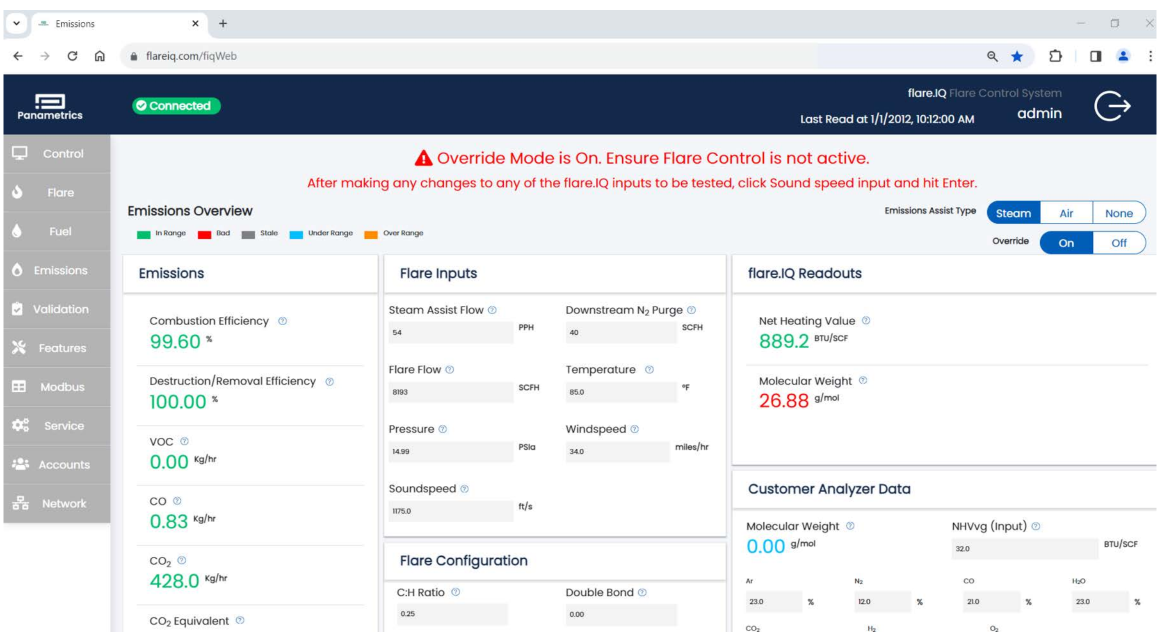


Figure 31: Emissions page with override enabled

3.3.11 Modbus status

As described in Section 3.3.2 above the end user can set up the IP configuration of both the Configure/Monitor port (LAN A) and the DCS/Modbus master connection (LAN B) for all DPU's on the flare.IQ. Section 3.4.1 below described how the DCS/Modbus master can be configured per the Modbus address list for each of the three main flare.IQ applications. Once this Modbus set up and programming are complete, the Operator can test a live Modbus connection to the DCS using the Modbus tab of the web console, which is available to all users.

Figure 32 shows the Modbus map for flare control while Figure 33 displays the Modbus map for Digital Validation. There is a slider bar in the top right that lets the Operator switch between the two pages.

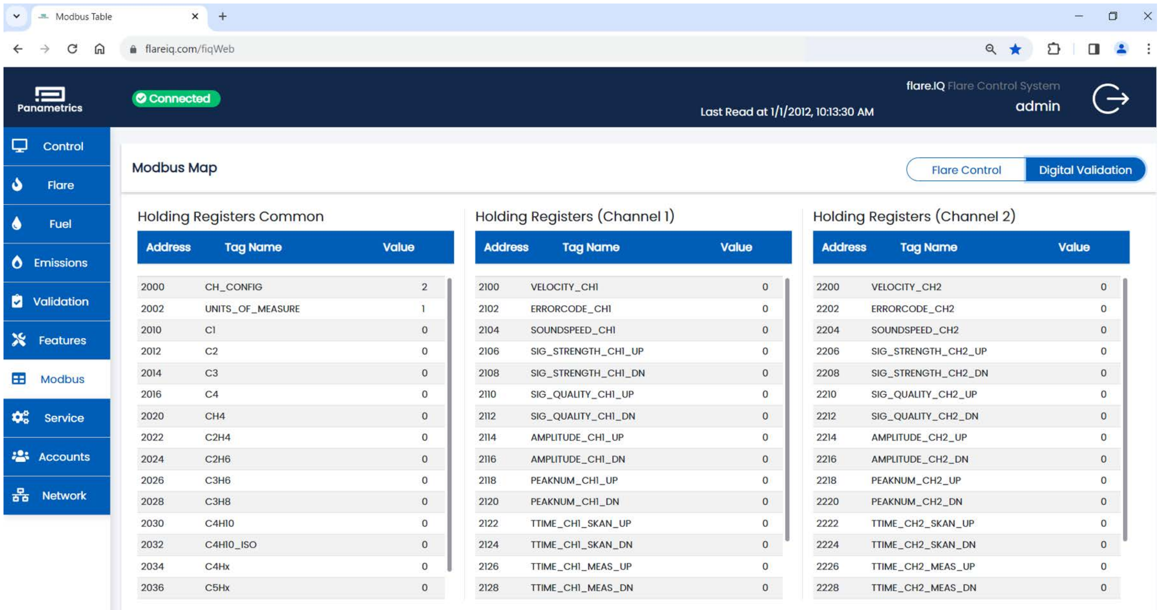


Figure 32: Modbus page showing Digital Validation

As shown in the figures above, these parameters for each of the two features are grouped into Holding (analog input), Input (analog output) and Boolean status and coil registers (where relevant). The intent of displaying live Modbus data is to enable the Operator to check the DCS/Modbus master configuration for each of these two features separately. If any of the displayed values are incorrect, out of range or static, the DCS configuration for those Modbus addresses should be checked.

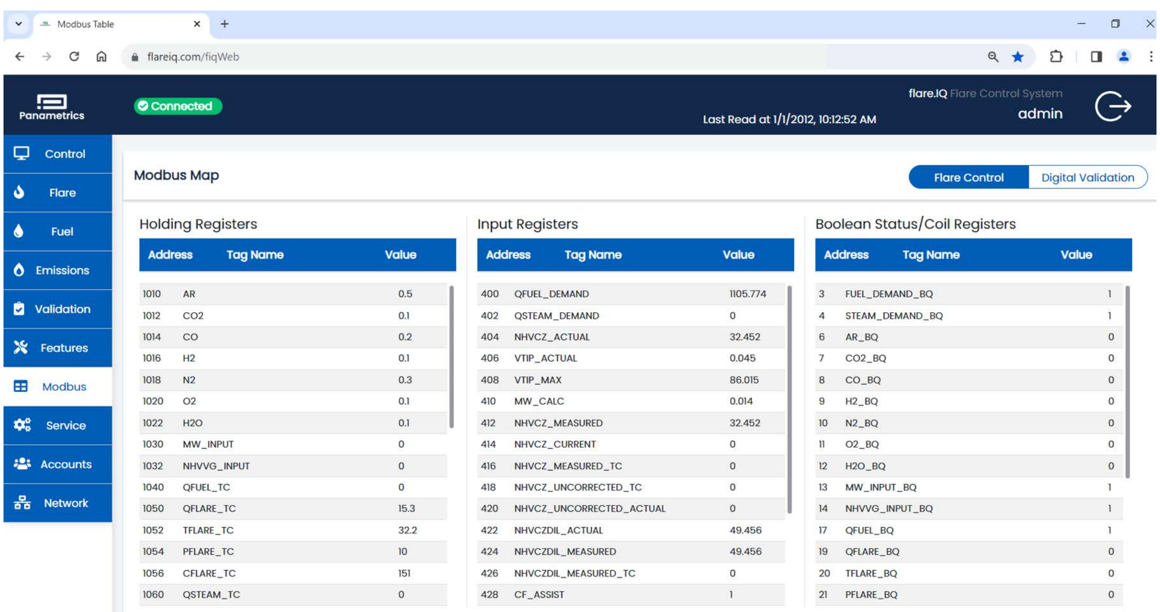


Figure 33: Modbus page showing flare control

3.4 Modbus

3.4.1 Modbus Configuration

The default Modbus TCP configuration is as follows:

Modbus Device Address = 1

TCP Port = 502

Byte Order = Most Significant Byte First.

Word Order = Most Significant Word First.

This configuration can be changed as required on the Network page of the Web Console.

3.4.2 Modbus Address List

flare.IQ Gen 2 uses 32-bit IEEE-754 Floating point representation for all analog inputs (Modbus holding registers) and outputs (Modbus Input registers). Hence, no scaling is required to maintain numerical accuracy. Please refer to the Modbus Messaging on TCP/IP Implementation Guide V1.0b from Modbus.org and to your DCS/PLC instruction manual for how to use this address information properly in Modbus messaging. Note this address list does not follow the legacy convention of using 00001-10000 for read/write discrete outputs or coils and 30001-40000 for16-bit analog input registers.

Holding registers should be written using the Modbus Preset Multiple Registers command (function code 16). All 32-bit values must be sent as an even number of registers (minimum 2) with an even starting address. flare.IQ register addressing is zero-based. The first Modbus register is address 0000. Some DCS configurations use ones-based addressing, where the first Modbus register is address 0001. In this case, address values may have to be corrected by adding/subtracting 1.

Many of the Modbus values are also displayed on the web console. For these critical parameters, the web console can be used to verify that Modbus data from the DCS is being sent to the correct register in the correct format. Extreme numeric values, 'INF', or 'NaN' displayed on the web console are an indication of incorrectly formatted Modbus data.

A signal is considered bad quality when its link to Modbus is broken, the signal value is unchanging, or the signal is out of range. In these cases, the signal value is held at the last known good value. Additionally, the flare.IQ will validate that inputs are reasonable; for example, if the total concentration of all specified composition gases exceeds 100%, the signal values of all gases will be set to bad quality until the composition is corrected.

Table 3: Modbus Address List - Holding Registers for Flare Control (analog inputs)

Register Tag Name	Register Address	Number of Registers	Description
AR	1010	2	Argon Concentration
CO2	1012	2	Carbon Dioxide Concentration
CO	1014	2	Carbon Monoxide Concentration
H2	1016	2	Hydrogen Concentration
N2	1018	2	Nitrogen Concentration
O2	1020	2	Oxygen Concentration
H2O	1022	2	Water Vapor Concentration
MW_INPUT	1030	2	Molecular Weight from GC/MS
NHVVG_INPUT	1032	2	Net Heating Value of Vent (flare) Gas
QFUEL_TC	1040	2	Fuel Gas Flow Rate
QFLARE_TC	1050	2	Flare Flow Rate
TFLARE_TC	1052	2	Flare Temperature
PFLARE_TC	1054	2	Flare Pressure

Table 3: Modbus Address List - Holding Registers for Flare Control (analog inputs) (cont.)

Register Tag Name	Register Address	Number of Registers	Description
CFLARE_TC	1056	2	Flare Sound Speed
QSTEAM_TC	1060	2	Steam Flow Rate
TSTEAM_TC	1062	2	Steam Temperature (future use)
PSTEAM_TC	1064	2	Steam Pressure (future use)
CUST_STEAM_OFFSET	1066	2	Custom Steam Offset Value
QAIR_TC	1070	2	Air Flow Rate
TAIR_TC	1072	2	Assist Air Temperature
PAIR_TC	1074	2	Assist Air Pressure
QN2_TC	1076	2	Volumetric flow of Nitrogen
MW_LOW_CF	1080	2	Low Molecular Weight Correction Factor
MW_NORM_CF	1082	2	Normal Molecular Weight Correction Factor
MW_HIGH_CF	1084	2	High Molecular Weight Correction Factor
GC_UPDATE_RATE	1090	2	Expected time between GC/MS updates
MW_LOW	1100	2	Low Molecular Weight to apply Correction Factor
MW_NORM	1102	2	Normal Molecular Weight to apply Correction Factor
MW_HIGH	1104	2	High Molecular Weight to apply Correction Factor
QFUEL_MIN	1130	2	Minimum Fuel Flow Parameter
QFUEL_MAX	1132	2	Maximum Fuel Flow Parameter
FLARE_DIAM	1140	2	Flare Tip Diameter
FLARE_METER_DIAM	1142	2	Flare Meter Diameter
QSTEAM_MIN	1150	2	Minimum Steam Flow Parameter
QSTEAM_MAX	1152	2	Maximum Steam Flow Parameter
QAIR_LOW	1160	2	Low Air Flow
QAIR_MID	1162	2	Mid Air Flow
QAIR_HIGH	1164	2	High Air Flow
QAIR_MIN	1170	2	Minimum Air Flow Parameter
QAIR_MAX	1172	2	Maximum Air Flow Parameter

Table 4: Modbus Address List - Holding registers for Digital Validation (analog inputs)

Register Tag Name	Register Address	Number of Registers	Description
CO2	1012	2	Carbon Dioxide Concentration
CO	1014	2	Carbon Monoxide Concentration
H2	1016	2	Hydrogen Concentration
N2	1018	2	Nitrogen Concentration
O2	1020	2	Oxygen Concentration

Table 4: Modbus Address List - Holding registers for Digital Validation (analog inputs) (cont.)

Register Tag Name	Register Address	Number of Registers	Description
H2O	1022	2	Water Vapor Concentration
TFLARE_TC	1052	2	Flare Temperature
PFLARE_TC	1054	2	Flare Pressure
CFLARE_TC	1056	2	Flare Sound Speed
CH_CONFIG	2000	2	Chanel Configuration of the Flare meter
UNITS_OF_MEASURE	2002	2	Units of Measure Configuration of the Flare meter
CH4	2020	2	Methane Concentration, percent
C2H4	2022	2	Ethylene Concentration, percent
C2H6	2024	2	Ethane Concentration, percent
C3H6	2026	2	Propylene Concentration, percent
C3H8	2028	2	Propane Concentration, percent
C4H10	2030	2	Butane Concentration, percent
C4H10_ISO	2032	2	Iso Butane Concentration, percent
C4Hx	2034	2	C4's (Olefins) Concentration, percent
C5Hx	2036	2	C5's Concentration, percent
C6Hx	2038	2	C6's Concentration, percent
H2S	2040	2	Hydrogen Sulfide Concentration, percent
VELOCITY_CH1	2100	2	Ch 1 velocity from Flare meter
ERRORCODE_CH1	2102	2	Ch 1 Error code from Flare meter
SOUNDSPEED_CH1	2104	2	Ch 1 Sound speed from Flare meter
SIG_STRENGTH_CH1_UP	2106	2	Ch 1 Upstream Signal Strength from Flare meter
SIG_STRENGTH_CH1_DN	2108	2	Ch 1 Downstream Signal Strength from Flare meter
SIG_QUALITY_CH1_UP	2110	2	Ch 1 Upstream Signal Quality from Flare meter
SIG_QUALITY_CH1_DN	2112	2	Ch 1 Downstream Signal Quality from Flare meter
AMPLITUDE_CH1_UP	2114	2	Ch 1 Upstream Amplitude from Flare meter
AMPLITUDE_CH1_DN	2116	2	Ch 1 Downstream Amplitude from Flare meter
PEAKNUM_CH1_UP	2118	2	Ch 1 Upstream Peak Number from Flare meter
PEAKNUM_CH1_DN	2120	2	Ch 1 Downstream Peak Number from Flare meter
TTIME_CH1_SKAN_UP	2122	2	Ch 1 Upstream Transit time, Skan from Flare meter
TTIME_CH1_SKAN_DN	2124	2	Ch 1 Downstream Transit Time, Skan from Flare meter
TTIME_CH1_MEAS_UP	2126	2	Ch 1 Upstream Transit time, Measure from Flare meter
TTIME_CH1_MEAS_DN	2128	2	Ch 1 Downstream Transit Time, Measure from Flare meter
DELTA_T_CH1_SKAN	2130	2	Ch 1 Upstream Delta T, Skan from Flare meter
DELTA_T_CH1_MEAS	2132	2	Ch 1 Upstream Delta T, Measure from Flare meter
PATH_LENGTH_CH1	2134	2	Ch 1 Path Length from Flare meter
AXIAL_LENGTH_CH1	2136	2	Ch 1 Axial Length from Flare meter
VELOCITY_CH2	2200	2	Ch 2 velocity from Flare meter
ERRORCODE_CH2	2202	2	Ch 2 Error code from Flare meter

Table 4: Modbus Address List - Holding registers for Digital Validation (analog inputs) (cont.)

Register Tag Name	Register Address	Number of Registers	Description
SOUNDSPEED_CH2	2204	2	Ch 2 Sound speed from Flare meter
SIG_STRENGTH_CH2_UP	2206	2	Ch 2 Upstream Signal Strength from Flare meter
SIG_STRENGTH_CH2_DN	2208	2	Ch 2 Downstream Signal Strength from Flare meter
SIG_QUALITY_CH2_UP	2210	2	Ch 2 Upstream Signal Quality from Flare meter
SIG_QUALITY_CH2_DN	2212	2	Ch 2 Downstream Signal Quality from Flare meter
AMPLITUDE_CH2_UP	2214	2	Ch 2 Upstream Amplitude from Flare meter
AMPLITUDE_CH2_DN	2216	2	Ch 2 Downstream Amplitude from Flare meter
PEAKNUM_CH2_UP	2218	2	Ch 2 Upstream Peak Number from Flare meter
PEAKNUM_CH2_DN	2220	2	Ch 2 Downstream Peak Number from Flare meter
TTIME_CH2_SKAN_UP	2222	2	Ch 2 Upstream Transit time, Skan from Flare meter
TTIME_CH2_SKAN_DN	2224	2	Ch 2 Downstream Transit Time, Skan from Flare meter
TTIME_CH2_MEAS_UP	2226	2	Ch 2 Upstream Transit time, Measure from Flare meter
TTIME_CH2_MEAS_DN	2228	2	Ch 2 Downstream Transit Time, Measure from Flare meter
DELTA_T_CH2_SKAN	2230	2	Ch 2 Upstream Delta T, Skan from Flare meter
DELTA_T_CH2_MEAS	2232	2	Ch 2 Upstream Delta T, Measure from Flare meter
PATH_LENGTH_CH2	2234	2	Ch 2 Path Length from Flare meter
AXIAL_LENGTH_CH2	2236	2	Ch 2 Axial Length from Flare meter

Table 5: Mobdus Address List - Holding Registers for CE/PEMS (analog inputs)

Register Tag Name	Register Address	Number of Registers	Description
EM_QN2_DN	2300	2	N2 Flow downstream of Flare flow meter
EM_DOUBLE_BOND_GAS	2310	2	Double Bond gas concentration
EM_CARBON_HYDROGEN_RATIO	2312	2	Ratio of Carbon atoms to Hydrogen atoms
EM_WIND_SPEED	2320	2	Cross wind speed

Table 6: Modbus Address List - Input Registers for Flare Control (analog outputs)

Register Tag Name	Register Address	Number of Registers	Description
QFUEL_DEMAND	400	2	Fuel Gas Demand
QSTEAM_DEMAND	402	2	Steam Demand
NHVCZ_ACTUAL	404	2	Net Heating Value in the Combustion Zone derived from Speed of Sound at Fuel and Steam set-points calculated by flare.IQ
VTIP_ACTUAL	406	2	Flare Tip Velocity Calculated
VTIP_MAX	408	2	Flare Tip Velocity Maximum
MW_CALC	410	2	Molecular Weight Calculated

Table 6: Modbus Address List - Input Registers for Flare Control (analog outputs (cont.))

Register Tag Name	Register Address	Number of Registers	Description
NHVCZ_MEASURED	412	2	Net Heating Value in the Combustion Zone derived from GC/Calorimeter at Fuel and Steam set-points calculated by flare.IQ
NHVCZ_CURRENT	414	2	Net Heating Value in the Combustion Zone derived from Speed of Sound at current Fuel and Steam flow
NHVCZ_MEASURED_TC	416	2	Net Heating Value in the Combustion Zone derived from GC/Calorimeter at Current Fuel and Steam flow
NHVCZ_UNCORRECTED_TC	418	2	NHVcz uncorrected for H2 derived from GC/Calorimeter at current Fuel and Steam flow
NHVCZ_UNCORRECTED_ACTUAL	420	2	NHVcz uncorrected for H2 derived from Speed of Sound at Fuel and Steam set-points calculated by flare.IQ
NHVCZDIL_ACTUAL	422	2	NHV Dilution Parameter derived from Speed of Sound (Air Assist only) at Fuel and Air set-points calculated by flare.IQ
NHVCZDIL_MEASURED	424	2	NHV Dilution Parameter derived from GC/Calorimeter (Air Assist only) at Fuel and Air set-points calculated by flare.IQ
NHVCZDIL_MEASURED_TC	426	2	NHV Dilution derived from GC/Calorimeter at Current Conditions (Air Assist only) at current Fuel and Air flow
CF_ASSIST	428	2	Air/Steam Correction Factor as a function of Mol Weight
QAIR_DEMAND	430	2	Air Demand

Table 7: Modbus Address List - Input registers for Digital Validation (analog outputs)

Register Tag Name	Register Address	Number of Registers	Description
MV_LAST_ATTEMPT	446	2	Timestamp of most recently attempted Meter Validation
MV_LAST_PASS	448	2	Timestamp of most recently passed Meter Validation
MV_LAST_RESULT	450	2	Previous Meter Validation result: - Pass (0), Fail (-1), Unavailable (-2), Unstable (-3)

Table 8: Modbus Address List - Input registers for CE/PEMS (analog outputs)

Register Tag Name	Register Address	Number of Registers	Description
EM_CO	432	2	Carbon Monoxide emissions
EM_CO2	434	2	Carbon Dioxide emissions
EM_CO2_EQUIVALENT	436	2	CO2-equivalent emissions based on Global Warming Potentials
EM_VOC	438	2	Volatile Organic Compound emissions
EM_DRE	440	2	Destruction & Removal Efficiency
EM_CE_CORRECTED	442	2	Calculated Combustion Efficiency (corrected for wind, velocity, and smoke)
EM_NHVVG	444	2	Emissions Net Heating Value of vent gas

Table 9: Modbus Address List - Boolean status registers (read only)

Register Tag Name	Register Address	Number of Registers	Description
HEARTBEAT	0	1	Heartbeat (from flare.IQ)
COMM_FAIL	1	1	Modbus Comm Failed (Timeout)
RESERVED_02	2	1	Reserved, returns 0
FUEL_DEMAND_BQ	3	1	Fuel Demand Exceeds Capacity
STEAM_DEMAND_BQ	4	1	Steam Demand Exceeds Capacity
AIR_DEMAND_BQ	5	1	Air Demand Exceeds Capacity
AR_BQ	6	1	Argon Content Value Bad
CO2_BQ	7	1	Carbon Dioxide Content Value Bad
CO_BQ	8	1	Carbon Monoxide Content Value Bad
H2_BQ	9	1	Hydrogen Content Value Bad
N2_BQ	10	1	Nitrogen Content Value Bad
O2_BQ	11	1	Oxygen Content Value Bad
H2O_BQ	12	1	Water Content Value Bad
MW_INPUT_BQ	13	1	Mol Weight from GC/MS Value Bad
NHVVG_INPUT_BQ	14	1	NHV (Vent Gas) from GC/MS Value Bad
RESERVED_15	15	1	Reserved, returns 0
RESERVED_16	16	1	Reserved, returns 0
QFUEL_BQ	17	1	Fuel Gas Flow Measurement Bad
RESERVED_18	18	1	Reserved, returns 0
QFLARE_BQ	19	1	Flare Flow Measurement Bad
TFLARE_BQ	20	1	Flare Temperature Measurement Bad
PFLARE_BQ	21	1	Flare Pressure Measurement Bad
CFLARE_BQ	22	1	Flare Sound Speed Measurement Bad
RESERVED_23	23	1	Reserved, returns 0

Table 9: Modbus Address List - Boolean status registers (read only) (cont.)

Register Tag Name	Register Address	Number of Registers	Description
QSTEAM_BQ	24	1	Steam Flow Measurement Bad
TSTEAM_BQ	25	1	Steam Temperature Measurement Bad
RESERVED_26	26	1	Reserved, returns 0
QAIR_BQ	27	1	Air Flow Measurement Bad
TAIR_BQ	28	1	Air Temperature Measurement Bad
PAIR_BQ	29	1	Air Pressure Measurement Bad
RESERVED_30	30	1	Reserved, returns 0
CALC_SS_BQ	31	1	Calculated Sound Speed Invalid
EM_QN2_DN_BQ	32	1	N2 Flow downstream Measurement Bad
EM_WIND_SPEED	33	1	Double Bond Gas Concentration Bad
EM_DOUBLE_BOND_GAS_BQ	34	1	Ratio of Carbon to Hydrogen atoms Bad
EM_CARBON_HYDROGEN_RATIO_BQ	35	1	Cross Wind Speed Measurement Bad
RESERVED_36	36	1	Reserved, returns 0
RESERVED_37	37	1	Reserved, returns 0
RESERVED_38	38	1	Reserved, returns 0
RESERVED_39	39	1	Reserved, returns 0
METERVAL_DATA_AVAILABLE	40	1	Validation has enough data to run

*Modbus Command 16 (Preset Multiple Registers) may be used if Command 06 (Preset Single Register) is not available.

Table 10: Modbus Address List - Boolean coil registers (read/write)

Register Tag Name	Register Address	Number of Registers	Description
AIR_ASSIST	1	1	TRUE = Continous Variation; FALSE = Discrete/3-speed
ASSIST_TYPE	2	1	TRUE = Air Assist; FALSE = Steam Assist
CALORIMETER	3	1	TRUE = Flare Energy Content from Calorimeter
EM_N2_PURGE	4	1	TRUE = PEMS N2 Purge (Up/Down) Enabled
FUEL_BYPASS	5	1	TRUE = Fuel line bypasses BOTH flare flow meter and GC/Calorimeter; FALSE = Fuel line goes through flare flow meter AND GC/Calorimeter
H2_BTU_CORR_ENABLE	6	1	TRUE = Customer GC/MS does NOT apply 1212 Rule
MB_OVERRIDE	7	1	TRUE = Modbus Override in effect
N2_CONST_VOL_ENABLE	8	1	TRUE = N2 Supplied at constant volume
SI_UNITS	9	1	TRUE = Data in SI Units; FALSE = Data in English Units

3.4.3 flare.IQ units

As shown in Figure 16 on page 18, the end user can configure the flare.IQ Gen 2 software to work with either SI (Metric) or English (Imperial) units using the Services page. The specific units that will be displayed on Flare, Fuel and Control pages of the Web Console for either choice are shown in Table 11.

Table 11: English and Metric (SI) units used in flare.IQ Gen2

Parameter	SI	English
Flare Page		
Flare Diameter	in	in
Flare Low Cut-off	m/s	ft/s
Steam Rate Limit	MTPH/min	PPH/min
Steam Min	MTPH	PPH
Steam Max	MTPH	PPH
Air Min	m^3/sec	CFM
Air Max	m^3/sec	CFM
Volumetric Flow of N2	Nm^3/h	SCFH
Flowmeter Flare Diameter	in	In
Fuel Page		
Fuel Net Heating Value	MJ/m^3	BTU/SCF
Update Rate	Seconds	Seconds
Fuel Min	Nm^3/h	SCFH
Fuel Max	Nm^3/h	SCFH
Monitor Page		
Net Heating Value (actual)	MJ/m^3	BTU/SCF
Fuel Demand	Nm^3/h	SCFH
Steam Demand	MTPH	PPH
Air Demand	m^3/s	CFM
Flare Flow	Nm^3/h	SCFH
Flare Sound	m/s	ft/s
Flare Temperature	°C	°F
Flare Pressure	bar_a	PSIa
Net Heating Value (vent gas)	MJ/m^3	BTU/SCF
Molecular Weight (calc)	g/mol	g/mol
NHVcz Measured	MJ/m^3	BTU/SCF
Tip velocity	m/s	ft/s
Assist Air	m^3/sec	CFM
Assist Air Pressure	pa_g	iwg
Assist Air Temperature	°C	°F
Fuel	Nm^3/h	SCFH
Net Heating Value (current)	MJ/m^3	BTU/SCF
Molecular Weight	g/mol	g/mol

[no content intended for this page]

Chapter 4. Installation & Maintenance

4.1 Power Distribution

Installation and startup must only be carried out by qualified personnel. The relevant country-specific electrical safety codes and regulations (e.g., VDE, DIN) must be observed. Before startup it is important to ensure that:

- The mains have been connected correctly and adequate protection is provided against electric shock.
- The device can be switched off outside the power supply according to EN 60950 regulations (e.g., by the line protection on the primary side).
- All supply lines have sufficient fuse protection and are the correct size.
- All output cables are the correct size for the maximum device output current or have separate fuse protection.
- Adequate convection is available.

After installation the terminal area must be covered to provide sufficient protection against unauthorized access to live parts. This is ensured by installing the system in the control cabinet or distributor box. For reliable and safe-to-touch connections strip 7 mm (0.28 in.) from the connector ends. The following cable cross sections can be used (Copper wiring recommended):

Table 12: Wiring specification for MINI 24 VDC power supply

	Solid [mm2]	Stranded [mm2]	AWG	Torque [Nm]	Torque [lb in]
1 – Input	0.2 - 2.5	0.2 - 2.5	25 - 14	0.5 - 0.6	4.4 - 5.3
2 – Output	0.2 - 2.5	0.2 - 2.5	25 - 14	0.5 - 0.6	4.4 - 5.3
3 – Signal	0.2 - 2.5	0.2 - 2.5	25 - 14	0.5 - 0.6	4.4 - 5.3

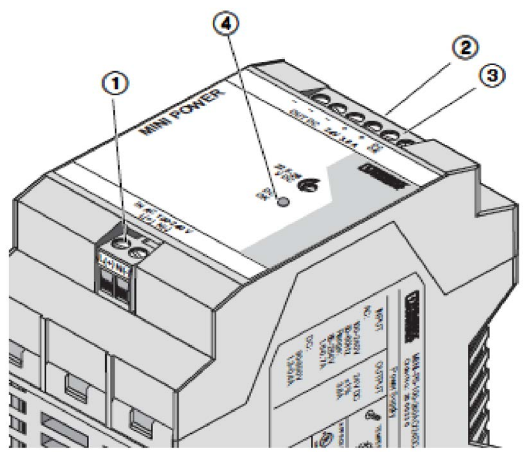


Figure 34: Phoenix Contact MINI-PS-100-240AC/24DC/C2LPS I/O connections

4.1.1 Input (1, Figure 34)

The 100 - 240 V AC connection is made using the L and N screw connections. The power supply in the top module can be connected to single-phase AC networks or to two external conductors for 3-phase networks (TN, TT or IT network according to VDE 0100 T300/IEC364-3) with nominal voltages of 100 - 240 V AC. The device must be installed according to the specifications of EN 60950. It must be possible to switch off the device using a suitable disconnecting device outside the power supply. Note that an all-pole disconnecting device must be provided for 2-phase operation using two external conductors for a three-phase network. For this, line protection on the primary side, for example, is suitable. Further device protection is not required, as an internal fuse is present.

4.1.2 Output (2, Figure 34)

The power supply unit meets the requirements of NEC Class 2. The 24 V DC connection is made using the "+" and "-" screw connections on the screw connection 2. The output voltage set upon delivery is 24 VDC and can be adjusted from 22.5 to 26 V DC on the potentiometer 4. The device is electronically short-circuit-proof and idling-proof. In the event of an error, the output voltage is limited to a maximum of 35 V DC. It should be ensured that all output cables are the correct size for the maximum output current or have separate fuse protection. The cable cross sections in the secondary circuit should be large enough to keep the voltage drops on the cables as low as possible.

4.1.3 Wiring Diagram

The control requires a single or redundant power source(s) and safety ground connection. While the Ethernet switches have built-in terminals to accept two redundant diode-OR'd inputs of 18-36 V DC, the DPU's are powered though a separate Diode redundancy module. The power and Ethernet wiring scheme for individual DPU's is modular in that slots 4 - 6 in the bottom module for redundant DPU's can be left empty (for Digital Validation and PEMS applications) without making any changes to the top module. See detailed wiring diagram in Figure 35 below for more details.

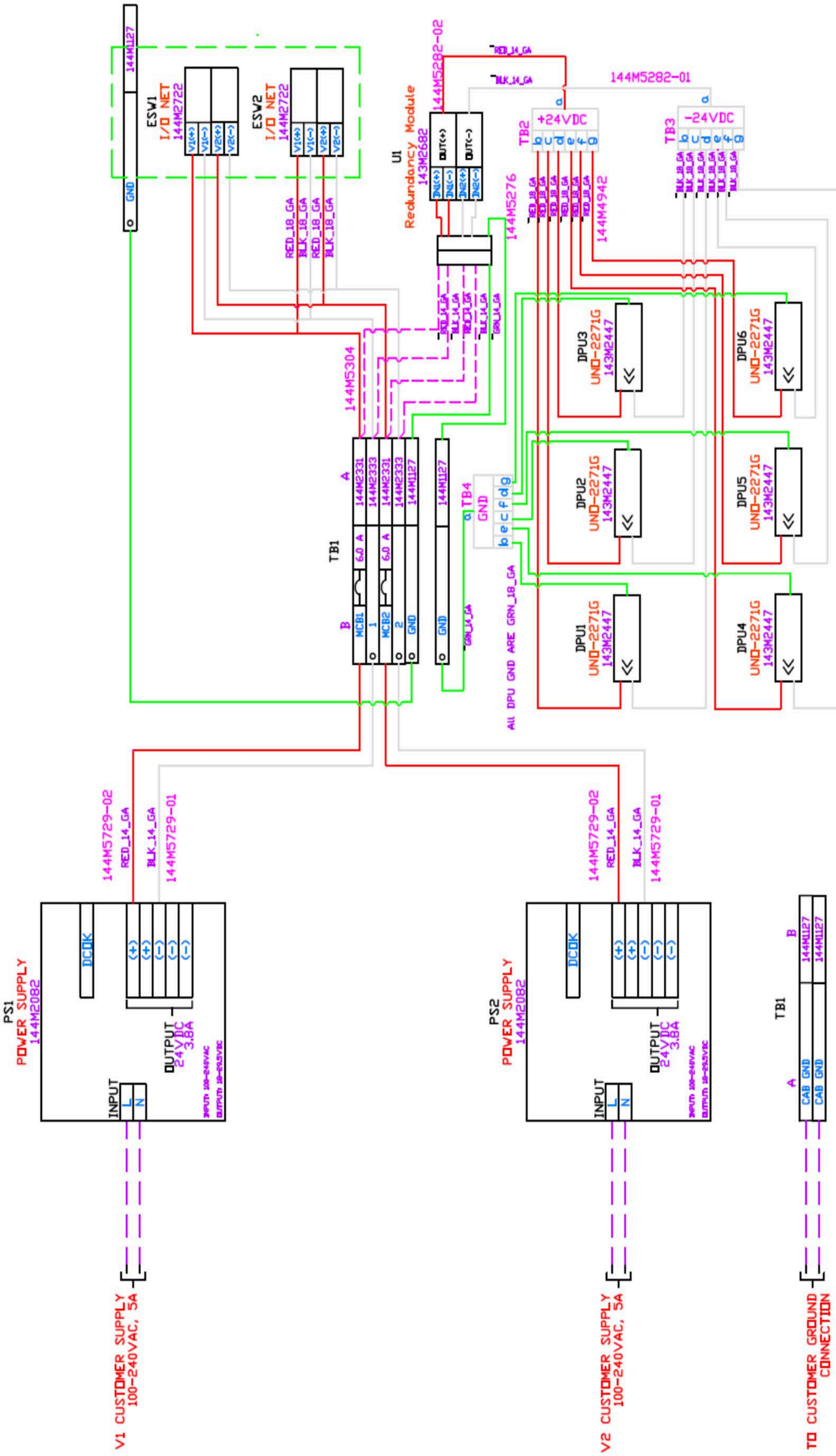


Figure 35: System Wiring Diagram

4.2 Communication Network Diagram

4.2.1 Functional Description

The flare.IQ Gen 2 has two independent unmanaged 8-port network switches installed on the top module – one labeled Flare Control/DCS (Modbus TCP) and the other labeled Configure/Monitor. As shown in Figure 36 below, each DPU installed in the bottom module has two independent ethernet ports – one dedicated to a Web console for configuration and monitoring via the fiqWeb application described in Section 3.3(LAN A), and the other dedicated to Modbus TCP for exclusive use by the plant DCS (LAN B). This scheme of DPU LAN A for plant/DCS inputs and DPU LAN B for system configuration/monitoring also applies to DV and PEMS applications. Any available Ethernet port on the top switch may be used for the Modbus TCP connection from the DCS, while any available port bottom switch may be used for an IP connection to the fiqWeb Web Console.

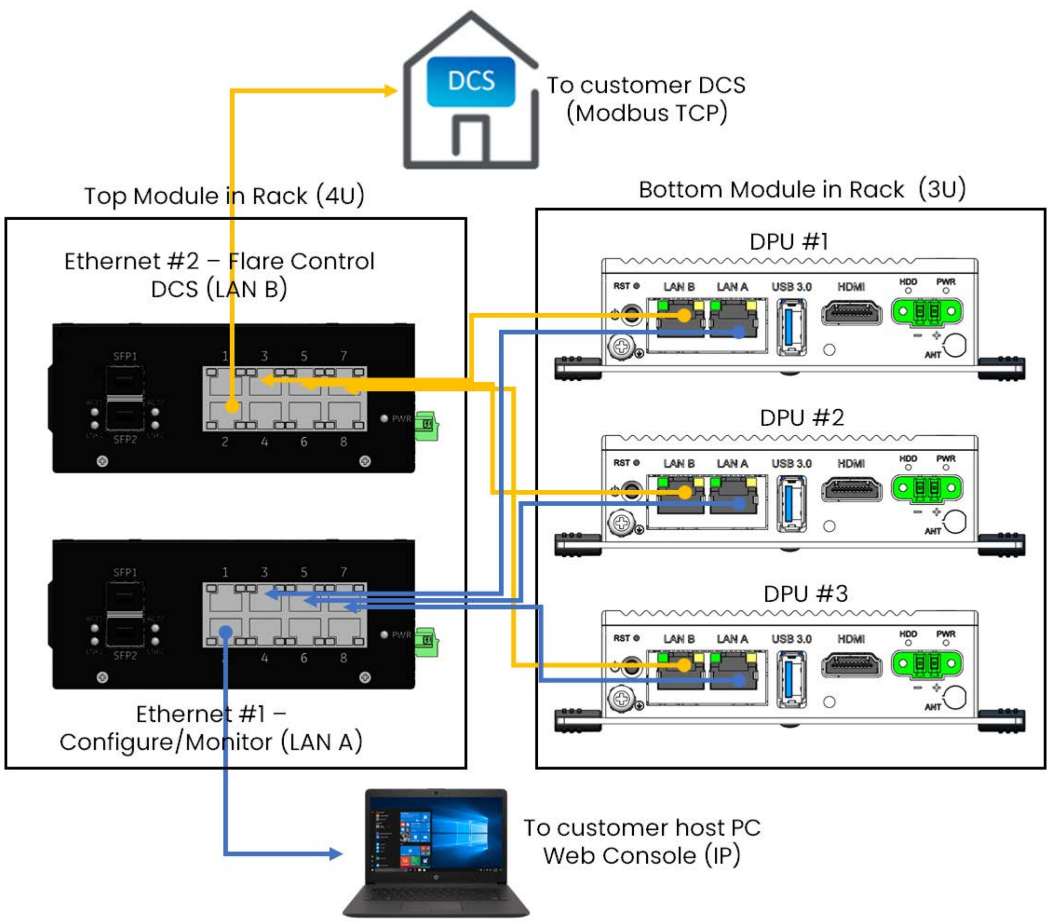


Figure 36: System I/O network connections

4.3 19" Rack Mounting

4.3.1 Functional Description

The flare.IQ Gen 2 system is designed to be mounted in a standard 19" rack mount cabinet. Please note mounting hardware is not included in the shipping box. The top power distribution and network module has 4 mounting points, and the bottom DPU module has 4 mounting points. Recommended mounting hardware is #10-32 X 0.75" long machine screws in conjunction with #10-32 snap-in cage nuts.

Installation shall be in an enclosed rack that requires tool access.

It is recommended that all mounting hardware be either steel with zinc plating or stainless steel. Note that required mounting hardware may vary with 19" rack design. Figure 37 below shows the recommended mounting method.

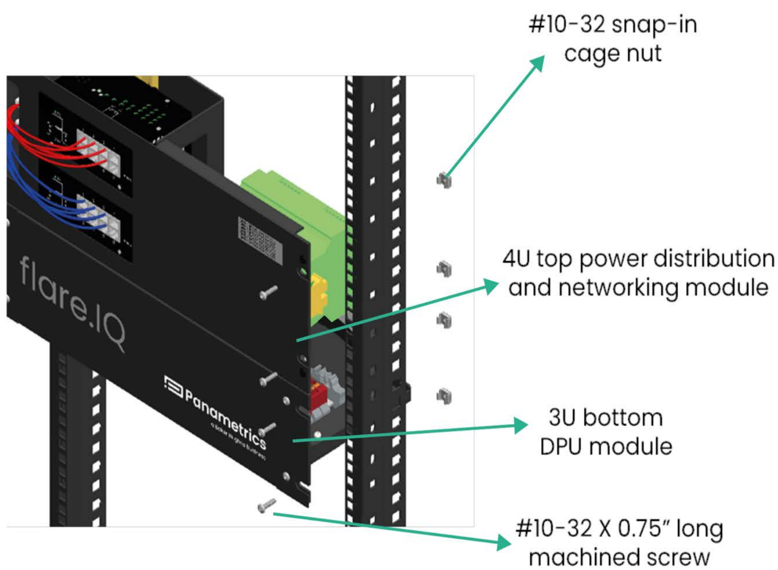


Figure 37: Recommended rack mounting method

The flare.IQ Gen 2 modules will be labelled with location and safety labels to indicate the order in which they are recommended to be installed in the rack. For example, a system with 3 flares will have 2 modules, 1 top power distribution and networking module (with two independent network switches) and 1 bottom DPU module with 6 DPU's. The top module must be installed right above the bottom module with networking cables routed through and they cannot be installed on separate racks.

The bottom module has an open design with the ability to swap out and add DPUs as required by field service engineers. The two Advantech UNO DPU modules for Flare 1 will be labeled #1 and #2, the DPU modules for Flare 2 will be labeled #3 and #4, and so on. The section labels will correspond with the DPU IP addresses for flare numbers as shown below in Table 2 on page 17. The section labels are located on the back of the modules, in the upper right corners. Figure 38 below shows recommended module placement for an example system with 3 flares.

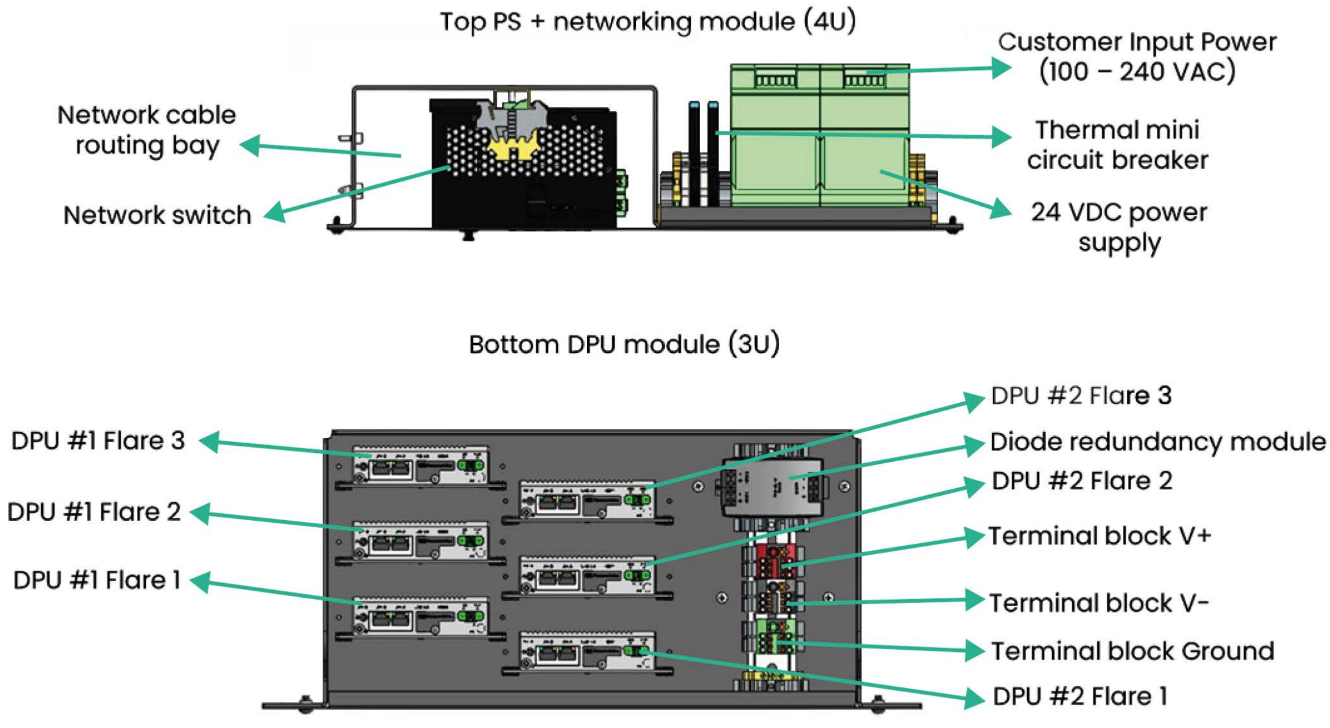


Figure 38: Recommended module and DPU placement (primary #1 and redundant #2 for each flare)

4.4 Replacing a DPU

4.4.1 Installation

The Advantech DPU mounts directly to the panel sheet metal.

To remove the controller

1. Unplug the 24V dc power cable from DPU.
2. Remove the Ethernet cables from the controller.
3. Loosen the upper and lower setscrews mounted on the controller. Slightly lift the module and take out the controller.

To install the controller

1. Mount an upper screw on the panel. Hang the controller on the screw and align it with the panel's lower screw hole.
2. Mount a lower screw and tighten both screws to secure the controller.
3. Connect the corresponding communication interface cables.
4. Plug the system network cables into the Ethernet ports (LAN A & LAN B) of the controller.
5. Plug the dual-24V dc power cable into the power input socket on the top of the controller.

Electronic controls contain static-sensitive parts. Observe the following precautions to prevent damage to these parts. Discharge body static before handling the control equipment.

Do not touch the components or connectors on electronic equipment with your hands.

4.5 Environment

4.5.1 Mounting Location

Consider these requirements when selecting the mounting location:

- Adequate ventilation for cooling.
- Space for servicing and repair.
- Protection from direct exposure to water or to a condensation-prone environment; a cabinet with at least an IP52 rating.
- Protection from high-voltage or high-current devices, or devices which produce electromagnetic interference.
- Avoidance of vibration.
- Selection of a location that will provide an operating temperature range of 0°C to 40°C (32°F to 104°F) with less than 95% humidity (non-condensing).

4.6 Spare Parts List

The following is the recommended spare parts list for flare.IQ Gen 2 hardware.

Table 13: Spare parts list

Part Number	Part Name	Part Description
flare.IQ_KT_DPU	flare.IQ Gen2 DPU & accessories Kit	Advantech UNO 2271G DPU with mounting hardware and cables
144M2082	Power Supply	Phoenix Contact 24VDC Power Supply
144M2722	Ethernet Switch	8 Port Ethernet Switch
144M5276	Power harness	Wiring harness (Top Module to Red Module)
144M5852, 144M5850	Ethernet cable	Ethernet Cables CAT5E Shielded (Blue, Yellow)

4.7 Reliability

The failure rates of the 4 major hardware components (Advantech UNO 2271G DPU, GEAE ESWx Network switch, Phoenix Contact MINI-PS-100 power supply, Puls MLY10.241 Dual redundancy module) are specified at an ambient temperature of 30°C or 40°C. Based on these specifications, the calculated Mean Time Between Failures (MTBF) for the flare.IQ Gen 2 system at 30°C ambient is **386,650 hours** or **44.14 years**.

4.8 Technical Regulations & Standards

The flare.IQ Gen 2 complies with IEC 61010-1:2010, AMD1:2016 and additional national differences. It also bears the CE mark in compliance with the 2014/30/EU EMC and the 2014/35/EU LVD directives.

4.9 Cyber Security

This product was developed with the guidance of the ISA/IEC 62443 cyber security standard. Even though reasonable efforts to investigate, confirm, and resolve security vulnerabilities in this product have been made, risks still exist.

4.9.1 Precautions

As such, the flare.IQ Gen 2 DPU ports LAN A / LAN B and the Ethernet switches they are connected to should **never** connect to a switch or computer that is connected to the internet or business IT infrastructure. The flare.IQ Gen 2's Ethernet switch should only be connected to the DCS's Modbus communications module as a direct connection if possible. The default password should also be changed to a password of 8 or more characters.

4.9.2 Exposed Ports and Services

The flare.IQ Gen 2 DPU uses or exposes the following ports and services to provide network communications:

Table 14: Network port assignments on DPU

Port	Service/Description
80	Web Console (TCP), http
443	Web Console (TCP), https / TLS
502*	Modbus/TCP

The port used by Modbus/TCP can be reassigned using the Web Console to another value if required by the local network infrastructure

The two Ethernet ports provided on each DPU are isolated from each other at both the hardware and software level. This is to isolate the DCS subnet carrying the Modbus/TCP traffic from any possible interference from a web console user connected to the alternate Ethernet port. Two independent TCP/IP network stacks run as separate processes on the DPU. There is no means or provision to 'bridge' the connections together. Network traffic on LAN A is not visible on LAN B, or the reverse. Care should be taken to only connect LAN A to the Configure/Monitor network switch, and LAN B only to the DCS/Control network switch. The two network switches should **never** be connected to each other.

Both LAN A and LAN B support Internet Control Message Protocol (ICMP), or 'ping' echo request and reply messages. As described in Section 3.3.2, DHCP is not supported. Static IP addresses must be reserved and assigned for each DPU connection.

The Web Console provides user accounts and pre-defined roles to limit access to authorized personnel. As shipped, only a single Web Console 'admin' account is provided. The default password for the admin account is 'admin'.

It is essential that the admin password be changed immediately by the customer and recorded in a secure location.

BH cannot retrieve a lost or forgotten admin password. Passwords are never stored or transferred in plaintext, only as a 'salted' hash, which is considered a 'one-way' function that is unfeasible to reverse.

Note that accounts created via the Web Console only provide access to the Web Console. These accounts have no access permissions on the host operating system.

The flare.IQ Gen 2 only requires that passwords be a minimum of eight characters in length. The product does not enforce specific combinations of numbers, symbols, or upper/lower case characters. It is expected that the customer is aware of the risks inherent in the use of weak passwords and will apply their own requirements at the time of account creation.

From time to time, BH may make available software updates to add features or correct defects. These updates will typically be provided by Panametrics Service, and available for download over the internet from a designated location. Depending on the agreed terms and conditions, please note these software updates to correct for defects are provided free of charge. Any newly added product software features have to be purchased.

BH digitally signs the software update packages it provides, and the flare.IQ Gen 2 verifies the digital signature before performing an update. Update packages not signed by BH are automatically refused by the flare.IQ. This is to prevent installation of malicious software that could damage the flare.IQ Gen 2, affect its accuracy, or compromise the network security of its customers.

Appendix A. Modbus map for legacy flare.IQ Gen 1 installations

flare.IQ Gen 2 is designed to be backward compatible with Gen 1 installations for flare control applications (digital meter verification feature is not available in Gen 1). For those customers that wish to continue to use their existing DCS configuration for flare control, the Gen 2 system supports the Modbus Map of unsigned integers shown in Table 11 (analog inputs) and Table 12 (analog outputs). Since all analog values sent and received must be integers, these values have to be scaled appropriately as described in section A.1 to maintain the desired range and accuracy. The "Scaling" column in the table below shows the scaling factor to multiple or divide a value by before sending or after receiving (/ = divide, * = multiply) on DCS master.

Table 15: Modbus address list for flare.IQ Gen 1 legacy customers (analog inputs) for flare control with scaling factors

Register Tag Name	Register Address	Number of Registers	Units	Description	Scaling factor
AR	10	1	Fraction	Argon Concentration (0.0 to 1.0)	*10
CO2	11	1	Fraction	Carbon Dioxide Concentration (0.0 to 1.0)	*10
CO	12	1	Fraction	Carbon Monoxide Concentration (0.0 to 1.0)	*10
H2	13	1	Fraction	Hydrogen Concentration (0.0 to 1.0)	*10
N2	14	1	Fraction	Nitrogen Concentration (0.0 to 1.0)	*10
O2	15	1	Fraction	Oxygen Concentration (0.0 to 1.0)	*10
H2O	16	1	Fraction	Water Vapor Concentration (0.0 to 1.0)	*10
MW_INPUT	20	1	g/mol	Molecular Weight from GC/MS	*100
NHVVG_INPUT	21	1	BTU/SCF	Net Heating Value of Vent (flare) Gas	*10
QFUEL_TC	30	1	SCFH	Fuel Gas Flow Rate	/10
QFLARE_TC	40	1	SCFH	Flare Flow Rat	/100
TFLARE_TC	41	1	Deg F	Flare Temperature	*10
PFLARE_TC	42	1	PSIa	Flare Pressure	*100
CFLARE_TC	43	1	ft/s	Flare Sound Speed	*10
QSTEAM_TC	50	1	PPH	Steam Flow Rate	/10
TSTEAM_TC	51	1	Deg F	Steam Temperature	*10
PSTEAM_TC	52	1	PSIg	Steam Pressure	*100
QAIR_TC	60	1	CFM	Air Flow Rate	/10
TAIR_TC	61	1	Deg F	Assist Air Temperature	*10
PAIR_TC	62	1	iwg	Assist Air Pressure	*100
QN2_TC	70	1	SCFH	Volumetric flow of Nitrogen	*10
MW_LOW_CF	81	1		Low Molecular Weight Correction Factor	*100
MW_NORM_CF	82	1		Normal Molecular Weight Correction Factor	*100
MW_HIGH_CF	83	1		High Molecular Weight Correction Factor	*100
GC_UPDATE_RATE	90	1	seconds	Expected time between GC/MS updates	*1
MW_LOW	110	1		Low Molecular Weight to apply Correction Factor	*100
MW_NORM	111	1		Normal Molecular Weight to apply Correction Factor	*100

Table 15: Modbus address list for flare.IQ Gen 1 legacy customers (analog inputs) for flare control with scaling factors (cont.)

Register Tag Name	Register Address	Number of Registers	Units	Description	Scaling factor
MW_HIGH	112	1		High Molecular Weight to apply Correction Factor	*100
QFUEL_MIN	130	1	SCFH	Minimum Fuel Flow Parameter	*1
QFUEL_MAX	131	1	SCFH	Maximum Fuel Flow Parameter	/10
FLARE_DIAM	140	1	in	Flare Tip Diameter	*100
FLARE_METER_DIAM	141	1	in	Flare Meter Diameter	*100
QSTEAM_MIN	150	1	PPH	Minimum Steam Flow Parameter	*1
QSTEAM_MAX	151	1	PPH	Maximum Steam Flow Parameter	/10
QAIR_LOW	160	1	CFM	Low Air Flow	/10
QAIR_MID	161	1	CFM	Mid Air Flow	/10
QAIR_HIGH	162	1	CFM	High Air Flow	/10
QAIR_MIN	170	1	CFM	Minimum Air Flow Parameter	*1
QAIR_MAX	171	1	CFM	Maximum Air Flow Parameter	/100

Table 16: Modbus address list for flare.IQ Gen 1 legacy customers (analog outputs) for flare control with scaling factors

Register Tag Name	Register Address	Number of Registers	Units	Description	Scaling Factor
QFUEL_DEMAND	0	1	SCFH	Fuel Gas Demand	*10
QSTEAM_DEMAND	1	1	PPH	Steam Demand	*10
NHVCZ_ACTUAL	2	1	BTU/SCF	Net Heating Value in the Combustion Zone Calculated	1
VTIP_ACTUAL	3	1	ft/s	Flare Tip Velocity Calculated	/100
VTIP_MAX	4	1	ft/s	Flare Tip Velocity Maximum	/100
MW_CALC	5	1	g/mol	Molecular Weight Calculated	/100
NHVCZ_MEASURED	6	1	BTU/SCF	Net Heating Value in the Combustion Zone derived from GC/Calorimeter	*1
NHVCZ_CURRENT	7	1	BTU/SCF	Net Heating Value in the Combustion Zone derived from Mol Weight	*1
NHVCZ_MEASURED_TC	8	1	BTU/SCF	Net Heating Value in the Combustion Zone at Current Fuel and Steam	*1
NHVCZ_UNCORRECTED_TC	9	1	BTU/SCF	NHVcz uncorrected for H2 at Current Fuel and Steam	*1

Table 16: Modbus address list for flare.IQ Gen 1 legacy customers (analog outputs) for flare control with scaling factors (cont.)

Register Tag Name	Register Address	Number of Registers	Units	Description	Scaling Factor
NHVCZ_UNCORRECTED_ACTUAL	10	1	BTU/SCF	NHVcz uncorrected for H2 at Demand Fuel and Steam	*1
NHVCZDIL_ACTUAL	11	1	BTU/SCF	NHV Dilution Parameter Calculated (Air Assist only)	/10
NHVCZDIL_MEASURED	12	1	BTU/SCF	NHV Dilution Parameter from GC/Calorimeter (Air Assist only)	/10
NHVCZDIL_MEASURED_TC	13	1	BTU/SCF	NHV Dilution from GC/Calorimeter at Current Conditions (Air Assist only)	/10
CF_ASSIST	14	1		Air/Steam Correction Factor as a function of Mol Weight	*1
QAIR_DEMAND	15	1	CFM	Air Demand	*10

A.1 Scaling Modbus Data (for legacy Gen 1 systems only)

All analog data is transferred to/from the flare.IQ as 16-bit, unsigned integers. Each input parameter and output value occupy a single 16-bit Modbus register. To maintain the desired dynamic range or turndown, data may be scaled by multiplying or dividing by a multiple of ten.

Example 1:

XH2_INPUT is a value written to the flare.IQ containing the percentage of Hydrogen in the flare gas, expressed in the Modbus Address List as:

Cmd: Address	Signal Name	Description	Cfg	Scaling	Units
X:0013	XH2_INPUT	Hydrogen Content (from GC/MS)		*10	%

The GC/MS data indicates that the H2 content is 27.5%. Applying the Scaling factor (*10):27.5 * 10 = 275.

275 is the integer value that should be written to Modbus register 0013 with Command 06 (Preset Single Register).

Example 2:
QFUEL_DEMAND is a value read from the flare.IQ containing the amount of supplemental fuel in Standard Cubic Feet per Hour (SCFH) required for compliance. It is expressed in the Modbus Address List as:

Cmd: Address	Signal Name	Description	Cfg	Scaling	Units
4:0001	QFUEL_DEMAND	Fuel Gas Demand		*10	SCFH

Reading Modbus register 0001 with Command 04 (Read Input Register) returns the integer value 3125.

Applying the Scaling factor (*10):3125 * 10 = 31,250

31,250 SCFH is the amount of supplemental fuel required for compliance.

Example 3:

EVTIP_ACTUAL is a value read from the flare.IQ containing the velocity of the flare gas through the flare tip in feet per second (ft/s). It is expressed in the Modbus Address List as:

Cmd: Address	Signal Name	Description	Cfg	Scaling	Units
4:0004	VTIP_ACTUAL	Flare Tip Velocity Calculated		/100	ft/s

Reading Modbus register 0004 with Command 04 (Read Input Register) returns the integer value 4833. Applying the Scaling factor (/100):4833/100 = 48.33
48.33 ft/s is the calculated flare gas velocity.

Appendix B. flare.IQ Secure Operations Guide

The following guidelines will help the end user operate the flare.IQ software application securely within their DCS network:

- To configure flare.IQ using the Web Console application, a direct hardwired connection between the PC and the flare.IQ Gen 2 DPU is recommended. Use of any USB to TCP/IP conversion software or devices is strictly prohibited.
- Regularly check for flare.IQ software upgrades and patches from Baker Hughes.
- When receiving any flare.IQ software installer or upgrade package, always check the software Checksum/Hash before installation or usage.
- Install and scan any PC's connected to the flare.IQ regularly with well-known and updated Anti-Virus software.
- For any flare.IQ software related problems, please contact Panametrics Tech Support at panametricstechsupport@bakerhughes.com
- Be vigilant and report back to Panametrics Tech Support any unusual activity on a PC connected to the flare.IQ DPU (which may not always be running the Web Console application) such as:
    - Unknown installed software applications
    - Change of security configurations without knowledge
    - Unknown files
- Ensure that any files generated using the flare.IQ software application are circulated only amongst trusted members.

IMPORTANT: *It is the end user's responsibility to abide by the above cyber security recommendations. Baker Hughes has no control over the flare.IQ usage environment or misuse of this product. The end user assumes all risk and responsibility for proper use of the product.*

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Appendix C. Glossary of Terms and Abbreviations

bara	Bars absolute (pressure relative to vacuum)
BTU/SCF	British Thermal Units Per Standard Cubic Foot
CFM	Cubic Feet Per Minute
DCS	Distributed Control System
DPU	Digital Processing Unit
ft/s	feet per second
g/mol	grams per mole
ICMP	Internet Control Message Protocol (Internet Engineering Task Force RFC 792)
In	Inches
iwg	Inches of Water Gauge
Nm^3/h	Normal Cubic Meters Per Hour
MACT	Maximum Achievable Control Technology (EPA Standard)
Mbps	Megabits Per Second
MBps	Megabytes Per Second
MJ/m^3	Megajoules Per Cubic Meter
m/s	Meters Per Second
m^3/s	Cubic Meters Per Second
MTPH	Metric Tons Per Hour
MTPH/min	Metric Tons Per Hour Per Minute (rate of change)
PPH	Pounds Per Hour
PPH/min	Pounds Per Hour Per Minute (rate of change)
PSIa	Pounds Per Square Inch Absolute (pressure relative to vacuum)
SCFH	Standard Cubic Feet Per Hour
TCP	Transmission Control Protocol
UDP	User Datagram Protocol

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Warranty

Each instrument manufactured by Panametrics is warranted to be free from defects in material and workmanship. Liability under this warranty is limited to restoring the instrument to normal operation or replacing the instrument, at the sole discretion of Panametrics. Fuses and batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If Panametrics determines that the equipment was defective, the warranty period is:

- One year from delivery for electronic or mechanical failures.
- One year from delivery for sensor shelf life.

If Panametrics determines that the equipment was damaged by misuse, improper installation, the use of unauthorized replacement parts, or operating conditions outside the guidelines specified by Panametrics, the repairs are not covered under this warranty.

The warranties set forth herein are exclusive and are in lieu of all other warranties whether statutory, express or implied (including warranties or merchantability and fitness for a particular purpose, and warranties arising from course of dealing or usage or trade).

Return Policy

If a Panametrics instrument malfunctions within the warranty period, the following procedure must be completed:

1. Notify Panametrics, giving full details of the problem, and provide the model number and serial number of the instrument. If the nature of the problem indicates the need for factory service, Panametrics will issue a RETURN MATERIAL AUTHORIZATION (RMA), and shipping instructions for the return of the instrument to a service center will be provided.
2. If Panametrics instructs you to send your instrument to a service center, it must be shipped prepaid to the authorized repair station indicated in the shipping instructions.
3. Upon receipt, Panametrics will evaluate the instrument to determine the cause of the malfunction.

Then, one of the following courses of action will then be taken:

- If the damage is covered under the terms of the warranty, the instrument will be repaired at no cost to the owner and returned.
- If Panametrics determines that the damage is not covered under the terms of the warranty, or if the warranty has expired, an estimate for the cost of the repairs at standard rates will be provided. Upon receipt of the owner’s approval to proceed, the instrument will be repaired and returned.

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Customer Support Centers

U.S.A.
The Boston Center
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Scan here for Panametrics support and service information

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