flare.IQ
Generation 2

Operation and maintenance manual

Panametrics
a Baker Hughes business

flare.IQ

Generation 2

Operation and maintenance manual

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Product registration

Thank you for purchasing your flare.IQ from Panametrics. Please register your product at https://info.bakerhughes.com/New-Product-Registration-LP.html for product support such as the latest software/firmware upgrades, product information and special promotions.

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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, extended warranties, service agreements and more. Please visit https://www.bakerhughesds.com/panametrics/flow-measurement/flow-measurement-services for more details.

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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 marking 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

	WARNING!
⚠️	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.
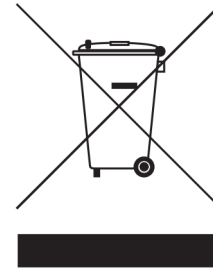
Environmental compliance

RoHS

The flare.IQ fully complies with RoHS regulations (directive 2011/65/EU).

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

Contents

Chapter 1. General information

1.1   Introduction

This manual contains information about the installation, operation, and maintenance of the flare.IQ Gen 2 control system. Proprietary flare control and flare flow meter validation software is installed on a rack mounted assembly of industrial embedded automation computers. 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.

1.2   Application

flare.IQ is a control computer that receives inputs and sends outputs to the customer's distributed control system (DCS) via TCP/IP Modbus to control a flare's fuel gas and steam supply valves (see figure 1). The software algorithm in flare.IQ uses the sound speed measured by Panametrics' 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 demand are then calculated based on current net heating values, hydrocarbon molecular weight and flare vent gas flow. 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 online vent gas BTU and/or composition analyzer such as a gas chromatograph. It also utilizes a variety of meter diagnostics such as signal strength, transit times, path length, and difference in channel velocities.
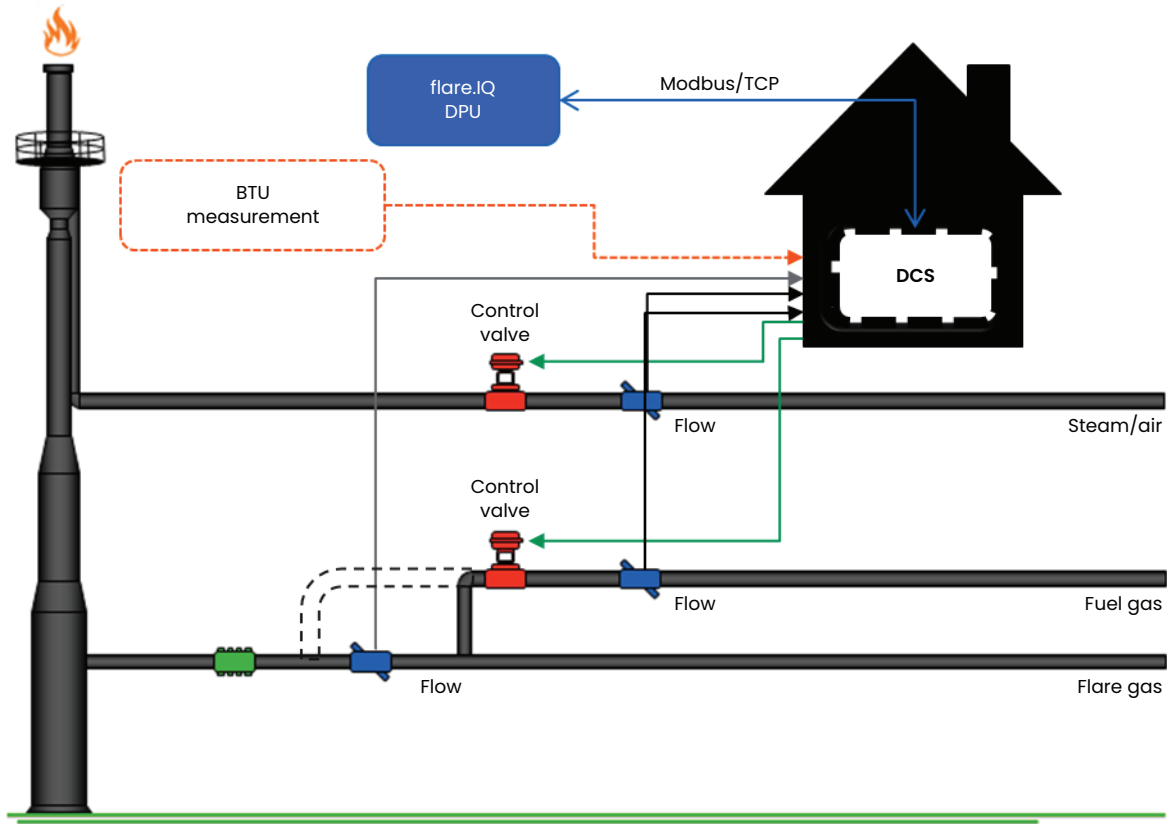
Figure 1: Schematic of flare.IQ-based control of flare assist (steam/air) and supplemental fuel

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. 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).

4U high power distribution and network module (top).

One power distribution and network module can support up to six DPUs

3U high DPU module (bottom)
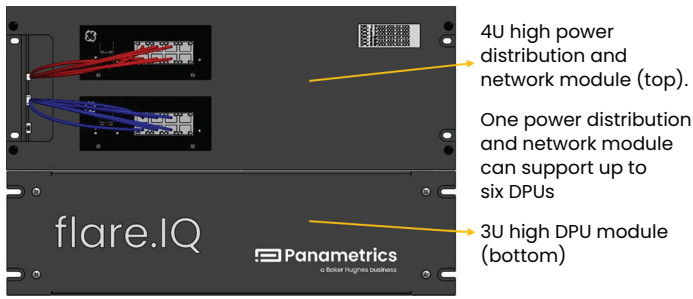
Figure 2: Front view of rack mounted control equipment

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

⚠	**WARNING!**
	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. 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.

⚠	**WARNING!**
	Installation shall be in an enclosed rack that requires tool access.

You should discuss environmental and installation factors with a Panametrics 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.

⚠	**WARNING!**
	Provisions have been made for landing protective earth connection on appropriately marked DIN rail mounted grounding modules as shown in figure 4. The ground module is electrically connected to the DIN rail, which in turn is connected to the chassis via a PEM fastener. The power cord's ground wire (25 – 14 AWG) terminates singly in the protective earth grounding module (figure 4) which includes captive screws.

Redundant 3.8A 24 VDC universal input power supplies

Mini circuit breaker distribution, and input source grounding

Diode redundancy module for DPU power
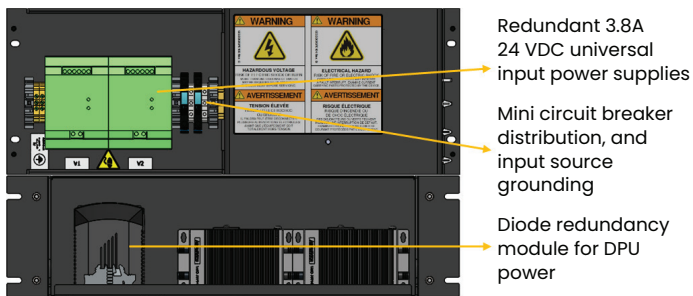
Figure 3: Rear view showing input power connections and power supplies

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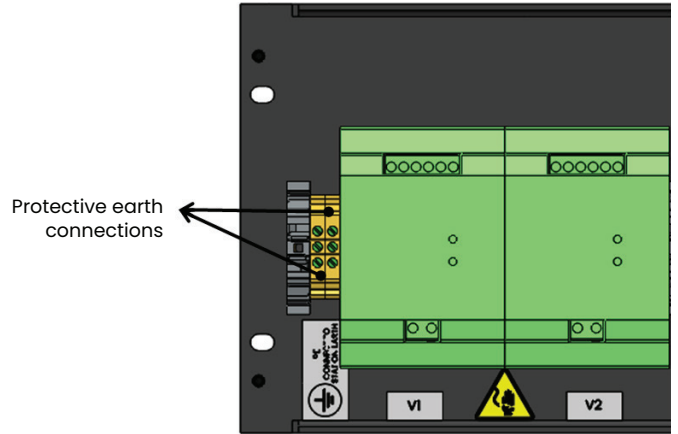
Figure 4: Rear view close-up of top module showing protective earth grounding

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.

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

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 software by itself does 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

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 sold-state storage.
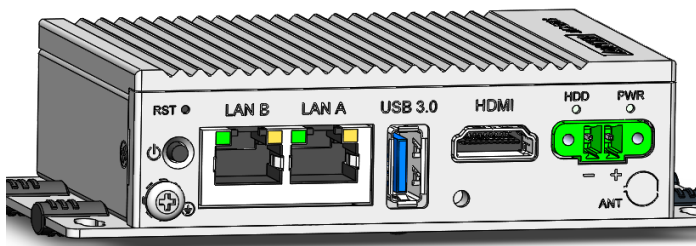

Figure 6: Advantech DPU front view

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.

Power connector

The DPU features a Phoenix contact connector that is compatible with 10–30 VDC input power shown in figure 7. The added inclusion of reversed wiring protection means reversed wiring of the ground line and power line wiring 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 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 attachment of a monitor display for use by service personnel if required. A silicone rubber dust plug is provided to increase protection of the DPU during regular operation.

RTC battery specification

The DPU is equipped with an 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, Panametrics reserves the right to change the DPU hardware provided 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 power 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

GE's 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

Chapter 3. Software

3.1   Overall architecture

All flare.IQ software applications run 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 flare control and meter validation data acquisition and processing, 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. It can also be used to monitor the functionality of flare.IQ during operation.

3.2   Functional description

3.2.1   Flare control

The flare control software algorithm uses the speed of sound measured by Panametrics' 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 (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.
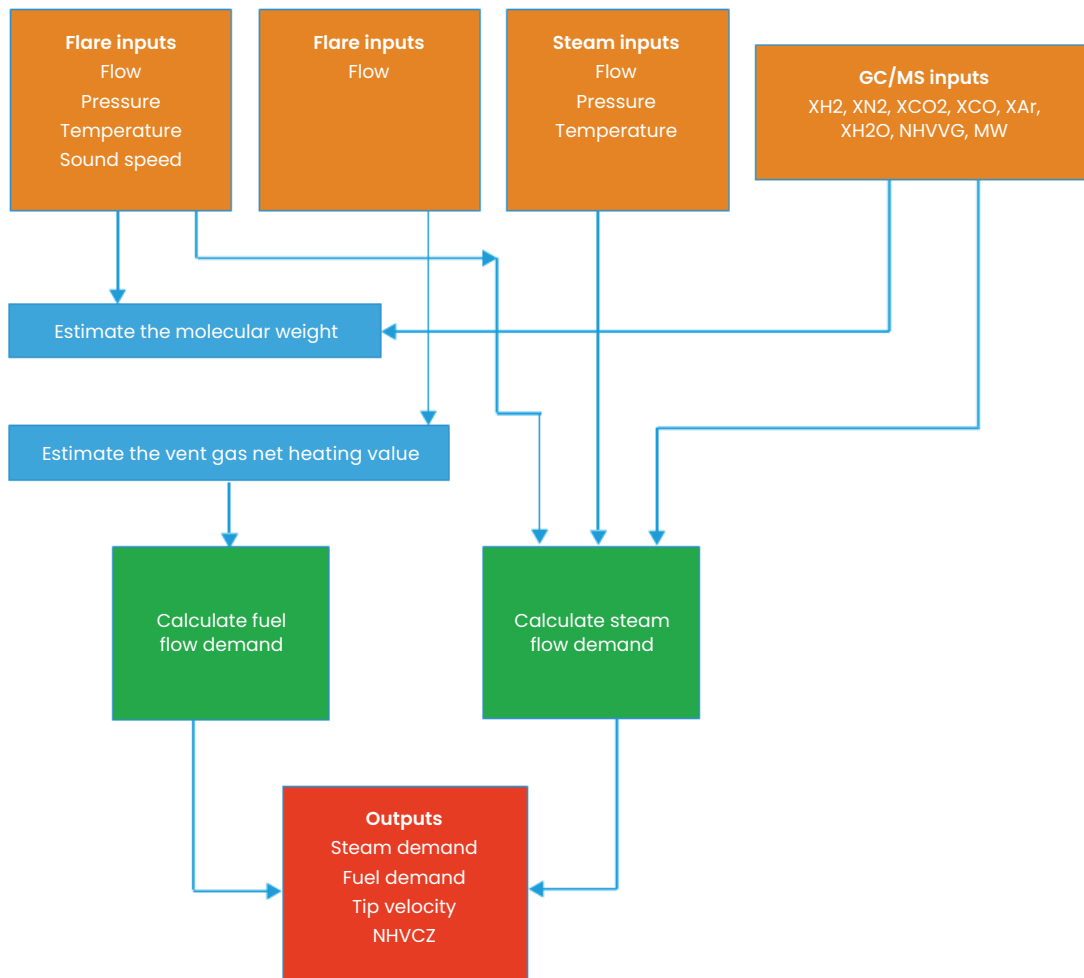

Figure 8: High-level flare control process logic flow

3.2.2 Flare meter validation

Ultrasonic flare flow meters are widely used 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. Currently, this typically 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, and generate a pass/fail evaluation report for the meter after performing certain tests and reviewing the 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 without human intervention into the flare.IQ Gen 2 system. 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.

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. 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.

The high-level logic for the GF 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. 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 in CSV format.
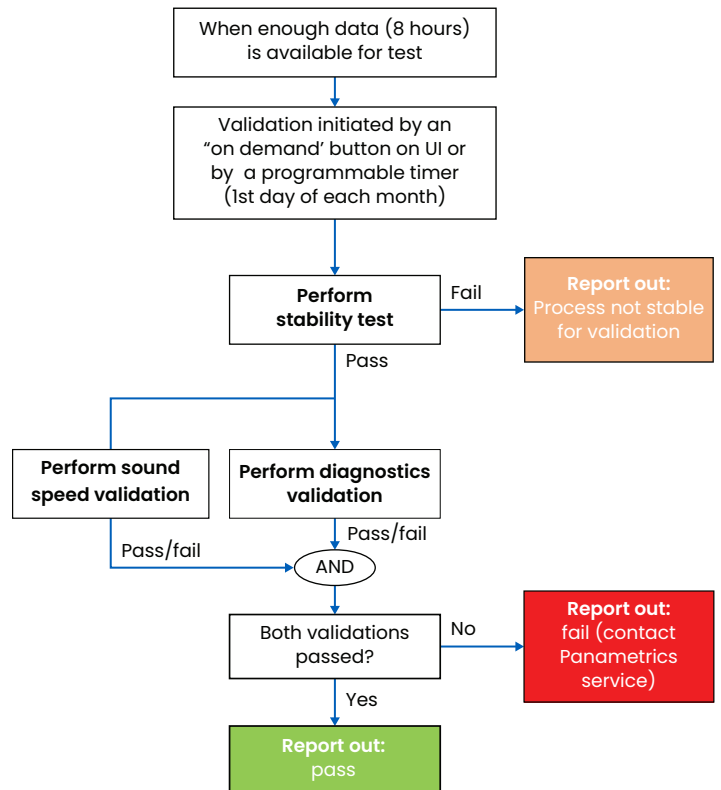
Figure 10: Flare flow meter validation logic
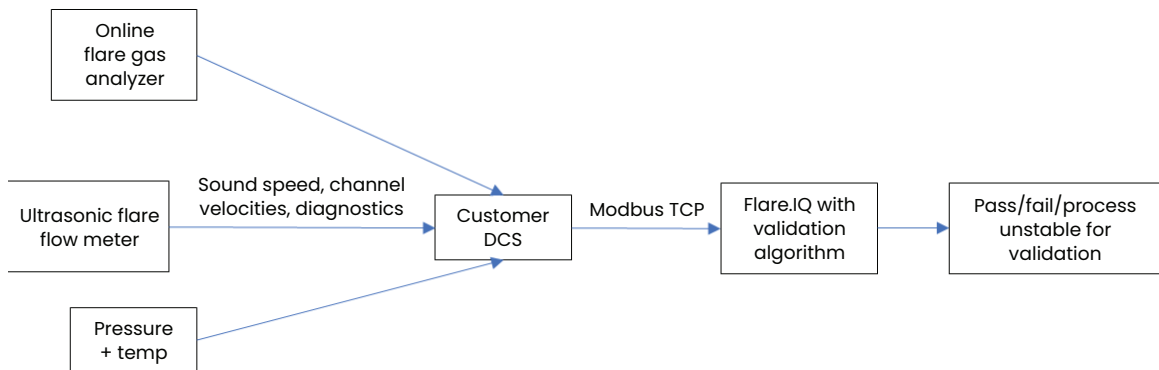
Figure 9: Digital flare flow meter validation scheme

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 and digital verification. 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. From your web browser enter <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 11 below.
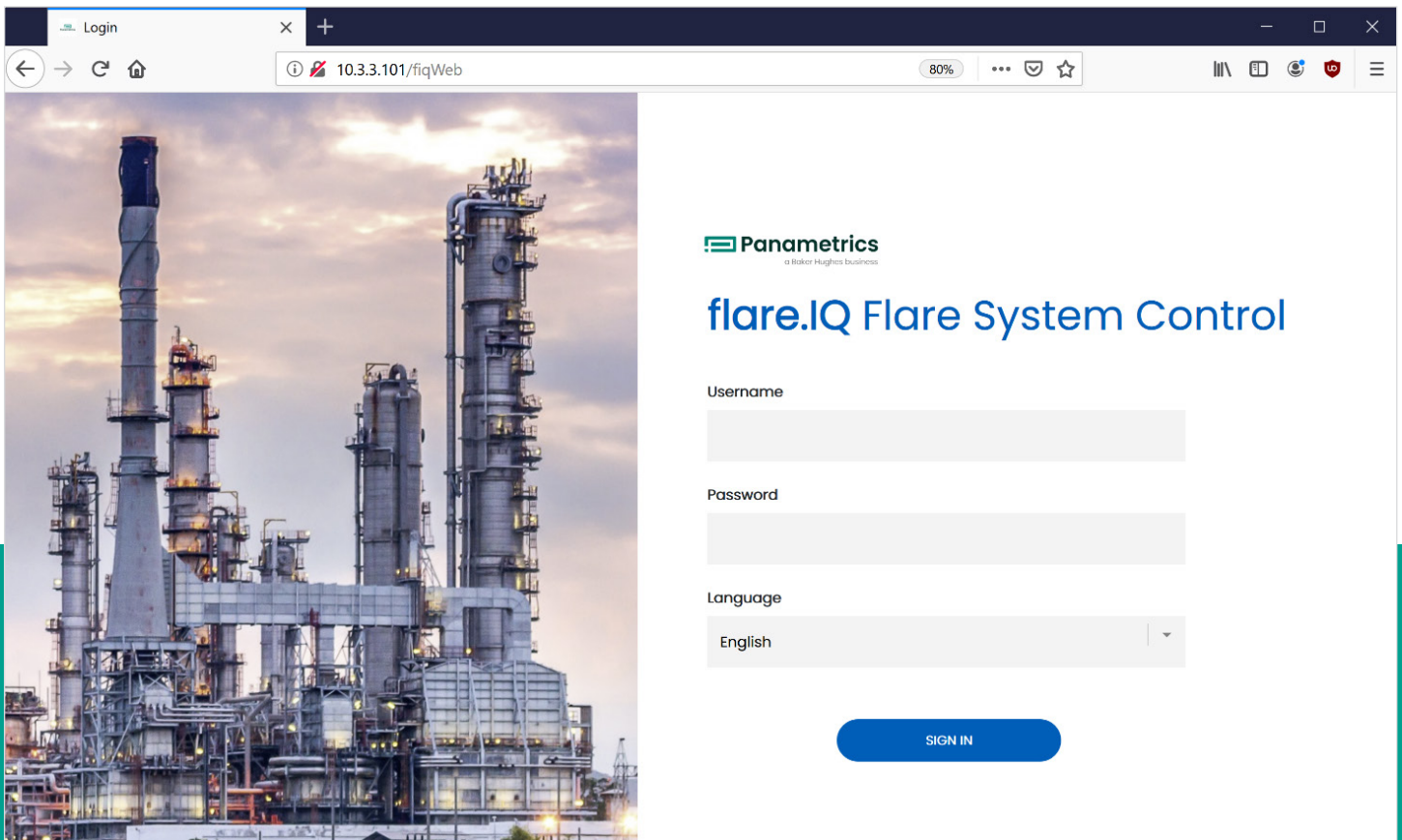
Figure 11: Log in screen of the web console application

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 administrative password, the user is led to the service tab from where they can navigate to the features tab shown in figure 12 to upload appropriate software 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 12.

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 13). 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.

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.

Figure 12: Web console service page upon initial login prior to installation of any valid licenses

Figure 13: Web console features page after uploading software license information

3.3.1 User roles

There are four 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.
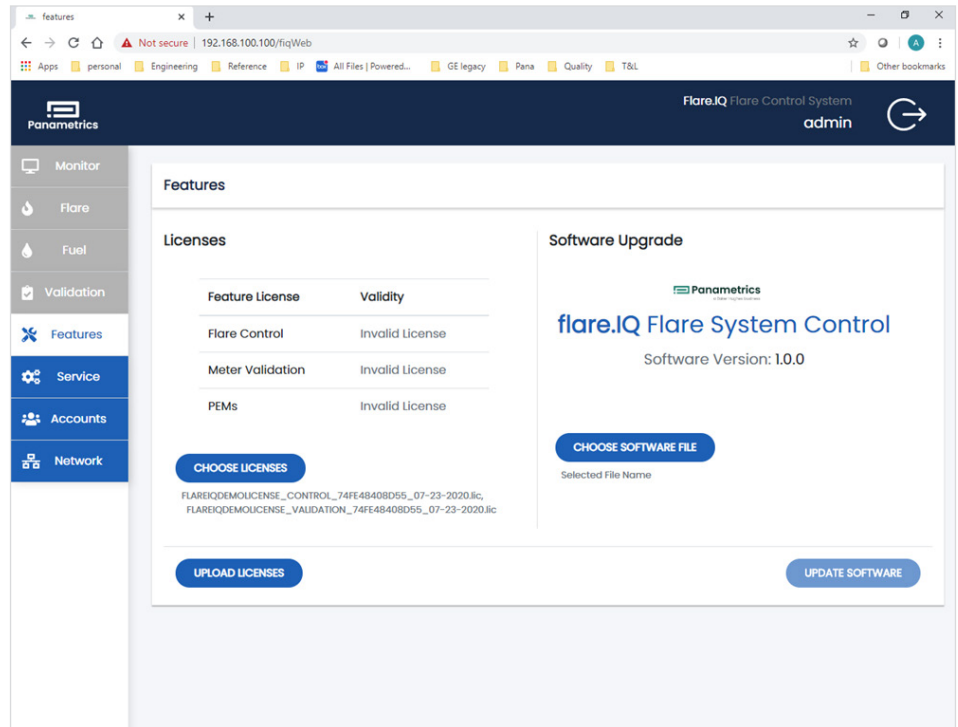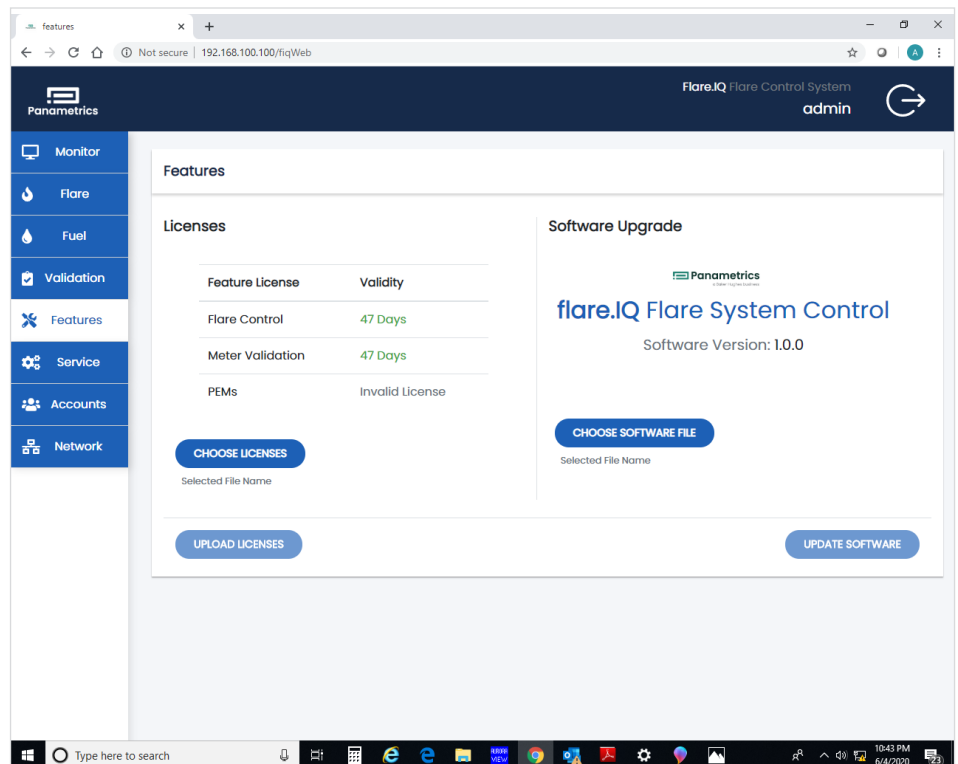
- **Field Service:** Field service accounts have the highest level of access with the added ability to update software via the Features page and upload/download configuration files for meter validation on the service page. Panametrics service personnel will typically create a field service account so 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 monitor, flare, and fuel 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 monitor page and may change their own password on the accounts page.

Figure 14 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.

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
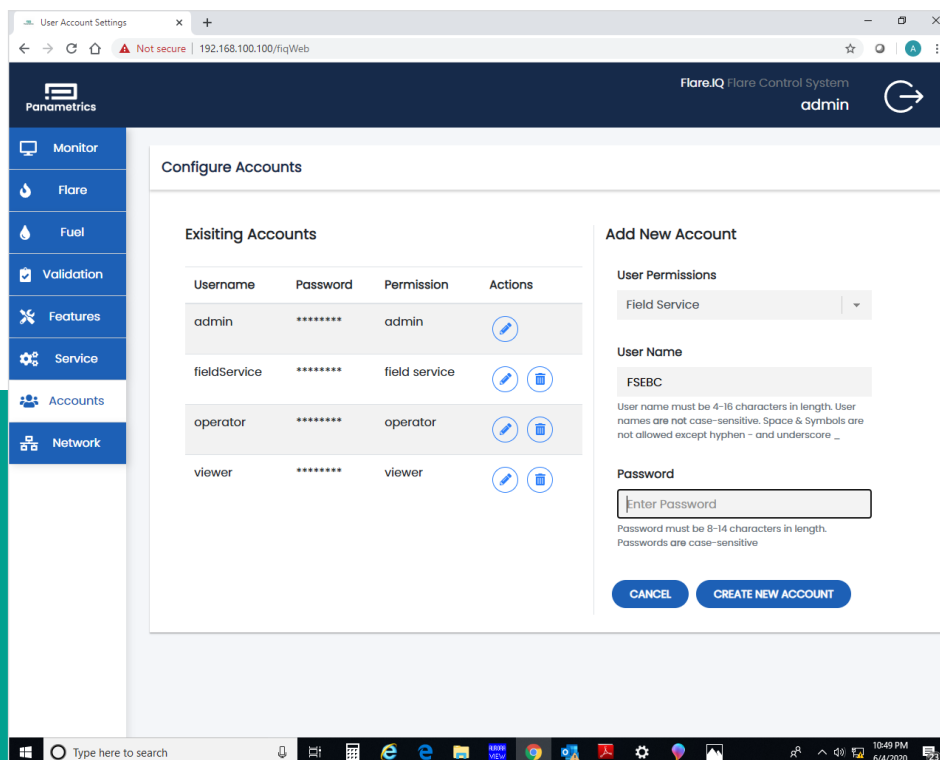
Figure 14: Web console accounts page showing procedure of setting up new accounts with different access levels.

Figure 15 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).

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 16 shows the service page of the web console which enables the following important system settings:

- Choice of units of measure – SI (metric) vs. English (imperial)

- Ability to download/upload 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).
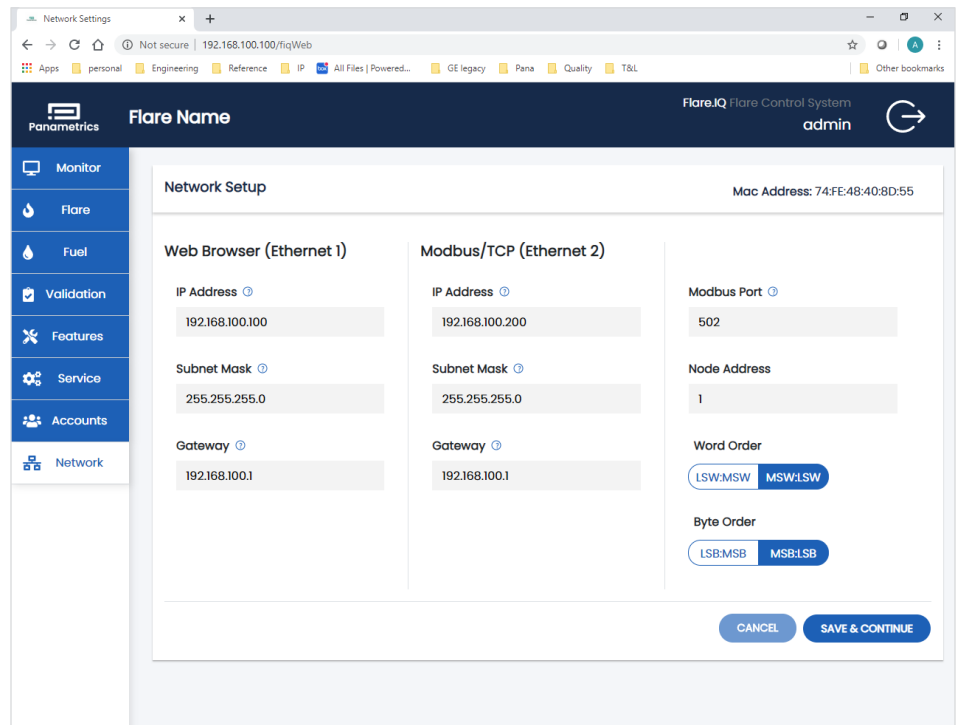
Figure 15: Network set-up page including IP address and Modbus word/byte order configuration
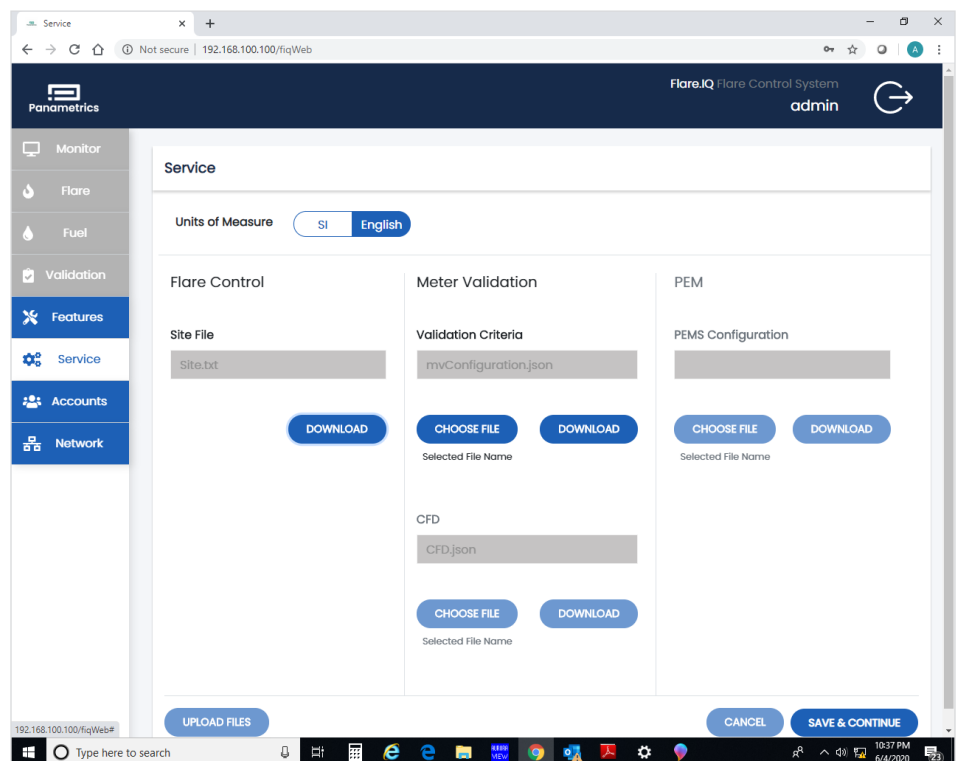
Figure 16: Service configuration page that enables uploading installation specific site files

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 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 17 shows the flare configuration page for the steam assist option. All quantities are displayed in English units as listed in table 7.

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 name

- Flare tip diameter

- Flare-to-steam ratio correction factor

- Flare flowmeter diameter

- Choice of flare assist: steam vs. air

- Choice of continuous velocity vs. 3-speed air assist

Figure 18 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.
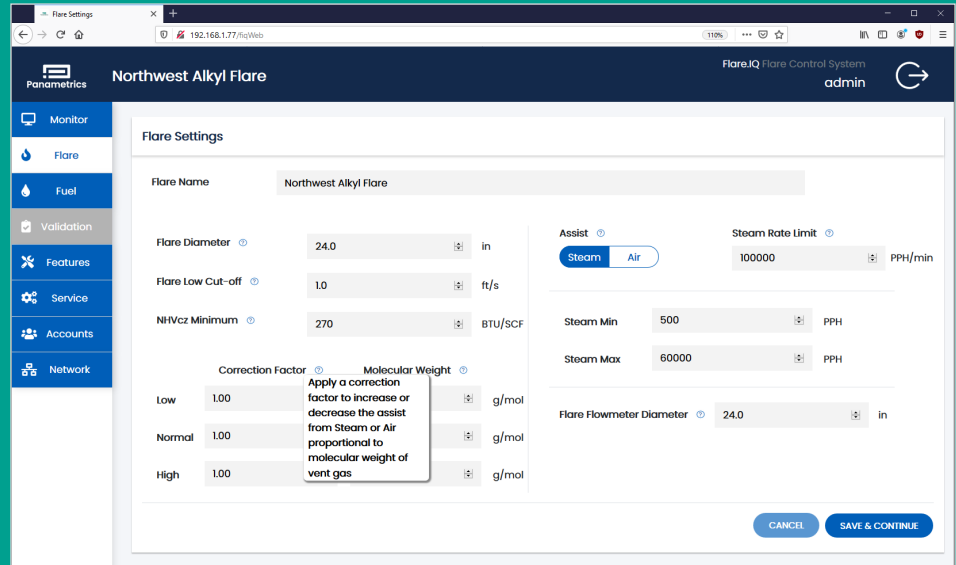
Figure 17: Flare configuration page showing tooltip example
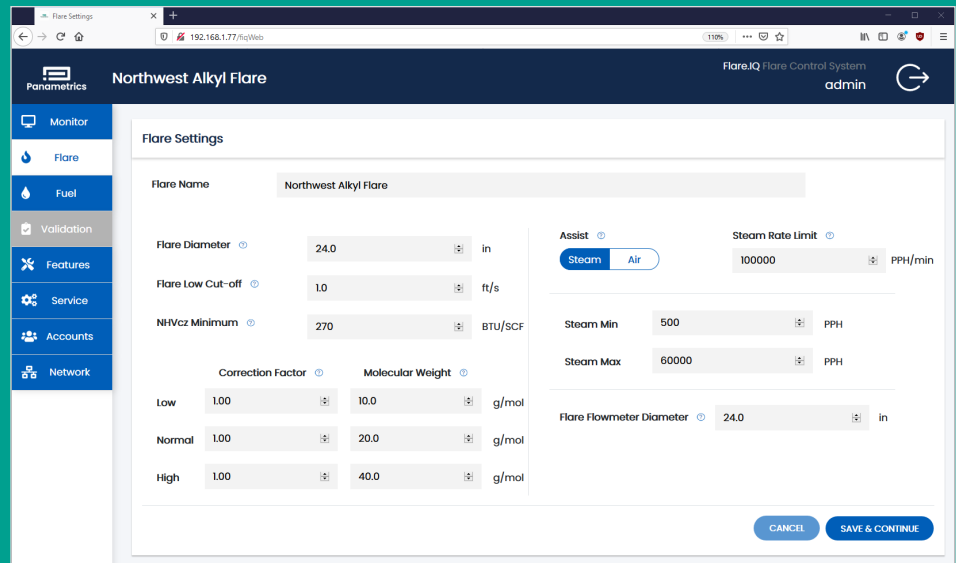
Figure 18: Flare settings for steam assist

Figure 19 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 and CONTINUE" at the bottom. One of these must be clicked for any of the other tabs to be available.

Figure 20 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
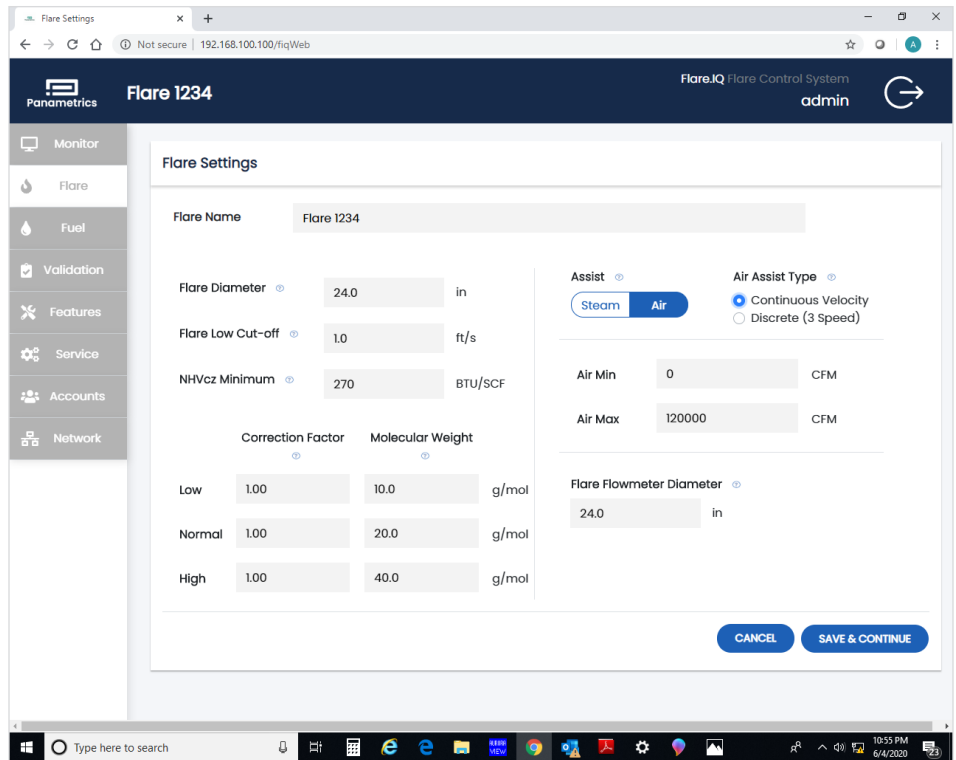
Figure 19: Flare settings for air assist (continuous)
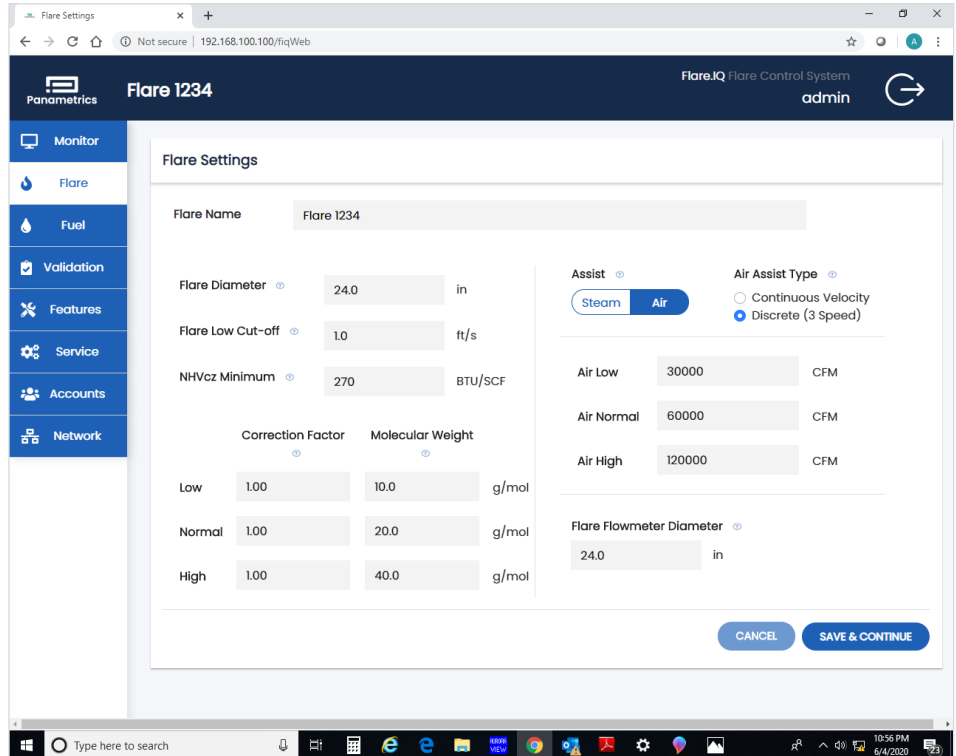
Figure 20: Flare settings for air assist (discrete)

3.3.4 Fuel configuration

As shown in figure 21 this page enables setting the following flare (supplemental) fuel specific parameters:

• Choice of online flare gas analyzer – GC/calorimeter

• Time interval between readings from GC/MS

• 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:

1. Choice of NHV for H2 between 275 BTU/SCF and 1212 BTU/SCF (apply EPA 1212 rule)

2. 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.

3.3.5 Monitor overview

After all configuration steps are complete, the monitor 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_{actual} 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.
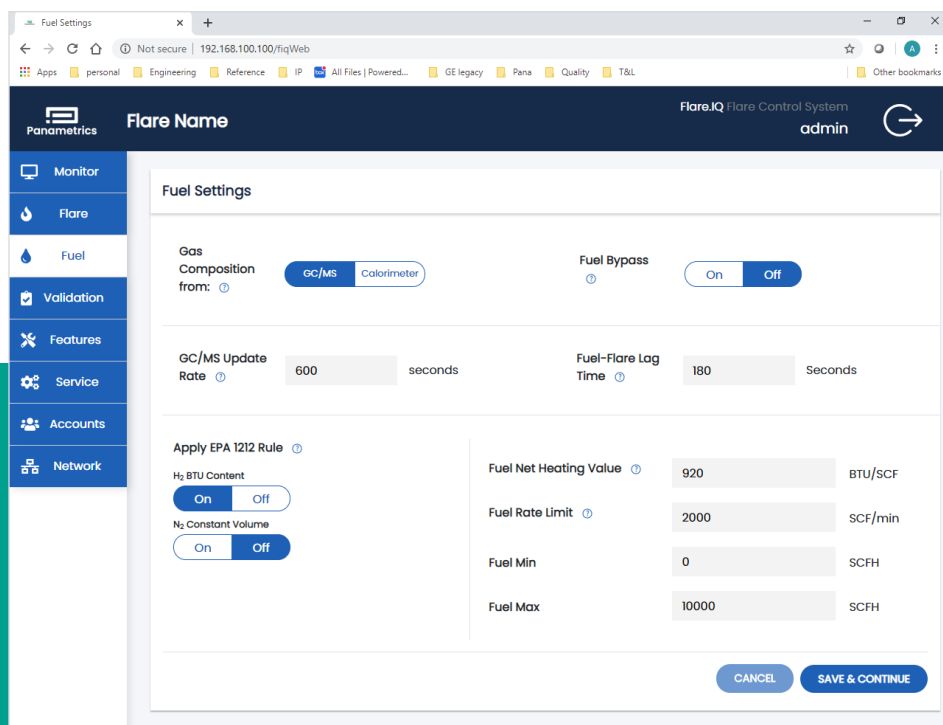
Figure 21: Fuel settings configuration page

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- 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 non-HC gas composition 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})

3.3.6   Data status color

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

Monitor Overview

■ In Range ■ Bad ■ Stale ■ Under Range ■ Over Range

- 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.

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 22).

- **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 23).

- **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 23).
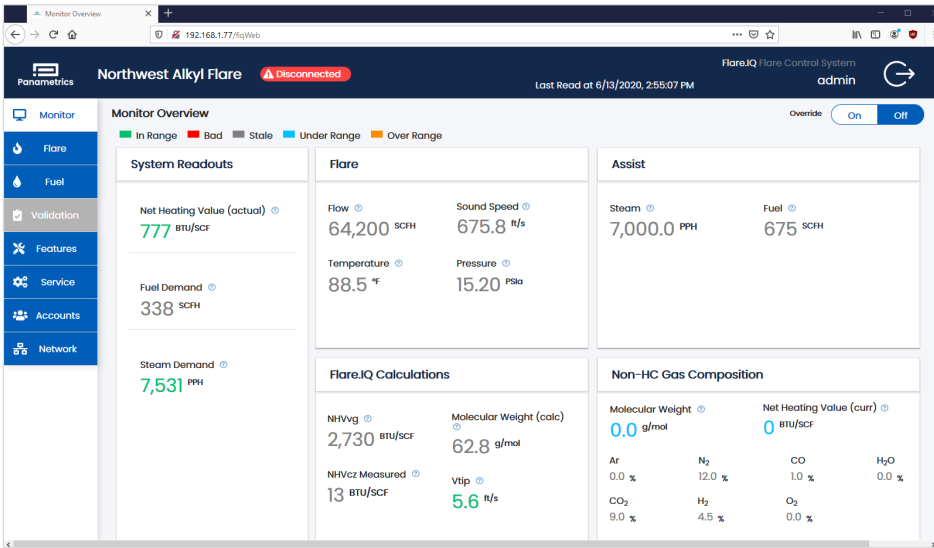
Figure 22:   Monitor page with no Modbus connection
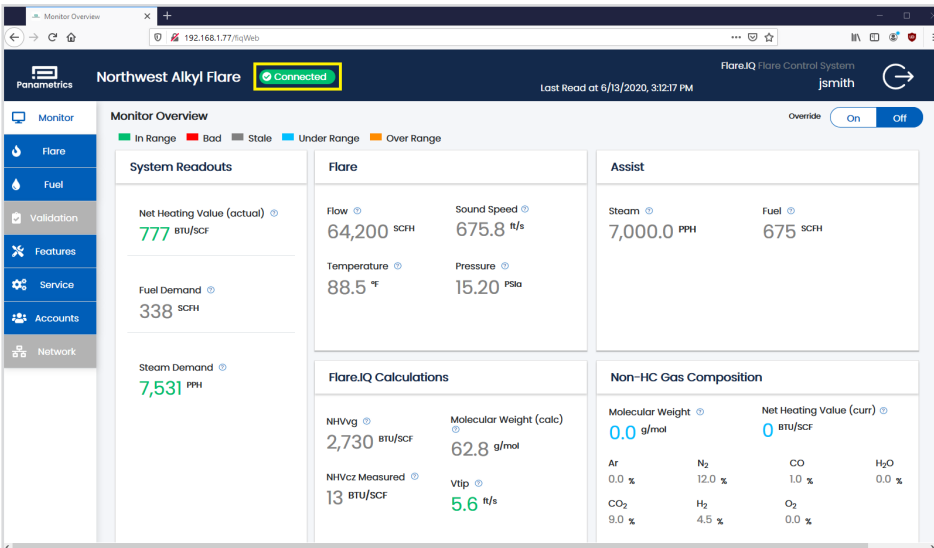
Figure 23:   Monitor page with active Modbus connection
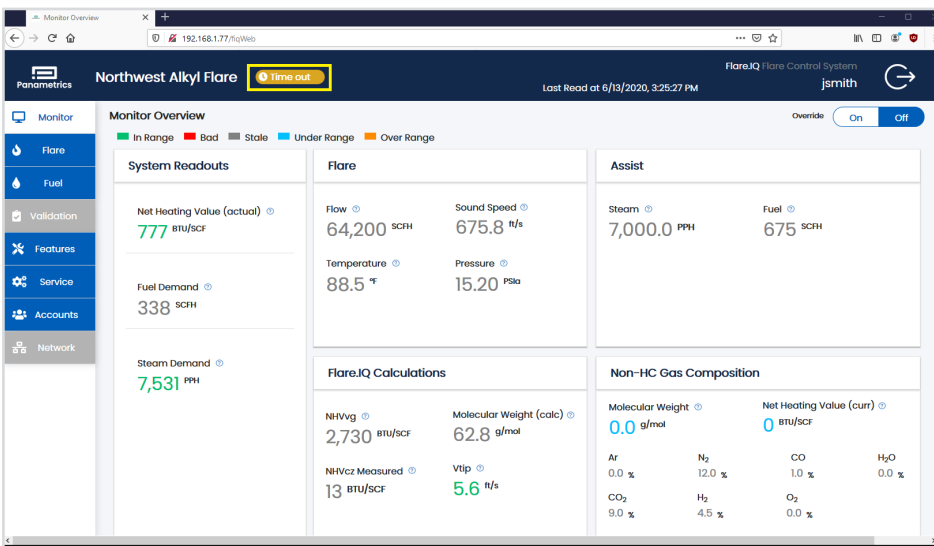
Figure 24:   Monitor page under timeout conditions

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3.3.8 Monitor override

When logged in as an administrator or operator, an override switch is displayed on the upper right of the monitor page. Override mode is a troubleshooting and diagnostic tool for flare.IQ calculations.

> ⚠️ When placed in override, the fuel and assist setpoint calculations are determined by values entered by the operator, **NOT** by the data provided 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!

When override is switched on, the flare.IQ ignores Modbus data from the DCS for specific parameters. These data values can then be entered manually by the operator on the monitor page, *overriding* the data from the DCS. 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.
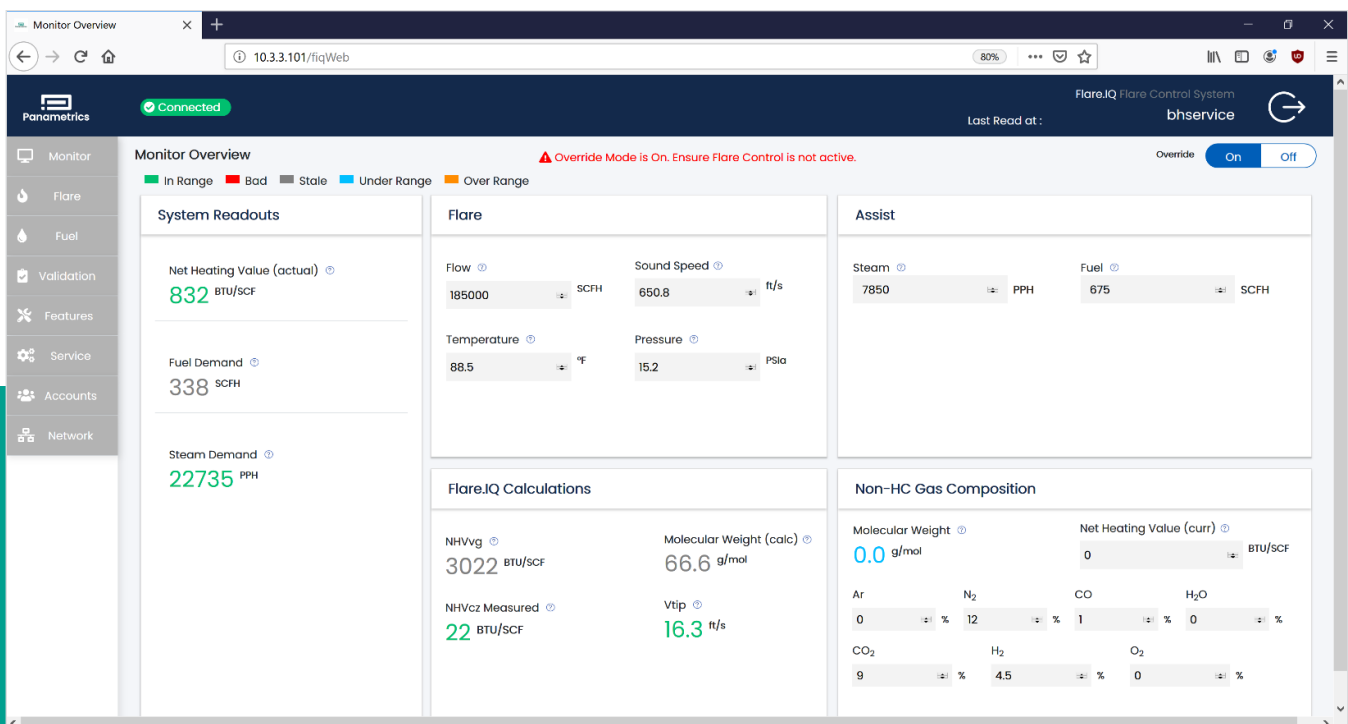
Figure 25: Monitor page with override enabled

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 26 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 Gen 2 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.

As shown in figure 10, 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 26 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 Gen 2 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 27 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 table is shown in the bottom.
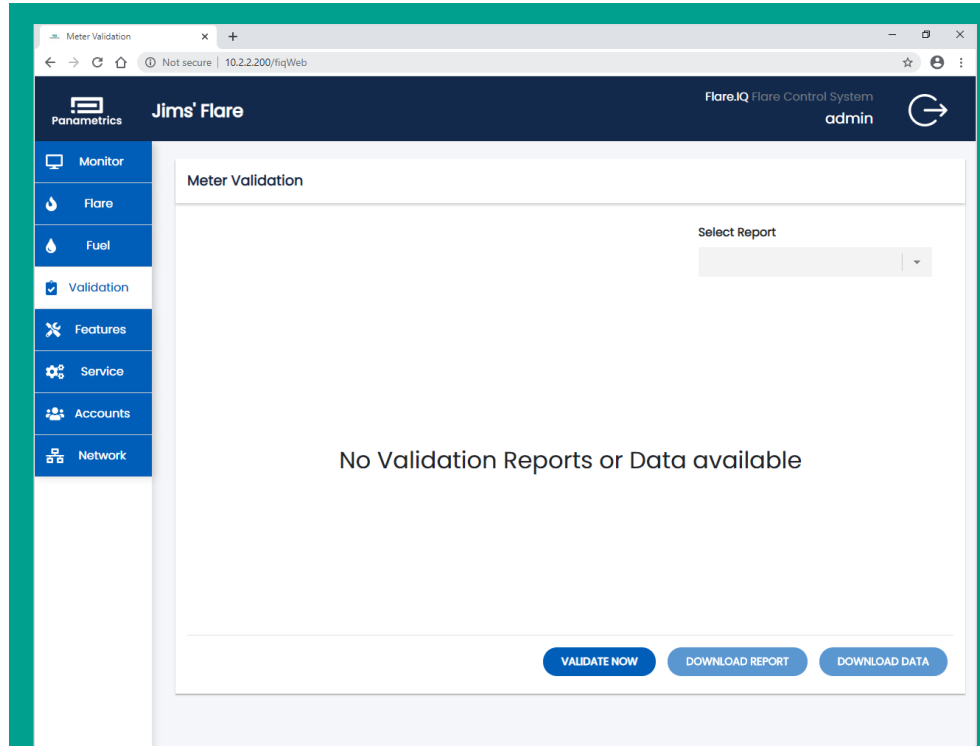
Figure 26: Validation page showing system is ready for on-demand digital verification
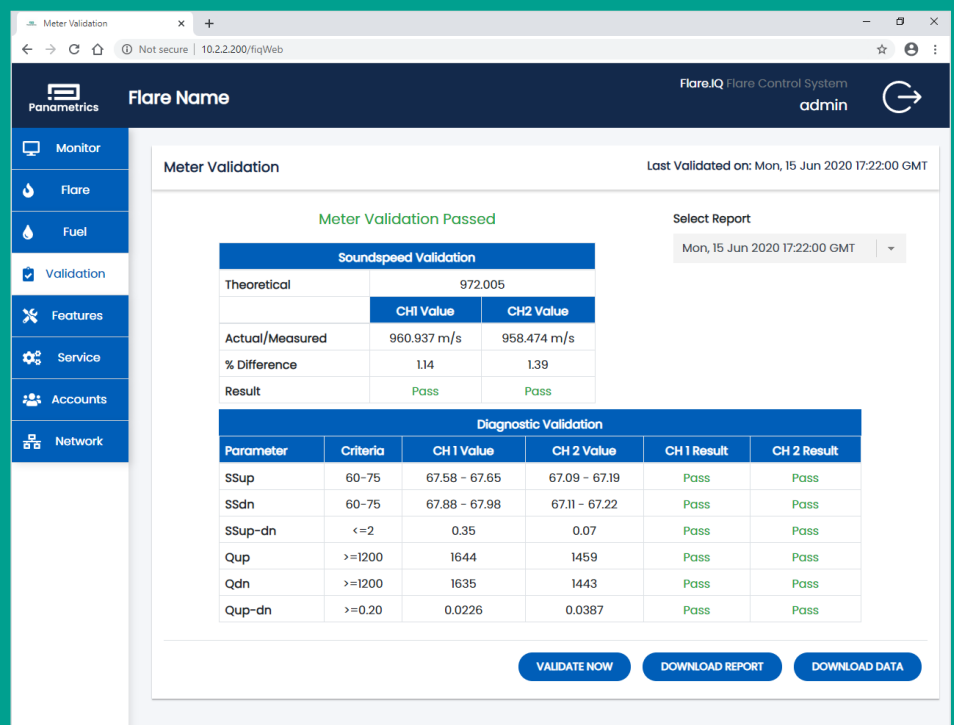
Figure 27: Validation page showing typical result for passing digital verification

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.

There are two other possible outcomes of the digital verification process as described in Section 3.2.2 – "validation failed" or "process unstable for validation". 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 28 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 (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.

Meter Validation

Last Validated on: Mon, 15 Jun 2020 17:43:00 GMT

Process is unstable for Meter Validation

Select Report: Mon, 15 Jun 2020 17:43:00 GMT

Stability Validation

Parameter	Criteria	CH 1 Value	CH 2 Value	CH 1 Stable ?	CH 2 Stable ?
Sound Speed	<=0.0040	0.0 %	0.0 %	No	No
AMPup	20-28	23.4 – 24.4	23.2 – 24.6	Yes	Yes
AMPdn	20-28	23.5 – 24.8	23.4 – 24.2	Yes	Yes
AMPup-dn	<=3	1.0	0.9	Yes	Yes
P#up Value	100-2300	1047 – 1117	1045 – 1115	Yes	Yes
P#dn Value	100-2300	1043 – 1115	1039 – 1111	Yes	Yes
P#up	<=10	17.591	17.651	No	No
P#dn	<=10	17.846	17.852	No	No
DeltaT, S/M	<=5/NA	1.801	0.959	Yes	Yes
Is Error Present	Yes/No?	No	No	Yes	Yes

Parameter	Criteria	Actual Value	Result
Composition Uncertainty	<=0.03	-0.0126	Pass

VALIDATE NOW   DOWNLOAD REPORT   DOWNLOAD DATA

Figure 28: Validation page showing results of an unsuccessful digital verification due to process instability

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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.

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.

The list of Modbus addresses of analog inputs (holding registers) used for flare control is shown in table 3 below. Table 4 shows all holding registers required for digital verification while table 5 lists all analog outputs (Input registers) for flare control. Table 6 provides the addresses for all Boolean status and coil registers.

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, fraction (0.0 to 1.0)
CO2	1012	2	Carbon dioxide concentration, fraction (0.0 to 1.0)
CO	1014	2	Carbon monoxide concentration, fraction (0.0 to 1.0)
H2	1016	2	Hydrogen concentration, fraction (0.0 to 1.0)
N2	1018	2	Nitrogen concentration, fraction (0.0 to 1.0)
O2	1020	2	Oxygen concentration, fraction (0.0 to 1.0)
H2O	1022	2	Water vapor concentration, fraction (0.0 to 1.0)
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
CFLARE_TC	1056	2	Flare sound speed
QSTEAM_TC	1060	2	Steam flow rate
TSTEAM_TC	1062	2	Steam temperature (future use)

Table 3: Modbus address list – holding registers for flare control (analog inputs)

Register tag name	Register address	Number of registers	Description
PSTEAM_TC	1064	2	Steam pressure (future use)
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	Normal molecular weight correction factor
GC_UPDATE_RATE	1090	2	Expected time between GC/MS updates, seconds
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 flare meter validation (analog inputs)			
Register tag name	Register address	Number of registers	Description
CH_CONFIG	2000	2	Channel configuration of the flare meter
UNITS_OF_MEASURE	2002	2	Units of measure configuration of the flare meter
CH4	2020	2	Methane concentration, fraction (0.0 to 1.0)
C2H4	2022	2	Ethylene concentration, fraction (0.0 to 1.0)
C2H6	2024	2	Ethane concentration, fraction (0.0 to 1.0)
C3H6	2026	2	Propylene concentration, fraction (0.0 to 1.0)
C3H8	2028	2	Propane concentration, fraction (0.0 to 1.0)
C4H10	2030	2	Butane concentration, fraction (0.0 to 1.0)
C4H10_ISO	2032	2	Iso butane concentration, fraction (0.0 to 1.0)
C4Hx	2034	2	C4's (olefins) concentration, fraction (0.0 to 1.0)
C5Hx	2036	2	C5's concentration, fraction (0.0 to 1.0)
C6Hx	2038	2	C6's concentration, fraction (0.0 To 1.0)
H2S	2040	2	Hydrogen sulfide concentration, fraction (0.0 To 1.0)
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

Register tag name	Register address	Number of registers	Description
Table 4: Modbus address list – holding registers for flare meter validation (analog inputs)			
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: 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 calculated
VTIP_ACTUAL	406	2	Flare tip velocity calculated
VTIP_MAX	408	2	Flare tip velocity maximum
MW_CALC	410	2	Molecular weight calculated
NHVCZ_MEASURED	412	2	Net heating value in the combustion zone derived from GC/calorimeter
NHVCZ_CURRENT	414	2	Net heating value in the combustion zone derived from mol weight
NHVCZ_MEASURED_TC	416	2	Net heating value in the combustion zone at current fuel and steam
NHVCZ_UNCORRECTED_TC	418	2	NHVcz uncorrected for H2 at current fuel and steam
NHVCZ_UNCORRECTED_ACTUAL	420	2	NHVcz uncorrected for H2 at demand fuel and steam
NHVCZDIL_ACTUAL	422	2	NHV dilution parameter calculated (air assist only)
NHVCZDIL_MEASURED	424	2	NHV dilution parameter from GC/calorimeter (air assist only)
NHVCZDIL_MEASURED_TC	426	2	NHV dilution from GC/calorimeter at current conditions (air assist only)
CF_ASSIST	428	2	Air/steam correction factor as a function of mol weight
QAIR_DEMAND	430	2	Air demand
SPARE_AR_3	432	2	Spare
SPARE_AR_4	434	2	Spare
SPARE_AR_5	436	2	Spare
SPARE_AR_6	438	2	Spare
SPARE_AR_7	440	2	Spare
SPARE_AR_8	442	2	Spare

Table 6: Modbus address list – Boolean status and coil registers

Register tag name	Register address	Number of registers	Description	Register type
HEARTBEAT	0	1	Heartbeat (from flare.IQ)	Status register
COMM_FAIL	1	1	Modbus comm failed (timeout)	Status register
RESERVED_02	2	1	Reserved, returns 0	Status register
FUEL_DEMAND_BQ	3	1	Fuel demand exceeds capacity	Status register
STEAM_DEMAND_BQ	4	1	Steam demand exceeds capacity	Status register
AIR_DEMAND_BQ	5	1	Air demand exceeds capacity	Status register
AR_BQ	6	1	Argon content value bad	Status register
CO2_BQ	7	1	Carbon dioxide content value bad	Status register
CO_BQ	8	1	Carbon monoxide content value bad	Status register
H2_BQ	9	1	Hydrogen content value bad	Status register
N2_BQ	10	1	Nitrogen content value bad	Status register
O2_BQ	11	1	Oxygen content value bad	Status register
H2O_BQ	12	1	Water content value bad	Status register
MW_INPUT_BQ	13	1	Mol weight from GC/MS value bad	Status register
NHVVG_INPUT_BQ	14	1	NHV (vent gas) from GC/MS value bad	Status register
RESERVED_15	15	1	Reserved, returns 0	Status register
RESERVED_16	16	1	Reserved, returns 0	Status register
QFUEL_BQ	17	1	Fuel gas flow measurement bad	Status register
RESERVED_18	18	1	Reserved, returns 0	Status register
QFLARE_BQ	19	1	Flare flow measurement bad	Status register
TFLARE_BQ	20	1	Flare temperature measurement bad	Status register
PFLARE_BQ	21	1	Flare pressure measurement bad	Status register
CFLARE_BQ	22	1	Flare sound speed measurement bad	Status register
RESERVED_23	23	1	Reserved, returns 0	Status register
QSTEAM_BQ	24	1	Steam flow measurement bad	Status register
TSTEAM_BQ	25	1	Steam temperature measurement bad	Status register
RESERVED_26	26	1	Reserved, returns 0	Status register
QAIR_BQ	27	1	Air flow measurement bad	Status register
TAIR_BQ	28	1	Air temperature measurement bad	Status register
PAIR_BQ	29	1	Air pressure measurement bad	Status register
RESERVED_30	30	1	Reserved, returns 0	Status register
CALC_SS_BQ	31	1	Calculated sound speed invalid	Status register
RESERVED_32	32	1	Reserved, returns 0	Status register
RESERVED_33	33	1	Reserved, returns 0	Status register

Table 6: Modbus address list – Boolean status and coil registers				
Register tag name	Register address	Number of registers	Description	Register type
RESERVED_34	34	1	Reserved, returns 0	Status register
RESERVED_35	35	1	Reserved, returns 0	Status register
RESERVED_36	36	1	Reserved, returns 0	Status register
RESERVED_37	37	1	Reserved, returns 0	Status register
RESERVED_38	38	1	Reserved, returns 0	Status register
RESERVED_39	39	1	Reserved, returns 0	Status register
RESERVED_40	40	1	Reserved, returns 0	Status register
RESERVED_41	41	1	Reserved, returns 0	Status register
RESERVED_42	42	1	Reserved, returns 0	Status register
RESERVED_43	43	1	Reserved, returns 0	Status register
RESERVED_44	44	1	Reserved, returns 0	Status register
RESERVED_45	45	1	Reserved, returns 0	Status register
RESERVED_46	46	1	Reserved, returns 0	Status register
RESERVED_47	47	1	Reserved, returns 0	Status register
RESERVED_48	48	1	Reserved, returns 0	Status register
RESERVED_49	49	1	Reserved, returns 0	Status register
RESERVED_50	50	1	Reserved, returns 0	Status register
RESERVED_51	51	1	Reserved, returns 0	Status register
RESERVED_52	52	1	Reserved, returns 0	Status register
RESERVED_53	53	1	Reserved, returns 0	Status register
RESERVED_54	54	1	Reserved, returns 0	Status register
RESERVED_55	55	1	Reserved, returns 0	Status register
RESERVED_56	56	1	Reserved, returns 0	Status register
RESERVED_57	57	1	Reserved, returns 0	Status register
RESERVED_58	58	1	Reserved, returns 0	Status register
RESERVED_59	59	1	Reserved, returns 0	Status register
RESERVED_60	60	1	Reserved, returns 0	Status register
RESERVED_61	61	1	Reserved, returns 0	Status register
RESERVED_62	62	1	Reserved, returns 0	Status register
RESERVED_63	63	1	Reserved, returns 0	Status register
RESERVED_64	64	1	Reserved, returns 0	Status register
HEARTBEAT	0	1	Heartbeat (from flare.IQ, 0.5 Hz)	Coil

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

3.4.3 flare.IQ units

As shown in figure 16, 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 monitor pages of the web console for either choice are shown in table 7.

Table 7: English and metric (SI) units used in flare.IQ Gen 2		
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	Sm^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	Sm^3/h	SCFH
Fuel max	Sm^3/h	SCFH
Monitor page		
Net heating value (actual)	MJ/m^3	BTU/SCF

Table 7: English and metric (SI) units used in flare.IQ Gen 2		
Parameter	SI	English
Fuel demand	Sm^3/h	SCFH
Steam demand	MTPH	PPH
Air demand	m^3/s	CFM
Flare flow	Sm^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	Sm^3/h	SCFH
Net heating value (current)	MJ/m^3	BTU/SCF
Molecular weight	g/mol	g/mol

Chapter 4. Installation and 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):
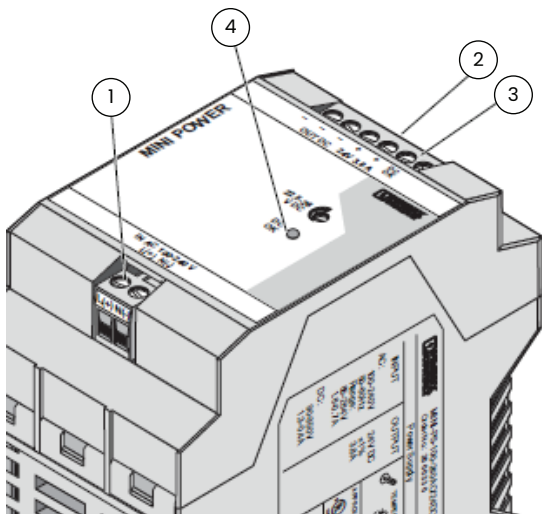

Figure 29: Phoenix Contact MINI-PS-100-240AC/24DC/C2LPS I/O connections

4.1.1 Input (1, figure 29)

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 3-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 29)

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 V DC 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. See detailed wiring diagram in figure 30 below for more details.

⚠	**CAUTION!**
	Make sure all electrical connections are correct and secure.

	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

Table 8: Wiring specification for MINI 24 VDC power supply
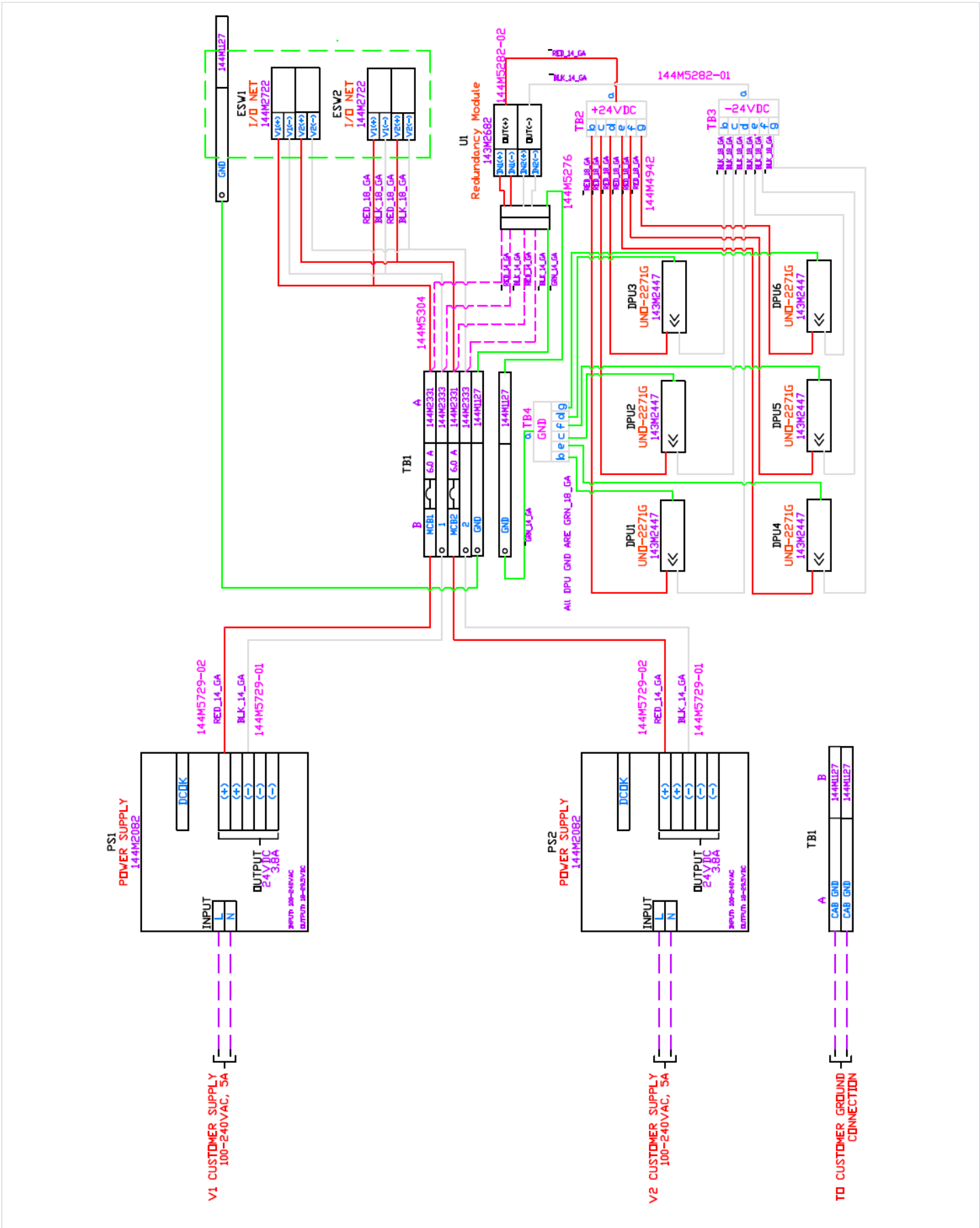
Figure 30: System wiring diagram

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 31 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). 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 31: 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. 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.

⚠	**CAUTION!**
	Installation shall be in an enclosed rack that requires tool access.

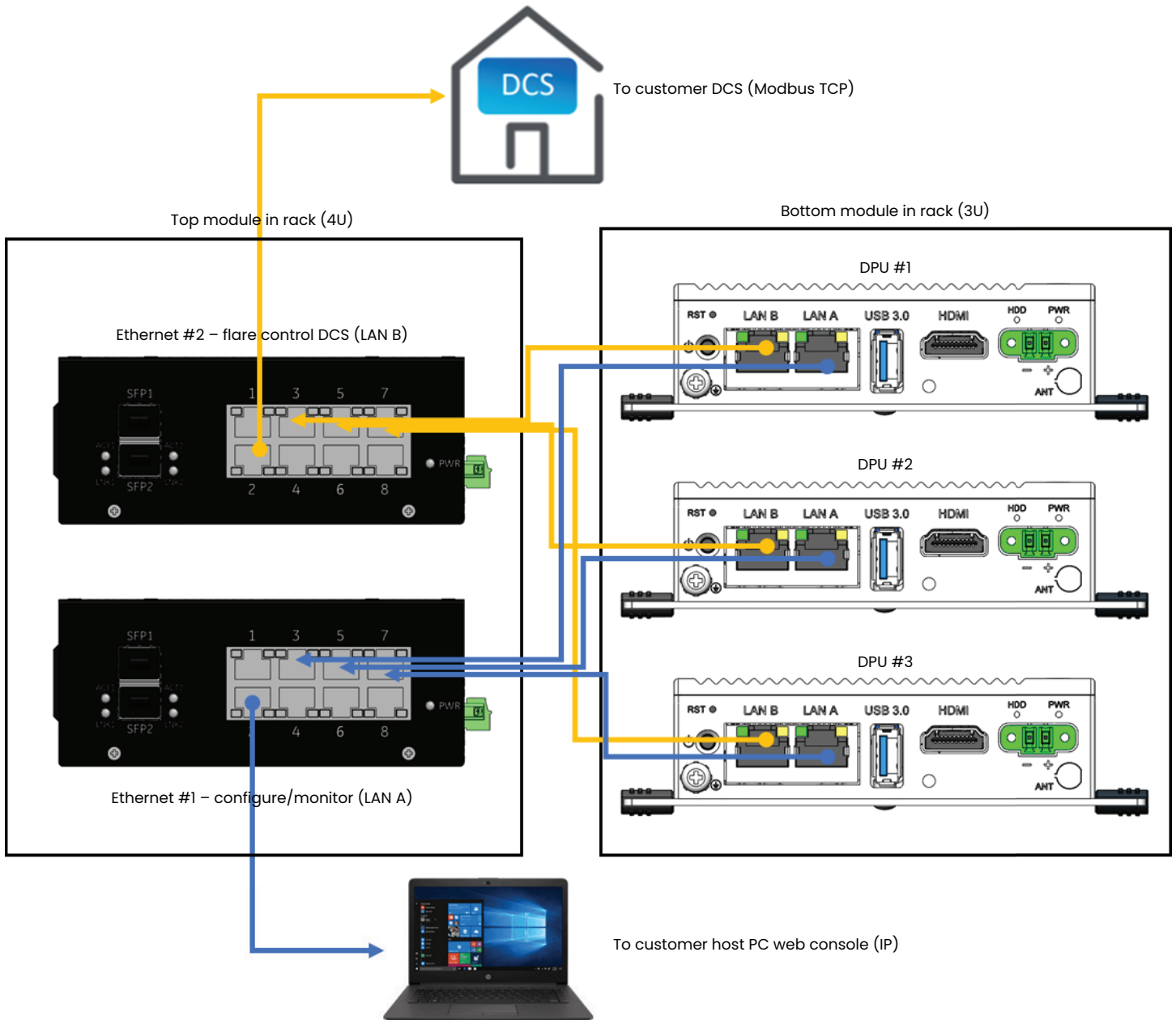It is recommended that all mounting hardware be either steel with zinc plating or stainless steel. Note that required mounting hardware may vary with 19" rack design. Figure 32 below shows the recommended mounting method.
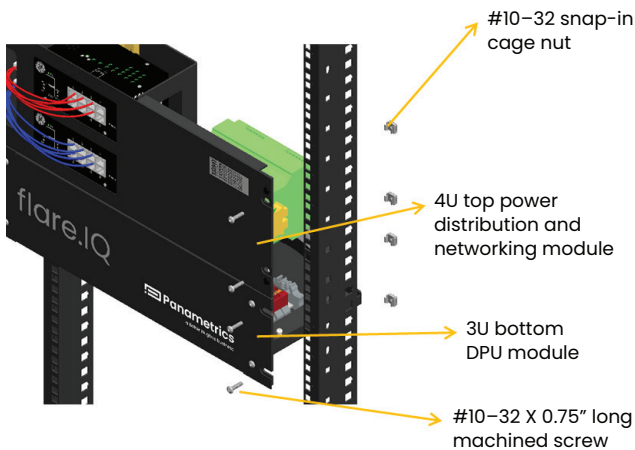
Figure 32: Recommended rack mounting method

4.3.2 Module installation

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 DPUs. 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 4, "Factory set IP addresses," on page 26. The section labels are located on the back of the modules, in the upper right corners. Figure 33 below shows recommended module placement for an example system with 3 flares.

Figure 33: Recommended module and DPU placement

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

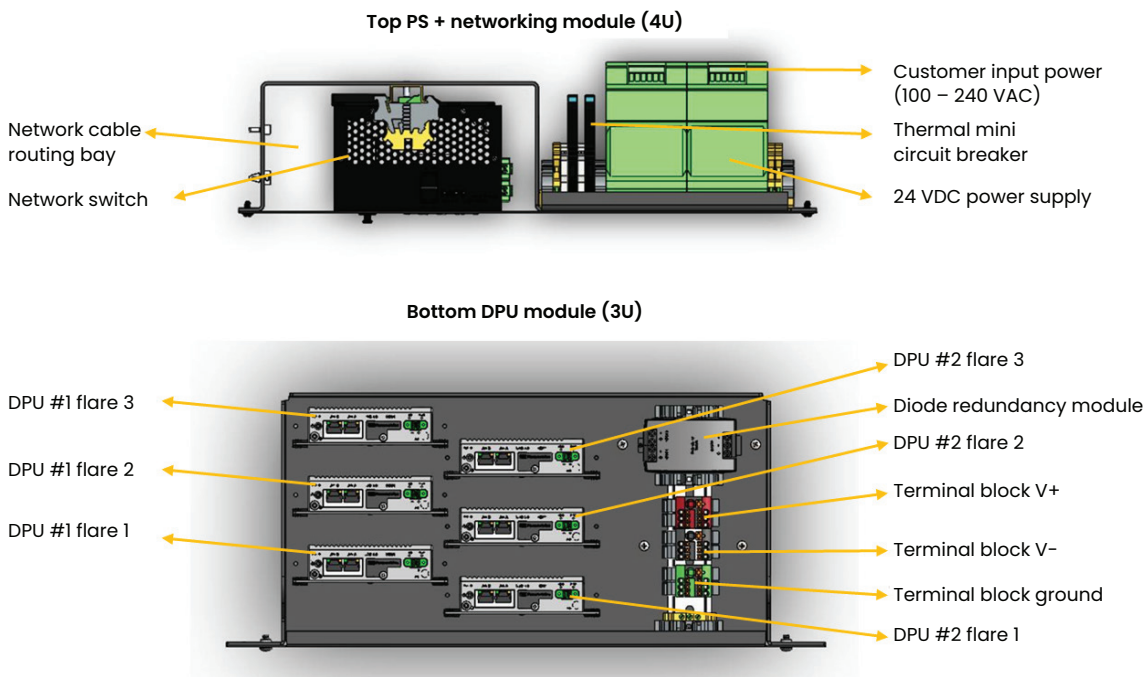1. Mount an upper screw on the panel. Hang the controller on the screw and align it with the panel's lower screw hole.

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 and LAN B) of the controller.

5. Plug the dual-24V dc power cable into the power input socket on the top of the controller.

	CAUTION!
⚠️	**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.

Part number	Part name	Part description
FLARE.IQ_KT_DPU	flare.IQ Gen 2 DPU and 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)

Table 9: Spare parts list

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 and 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. Please refer to the DoC at the end of this manual.

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:

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

Table 10: Network port assignments on DPU

*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 above, 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'.

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

Panametrics **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 8 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, Panametrics 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.

Panametrics 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 Panametrics 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 11: Modbus address list for flare.IQ Gen 1 legacy customers (analog inputs for flare control)				
Register tag name	Register address	Number of registers	Description	Scaling factor
AR	10	1	Argon concentration, fraction (0.0 to 1.0)	*10
CO2	11	1	Carbon dioxide concentration, fraction (0.0 to 1.0)	*10
CO	12	1	Carbon monoxide concentration, fraction (0.0 to 1.0)	*10
H2	13	1	Hydrogen concentration, fraction (0.0 to 1.0)	*10
N2	14	1	Nitrogen concentration, fraction (0.0 to 1.0)	*10
O2	15	1	Oxygen concentration, fraction (0.0 to 1.0)	*10
H2O	16	1	Water vapor concentration, fraction (0.0 to 1.0)	*10
MW_INPUT	20	1	Molecular weight from GC/MS, g/mol	*100
NHVVG_INPUT	21	1	Net heating value of vent (flare) gas, BTU/SCF	*10
QFUEL_TC	30	1	Fuel gas flow rate, SCFH	/10
QFLARE_TC	40	1	Flare flow rate, SCFH	/100
TFLARE_TC	41	1	Flare temperature, degrees Fahrenheit	*10
PFLARE_TC	42	1	Flare pressure, PSIa	*100
CFLARE_TC	43	1	Flare sound speed, ft/s	*10
QSTEAM_TC	50	1	Steam flow rate, PPH	/10
TSTEAM_TC	51	1	Steam temperature, degrees Fahrenheit (future use)	*10
PSTEAM_TC	52	1	Steam pressure, PSIg (future use)	*100
QAIR_TC	60	1	Air flow rate, CFM	/10
TAIR_TC	61	1	Assist air temperature, degrees Fahrenheit	*10

Table 11: Modbus address list for flare.IQ Gen 1 legacy customers (analog inputs for flare control)

Register tag name	Register address	Number of registers	Description	Scaling factor
PAIR_TC	62	1	Assist air pressure, iwg	*100
QN2_TC	70	1	Volumetric flow of nitrogen, scfh	*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	Expected time between GC/MS updates, seconds	*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
MW_HIGH	112	1	High molecular weight to apply correction factor	*100
QFUEL_MIN	130	1	Minimum fuel flow parameter, SCFH	*1
QFUEL_MAX	131	1	Maximum fuel flow parameter, SCFH	/10
FLARE_DIAM	140	1	Flare tip diameter, inches	*100
FLARE_METER_DIAM	141	1	Flare meter diameter, inches	*100
QSTEAM_MIN	150	1	Minimum steam flow parameter, PPH	*1
QSTEAM_MAX	151	1	Maximum steam flow parameter, PPH	/10
QAIR_LOW	160	1	Low air flow, CFM	/10
QAIR_MID	161	1	Mid air flow, CFM	/10
QAIR_HIGH	162	1	High air flow, CFM	/10
QAIR_MIN	170	1	Minimum air flow parameter, CFM	*1
QAIR_MAX	171	1	Maximum air flow parameter, CFM	/100

Table 12: Modbus address list for flare.IQ Gen 1 legacy customers (analog outputs for flare control)				
Register tag name	Register address	Number of registers	Description	Scaling factor
QFUEL_DEMAND	0	1	Fuel gas demand, SCFH	*10
QSTEAM_DEMAND	1	1	Steam demand (PPH)	*10
NHVCZ_ACTUAL	2	1	Net heating value in the combustion zone calculated, BTU/SCF	1
VTIP_ACTUAL	3	1	Flare tip velocity calculated, ft/s	/100
VTIP_MAX	4	1	Flare tip velocity maximum, ft/s	/100
MW_CALC	5	1	Molecular weight calculated, g/mol	/100
NHVCZ_MEASURED	6	1	Net heating value in the combustion zone derived from GC/calorimeter, BTU/SCF	1
NHVCZ_CURRENT	7	1	Net heating value in the combustion zone derived from mol weight, BTU/SCF	1
NHVCZ_MEASURED_TC	8	1	Net heating value in the combustion zone at current fuel and steam, BTU/SCF	1
NHVCZ_UNCORRECTED_TC	9	1	NHVcz uncorrected for H2 at current fuel and steam, BTU/SCF	1
NHVCZ_UNCORRECTED_ACTUAL	10	1	NHVcz uncorrected for H2 at demand fuel and steam, BTU/SCF	1
NHVCZDIL_ACTUAL	11	1	NHV dilution parameter calculated (Air Assist only), BTU/SCF	/10
NHVCZDIL_MEASURED	12	1	NHV dilution parameter from GC/calorimeter (air assist only), BTU/SCF	/10
NHVCZDIL_MEASURED_TC	13	1	NHV dilution from GC/calorimeter at current conditions (air assist only), BTU/SCF	/10
CF_ASSIST	14	1	Air/steam correction factor as a function of mol weight, unitless	1
QAIR_DEMAND	15	1	Air demand (CFM)	*10
SPARE_AR_3	16	1	Spare	
SPARE_AR_4	17	1	Spare	
SPARE_AR_5	18	1	Spare	
SPARE_AR_6	19	1	Spare	
SPARE_AR_7	20	1	Spare	
SPARE_AR_8	21	1	Spare	

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:

VTIP_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:
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
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
Sm^3/h	Standard cubic meters per hour
TCP	Transmission Control Protocol
UDP	User Datagram Protocol

Panametrics flare.IQ Flare Control System [1]

We,

Panametrics LLC,
1100 Technology Park Drive,
Billerica, MA 01821, USA [2]

declare under our sole responsibility [3] that the **flare.IQ Gen2 System** [4] is in conformity with the following harmonising directives:[5]

- 2014/30/EU   EMC
- 2014/35/EU   LVD
- 2011/65/EU   RoHS

Conformity is declared based on assessment against the following harmonised standards:[6a]

- EN 55032:2012+AC:2013   Class A, Tables A.2, A.3, A.9, and A.11
- EN 55024: 2010   Tables 1, 2 and 4

- EN 61010-1: 2010   Permanently Connected,
                               Equipment Class I, Pollution Degree 2, Overvoltage Category II

and other technical specifications:[6b]

- EN 61010-1: 2010+A1:2019   Permanently Connected
                               Equipment Class I, Pollution Degree 2, Overvoltage Category II
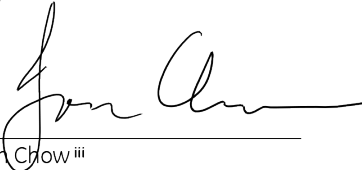
Notified Body involvement:[7]

- -

Other information:[8]
A product type examination, for safety of electrical equipment, was performed and an IECEE CB Test Certificate was issued by

- CSA, Toronto, ON M9W 1R3, Canada
  CA/24067/CSA   IEC 61010-1:2010 & IEC 61010-1:2010/AMD1:2016

Signed for and on behalf of Panametrics LLC [i]

Jon Chow [iii]
Panametrics Technology Leader

Billerica – June 15th, 2020 [ii]

[no content intended for this page]

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Panametrics, a Baker Hughes Business, provides solutions in the toughest applications and environments for moisture, oxygen, liquid and gas flow measurement. Experts in flare management, Panametrics technology also reduces flare emissions and optimizes performance.

With a reach that extends across the globe, Panametrics' critical measurement solutions and flare emissions management are enabling customers to drive efficiency and achieve carbon reduction targets across critical industries including: Oil & Gas; Energy; Healthcare; Water and Wastewater; Chemical Processing; Food & Beverage and many others.

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