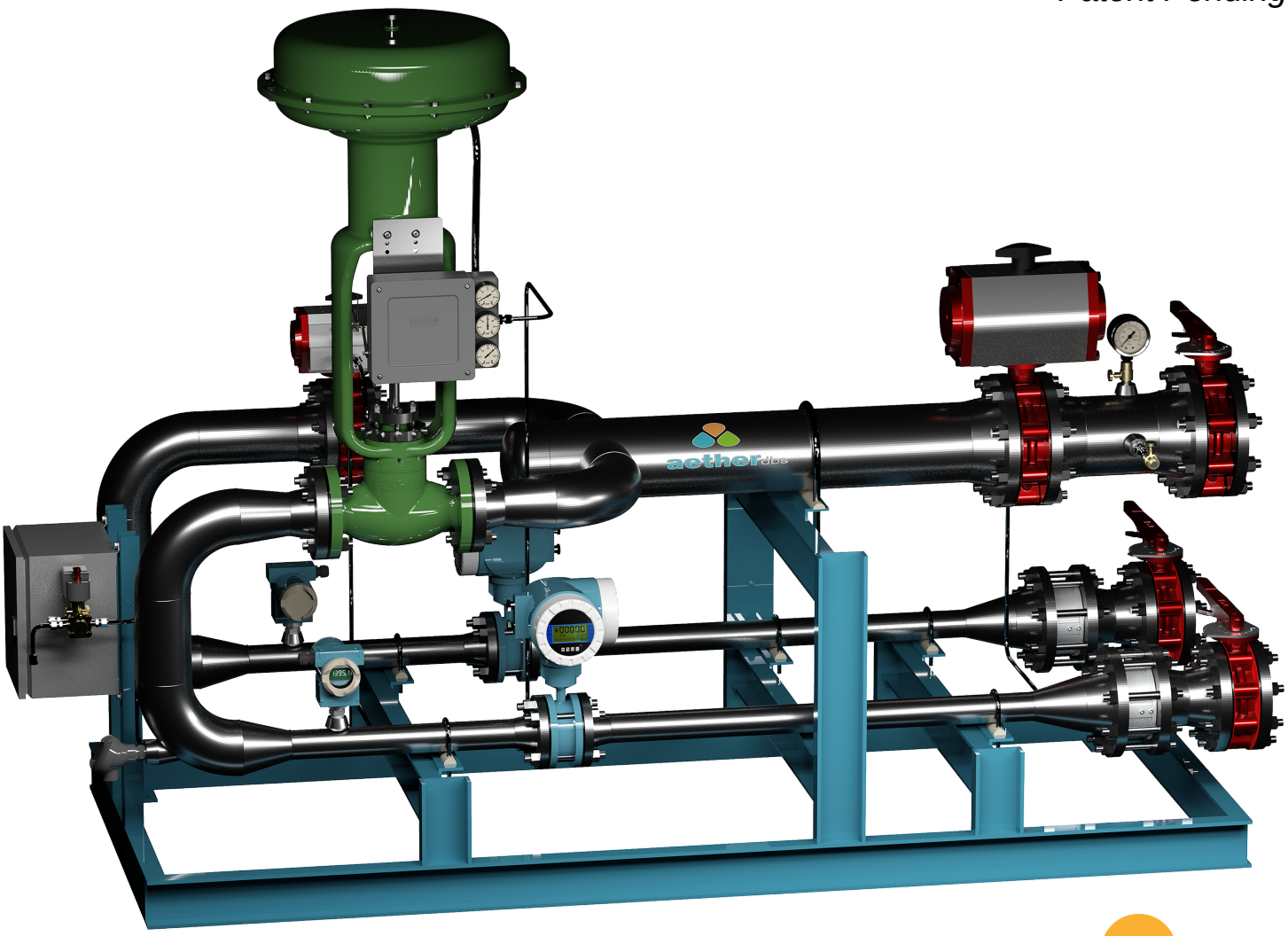
Sagebrush

EXPERTS IN ENERGY EQUIPMENT

AFC™ HYDROGEN GAS H2NG BLENDER™

Patent Pending



- **Works with Existing Equipment**
- **Fully Modular & Automated**
- **Easy to Install & Operate**
- **Smaller Carbon Footprint**
- **Precise and Reliable**

aether

The Green Energy Transition

Hydrogen now represents a viable, renewable fuel for our green energy transition. The transition from straight fossil fuels to hydrogen will take place over time and will be implemented in phases. Initially, the use of hydrogen in blends with natural gas will be the most attractive way to introduce this fuel to our existing facilities. When used in controllable blends, it can be used within your existing infrastructure. But how can you get precision control of that hydrogen blend reliably, in a repeatable way? Get maximum flexibility out of your hydrogen blend, by installing an Aether AFC™ H2NG Hydrogen Blender (patent pending).

Demand a hydrogen blender equipped with standard critical safety and control functions, including all stainless steel construction, Auto-Flow-Controls, Class 1 Division 1 Group D location suitability, independent gas flow meters, independent pressure transmitters, integral control valves, and a control system to precisely regulate your hydrogen blend and communicate with your existing controls. Whether your hydrogen comes from a grey, blue, or green source, the AFC™ H2NG Hydrogen Blender gives you maximum flexibility to utilize your hydrogen blends in existing infrastructure. Reduce your carbon emissions by up to 10% or more, using the H2NG blender, replacing methane with hydrogen.

Hydrogen Blending is Green

Hydrogen represents a new paradigm for fuel gas usage and supply, with green implications for utilities and industrial customer alike. The AFC™ H2NG Hydrogen Blender blends your natural gas with hydrogen, to produce a consistent stream of usable fuel. Blending with intelligence, the AFC™ automatically adjusts the hydrogen blend for variable flow and pressures present in the distribution system, varying hydrogen and natural gas flowrates to maintain a repeatable ratio or percentage or hydrogen limit. No manual operation is required!

Blend Automatically with Intelligence

AFC™ stands for Active Flow Control. The AFC™ H2NG utilizes a combined “feed-forward” and “feedback” control strategy. Simultaneously, actual flow through the H2NG Blender is compared with the calculated theoretical flow required to provide the user defined hydrogen blend. The H2NG performs this fine tuning with an immediate process response cycle time the blend is adjusted. No operator attention or time consuming “change overs” between fuel trains are required.

Only the AFC™ delivers an accurate hydrogen blend instantaneously upon start-up and under rapid load changes.

When the AFC™ is started, the natural gas flow meter sends a value to the control system, which pre-determines the position of the natural gas fuel flow control valve relative to the natural gas flow rate. The AFC™ is now online. Consistent, reliable blended fuel gas - even changing the blend “on the fly” at varying flowrates and pressures for use within existing production, utility distribution, or in new facility construction.

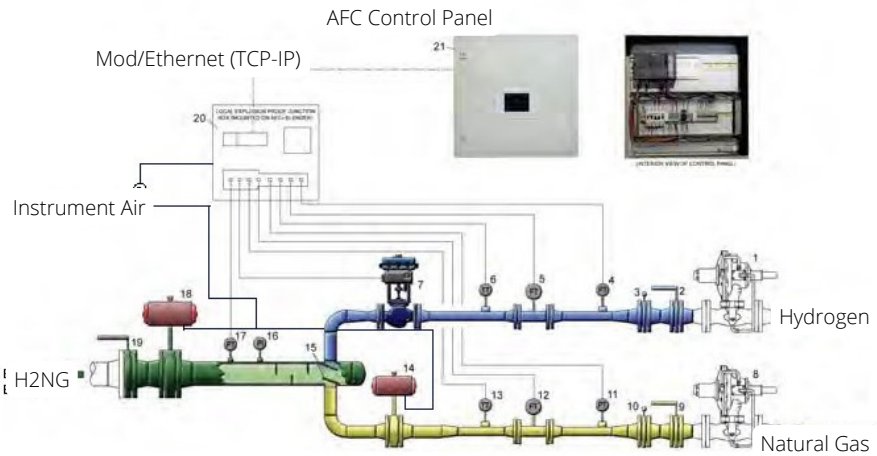
Operation

The AFC™ H2NG Blender (Patent Pending) mixes hydrogen and natural gas at a specific ratio to produce a repeatable, reliable hydrogen gas blend. Pressure and temperature compensated flow meters, as shown in the schematic, measure the regulated flow of hydrogen and natural gas. The volumetric or mass flow of both gas streams are converted to their true molar values with a sophisticated gas flow algorithm that takes into account the system process conditions. The ratio of the flow rates is then compared to the required ratio for the user-controlled blend desired.

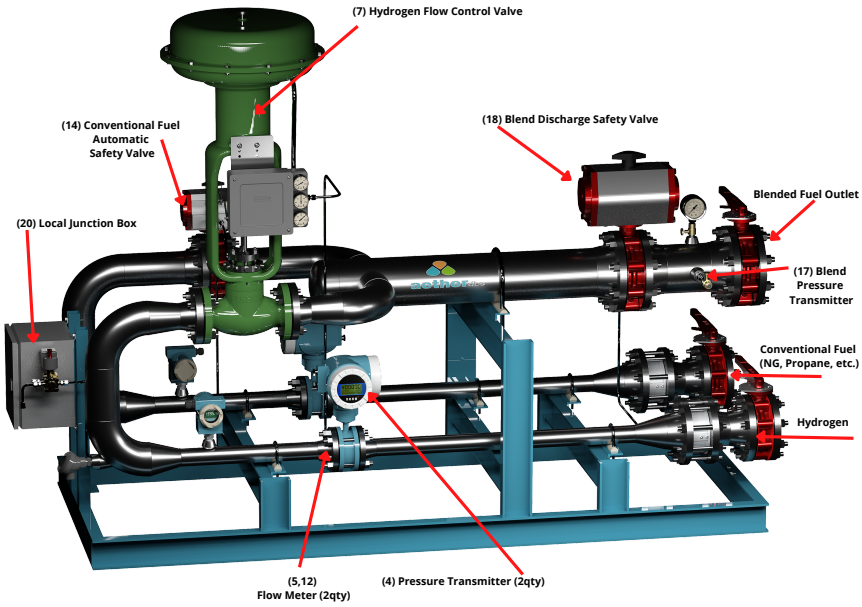
Adjustments to the ratio are made on the hydrogen side of the system. Adjustments are automatic and are performed by the Flow Control Valve. The outlet inline H2 analyzer feeds back the actual H2 content of the blend, of the total blended flow rate, and makes fine adjustments to the control valve to maintain the desired % or ratio or H2 limit that has been set by the Customer. As the demand for blended gas either increases or decreases, the Flow Control Valve modulates and maintains a consistent mixing ratio between the hydrogen and conventional fuel streams. Manual or automatic adjustments of the mixing ratio are performed from the touch screen of the HMI (Human Machine Interface) of the AFC™ and can be interfaced with a customer DCS for remote operation.

AFC Hydrogen Gas H2NG Blender

Key Components



1,8 = Pressure Regulators (optional)
2,9 = Isolation Valves
3,10 = Wafer-type Back Flow Check Valve
4,11 = Pressure Transmitters (Pressure correction of the flow data)
5,12 = Flow Meters
6,13 = Temperature Transmitters
7 = Hydrogen Flow Control Valve (Controls Hydrogen flow based on flow and control parameters)
14 = Fuel Pressure Control Valve (Controls Natural Gas Pressure Flow)
15 = Turbulators (Internal to header)
16 = Pressure Indicator (Displays blended gas discharge pressure)
17 = Pressure Transmitter (Provides blended gas discharge pressure signal to the control system)
18 = Discharge Safety Valve (Pneumatically opens-spring close; Valve closes when there is a safety violation)
19 = Butterfly-type Isolation Valve
20 = Local Junction Box (Mounted on the AFC™ /Blender
21 = Modbus/Ethernet (TCP/IP) Cable
22 = Control Panel (Simple Touch Screen design; Operator friendly and compact)



Intelligent Instruments:

- No analog scaling errors or drift:
  -All data transmitted directly to the PLC via digital signal
  -Values transmitted directly - eliminates scaling errors
- Advanced diagnostic information:
  -Process values transmitted with a diagnostic byte to indicate signal quality
  -Alarms triggered when signal quality is questionable, no guess work!

Intelligent Process Control:

- Automatic calculation of mixing ratio set-point to achieve the target hydrogen mix
- Automatic Ratio Adjustment via a H2 analyzer
- Adjustable alarm set-points and process response via HMI screens
- Automatic Daily Recalibration
- Alarm messages with process value history
- Extensive process value display for process diagnostics:
  -For each flow stream the AFC™ can display:
  --Real-time: pressure, temperature, actual flow, corrected flow at standard conditions, molar flow, stream velocity, volumetric ratio, and molar ratio
  --Totalized flow at standard conditions
  -Blended gas pressure
  -Blended gas totalized flow at standard conditions
  -Control valve throttle position
  -Real time H2% of blended gas
- Communication interfaces available:
  -RS-232 (ASCII, 3964R)
  -RS-485 (Modbus)
  -Ethernet (TCP/IP)

Optional:

- Remote Monitoring
- Hydrogen Supply Compensation
- DCS Interface
- Inlet and Discharge Pressure Regulators
- Electric Actuation
- Instrument Air Package
- Mobile Option
- Bypass Control

True Digital Flow Control Valve Positioning:

- Robust piezoelectric valve block is virtually wear proof
- Minimum air consumption required by piezoelectric valves
- One touch, “push button” self-tuning of valve positioner
- Local display of controller set-point and valve position
- Extended diagnostic information

Robust flow measurement:

- Immune to:
  -Vibration to over 1 g in all axis
  -Thermal shock > 150 K/s
  -Dirty media
- Permanent self-monitoring and diagnostic of electronics and sensor.
- No maintenance, no moving parts, no zero-point drift on flow sensor.

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Capacities and Sizes

Sagebrush provides custom-engineered H2NG blending systems based on your specific requirements for reliability, accuracy and precision. For planning purposes, the following table provides relative H2NG Blender capacities and sizes.

Skid Capacities @ 60 psig discharge pressure (5% to 20% of Hydrogen Vol% or Mol% in Blend Gas)							
Natural Gas Inlet Pipe Size (inch)	Hydrogen Gas Inlet Pipe Size (inch)	Skid Blended Gas Outlet Pipe Size (inch)	Natural Gas Minimum Inlet Pressure (PSIG)	Hydrogen Gas Minimum Inlet Pressure (PSIG)	Natural Gas Flow Rate (SCFH)	Hydrogen Gas Flow Rate (SCFH)	Approximate Skid Dimension (L' xW'x H')
1	1	2	70	80	1,300 - 7,800	350 -1,960	15 X 8 X 6
2	1	3	70	80	5,500 - 33,000	1,500 - 8,400	15 X 8 X 6
3	2	4	70	80	13,000 - 80,000	3,000 - 20,000	20 X 10 X 8
4	3	6	70	80	23,000 - 140,000	5,000 - 35,000	20 X 10 X 8
6	4	8	70	80	53,000 - 320,000	13,000 - 80,000	25 X 12 X 8

Notes: Larger capacities and higher H2 concentrations are available. Changes in pressures will affect the capacities shown. Contact Sagebrush to confirm sizes and capacities for all your hydrogen blending needs.

Contact us today.

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