Project F.I.O
Five In One

PRELIMINARY

Non invasive Flow measurement
Flow rate limitation
Remote pressure modulation

Remote disconnection   Remote monitoring

What is?

FIO (Five In One) is a system that allows to remotely control and monitor the natural gas pressure reduction stations installed in the network.

FIO is designed to be applied to Fiorentini regulators only.

In particular, FIO may be presently applied to all Fiorentini pilot-operated regulators, while the IFM (Indirect Flow Measurement) function, is available only for REFLUX, REVAL, DIXI regulators.

Five functions with one single device

The specific feature of FIO is the integration of 5 functions in one single battery-operated device :

- *(IFM) Flow rate measurement*, performed in an "indirect" mode, that is to say in a non "intrusive mode", instead of traditional measurement device,by means of the values correlations of the pressures and of the relevant displacement of the plug.
- *(OPC) Outlet Pressure control* of the regulator, that is to say the control of the outlet pressure set point through remote controls or locally in compliance with a daily/weekly program or according to flow condition if IFM is implemented.
- *(FL) Flow rate limitation*, by acting on the outlet pressure in order to keep the delivered flow rate below a configurable limit; it replaces the mechanical flow limitation devices without any intrusive component and any pressure loss under standard operating conditions
- *(RM) Remote-monitoring* of the meaningful parameters of the station functionality and safety (inlet and outlet pressure, safety valves, filters, monitor takeover, slam-shut tripping, intrusion, gas losses, cathodic protection, …)
- *(EUM) End User Management,* that means an interruption of supply to the users in case of emergency or in case of arrearages.
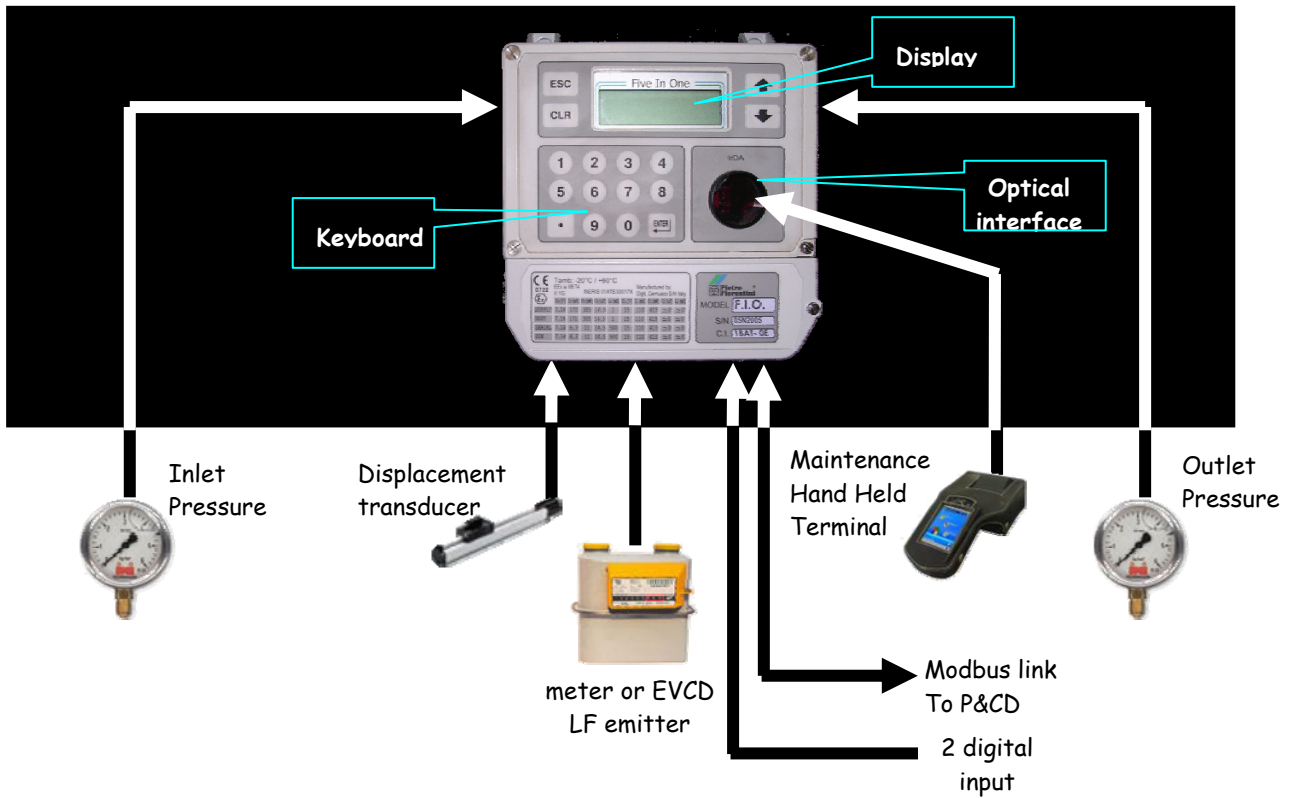
FIO is manufactured on the hardware platform of the EXPLORER family, from which it inherits the electrical specifications, the electromagnetic and safety compatibility.
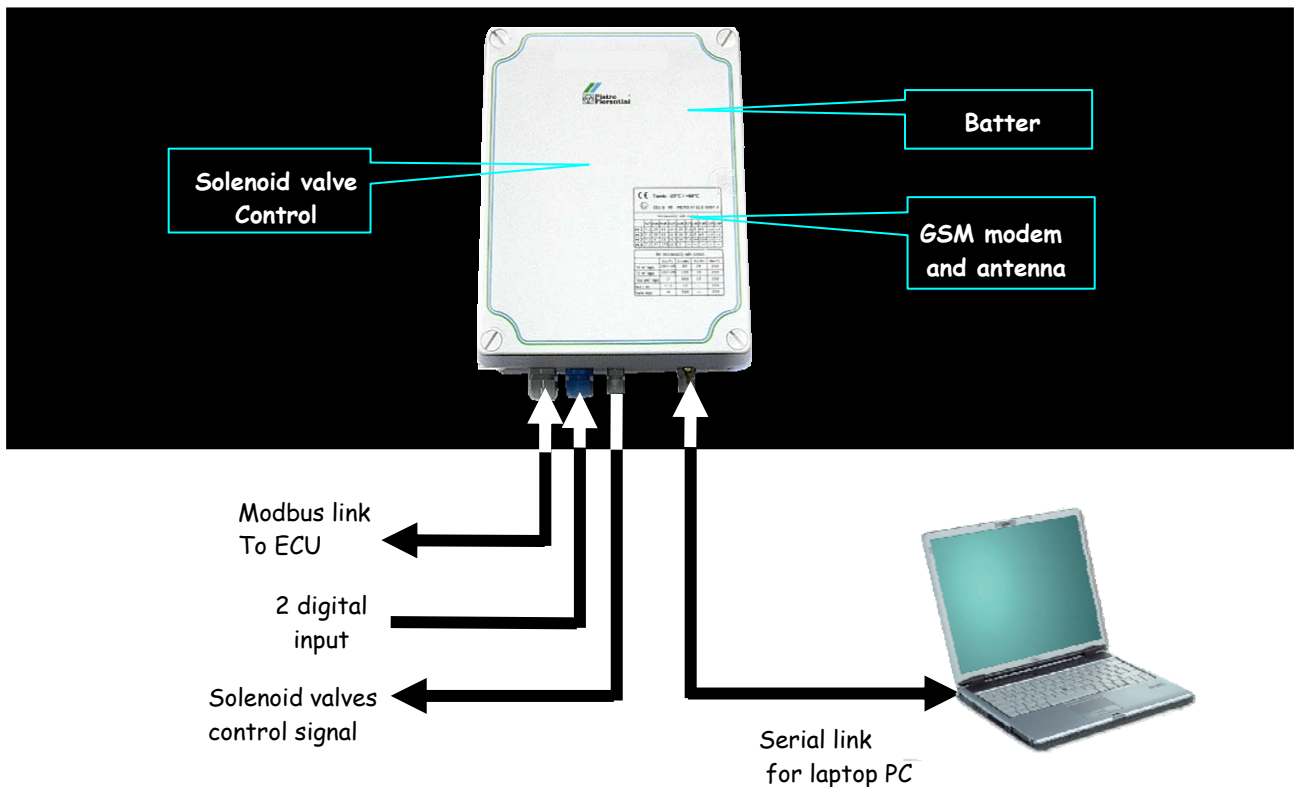The FIO functions may be integrated into Fiorentini – Explorer FT volumes converter.

The FIO is always composed by to units:

1) E.C.U. = Electronic Control Unit / Acquisition unit
   This unit, suitable for installation in Hazardous area, controls the FIO calcutation functions and act as a gateway for all the field sensors

2) P&CD = Power & Communication Device
   This unit, suitable for installation in Hazardous area, control the solenoid valves, host the battery and the communication system

E.C.U. – Electronic Control Unit

Display

Optical interface

Keyboard

Inlet Pressure

Displacement transducer

meter or EVCD LF emitter

Maintenance Hand Held Terminal

Modbus link To P&CD

2 digital input

Outlet Pressure

P&CD – Power & Communication device

Solenoid valve Control

Batter

GSM modem and antenna

Modbus link To ECU

2 digital input

Solenoid valves control signal

Serial link for laptop PC

The ECU that may be either a stand alone type or including EVCD function is connected with:

- The linear trasducer for detecting the plug diplacement (used for the "indirect" flow rate metering function);
- The double diaphragm CS series pilot
- upstream pressure take-off
- downstream pressure take-off
- Meter or external EVCD via low frequency pulses cable
- The P&CD via Modbus link

The ECU is equipped with an IrDA port for connecting a maintenance terminal and has available 2 digital input for alarms.

The P&CD, which is hosting batteriy and GSM modem + antenna is connected with:

- The solenoid valves for controlling the outlet pressure;
- The ECU via Modbus link

The P&CD has a serial link available for FIO set-up using a laptop and has available 2 digital input for alarms.

The FIO system, includes as well other equipment installed on the regulator:
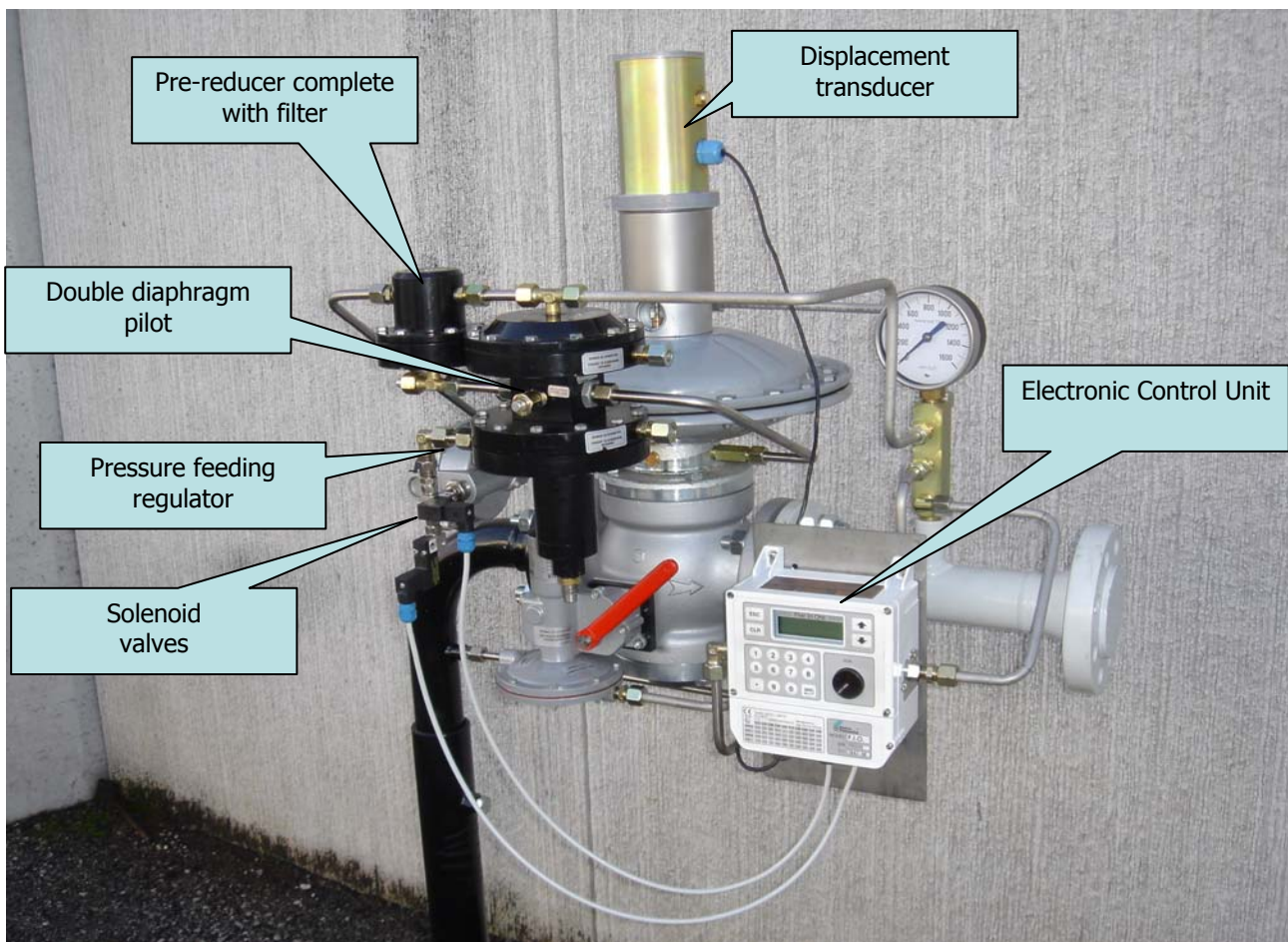
- The feeding regulator (optional) for generating the feeding pressure to the pilot
- The double diaphragm CS series pilot

Of the 5 functions of FIO 3 are independent (Indirect flow rate metering, Outlet pressure modulation, Remote monitoring) while the other 2 are dependent, that is they require the implementation of one or more independent functions.

	Indirect Flow Metering (*)	Outlet Pressure Control (*)	Flow Limitation	Remote Monitoring (*)	End User Management
Electronic Control Unit	✓	✓	✓	✓	✓
Displacement transducer	✓				
Solenoid Valves		✓	✓		✓
Double Diaphragm pilot		✓	✓		
Pilot feeding regulator		(✓)	(✓)		
Power & Communication Device.	✓	✓	✓	✓	✓

(✓) required only in specific conditions   (*) Independent function

Pre-reducer complete with filter

Displacement transducer

Double diaphragm pilot

Electronic Control Unit

Pressure feeding regulator

Solenoid valves

[IFM] Indirect Flow Measurement

Knowing the gas flow rate through a pressure reguaction station who is feeding the gas network allows to perform more accurate balancing of the network itself.

Presently the metering of the flow rate of the existing units, performed by means of meters or quantometers, requires the modification of the units or the availability of important energy sources (ultrasonic, annubars) and, anyway, high costs that do not often justify the investment.

The functioning principle of the indirect metering is based on the assumption that, for each type of regulator, there is a functional relation among the instantaneous flow rate under basic conditions, the regulator diaphragm position and the inlet and outlet pressures:

By considering the errors due to the actual compliance of the regulator with the correlation formula, the total accuracy of the metering, in all operating conditions, is better than the **8% of the regulator full scale value**

FIO performs the instantaneous flow rate calculation every 30 seconds

[OPC] Outlet Pressure Control

Modify the outlet pressure set point of a regulator without an operator's intervention, is useful in those cases in which the outlet pressure is highly variable during daytime due to different gas consuption conditions by the users downstream of the regulator.

In order to increase or decrease the outlet pressure in the pilot operated regulators, it is sufficient to decrease or increase the spring force of the pilot operated regulator.

Such increase or decrease of spring force may be obtained by increasing or decreasing the air or gas pressure ("feeding pressure") injected into the spring chamber. The pilot operated regulator spring shall be set in order to obtain the required minimum pressure in case of a lack of forward pressure.

For safety reasons the pilot has two separate chambers.

The double chamber and the double diaphragm guarantee a full separation between the main regulation hydraulic circuit and the motorization circuit for the modulation.

The system is able to pilot also two or more lines by keeping the intervention delta of the single lines constant.

In the self-control function an automatic control allows to position the outlet pressure value at specific values depending on the hour of the day.

The setting accuracy is 2% better than the nominal Po full scale.
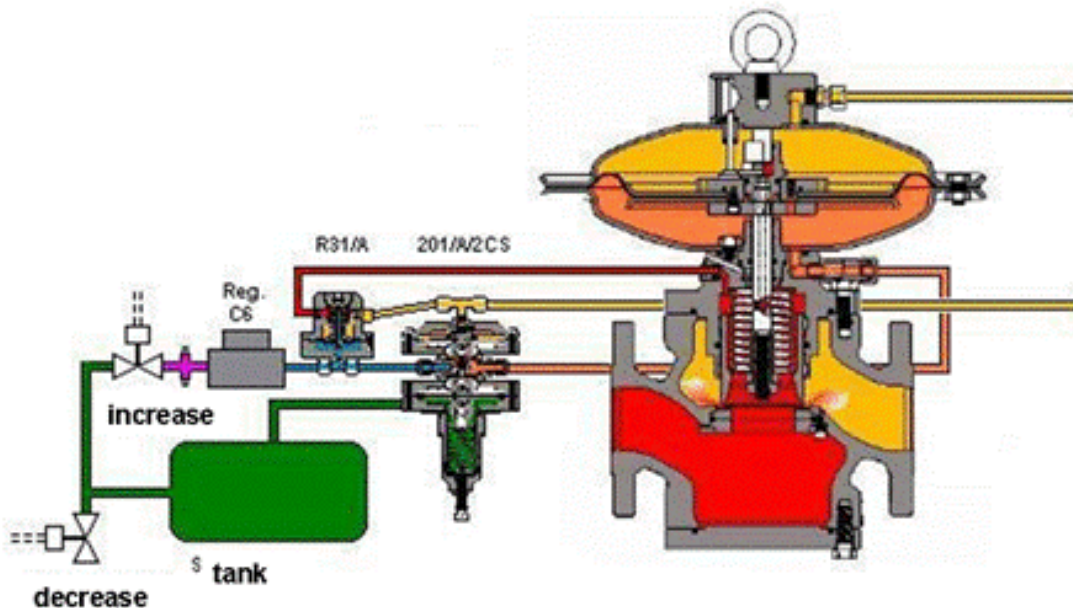
[FL] Flow Limitation (Over-flow protection)

The flow rate limitation of the industrial customers allows to comply with the contractual obligations, the technical specifications of gas consumption according to which the regulation and metering unit was designed as well as to grant a safety operation in the network.

The flow limitation applied to a multi-working runs system allows to balance the load between the streams and therefore to size them in the best way.

The flow rate limiting function may be performed only if the outlet pressure modulation function is available.

When the flow rate value at reference conditions, calculated with the indirect flow rate metering function or detected from an external metering system (meter, converter), reaches or exceeds the set and configurable limit flow rate value (Qlim), FIO modulates Po so to keep the flow at the standard condition with respect to Qlim up to the achieving of the configurable pressure limits

The overall accuracy, according to the procedures with which the flow rate is calculated, may vary from 1% to 10% of the regulator nominal flow rate at the Pi and Po operating conditions.

[RM] Remote-Monitoring

To remotely control the functionality of the units is very important for the network safety and this allow as well to achieve high quality of the distribution service and to reduce the operational costs because it can reduce the inspections frequency.
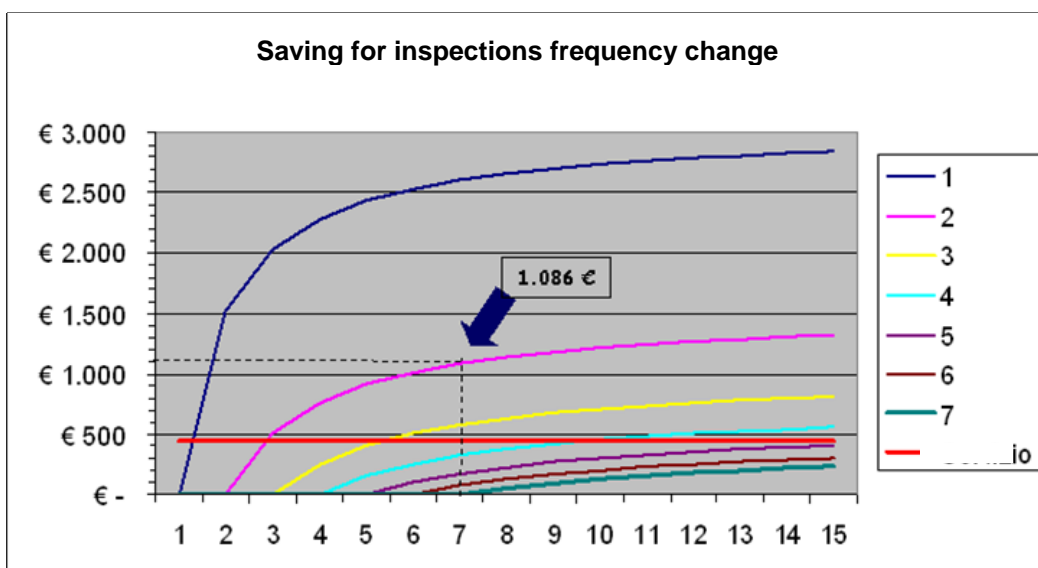
Ex.: the reduction of the inspections frequency from 1 every 2 days to 1 every 7 days for the implementation of the remote control produces a saving of over 1.000 € / year

FIO supports all the remote monitor functions presently implemented in the devices of the EXPLORER family.

In particular the control unit at its maximum configuration is able to monitor:

- The inlet and outlet pressure of the unit, with two integrated transducers with a stability and accuracy higher than 1% of the scale value
- The gas temperature value by means of an external type PT100 sensor (the function is not available if the flow rate indirect metering function is enabled)
- The flow rate calculated by an external apparatus (meter or volumes converter) and transmitted through low frequency pulse emitter
- Two inputs on ECU/Explorer + 2 inputs on P&CD able to detect the operating status (ON-OFF) of some system functional conditions (clogged filters, slam-shut valve tripping, monitor override, intrusion, flooding, etc.);

When FIO is battery powered and if the remote modulation function of the outlet pressure is not required, in order to increase the battery life , the control unit and the communication unit are usually kept in the sleep status.

The control unit periodically exits from the sleep status to perform the alarm management and if alarm conditions are detected that must generate calls to the control center or in case an SMS is received specifically requiring the connection, the unit enables the communication module and establishes the connection with the control center.
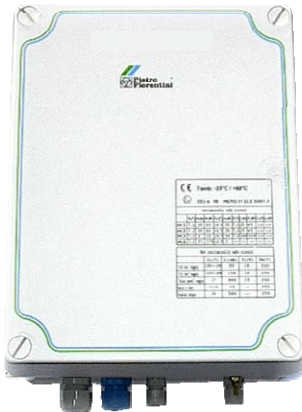
Wake-up time for calculation and alarm checking every 30 seconds. In case of alarm detection the unit will call immedialety or send SMS

Wake-up time for standard communication (sms checking) minimum every 15 minutes (up to 1/months, default 1/day)

LOCAL Interfaces:

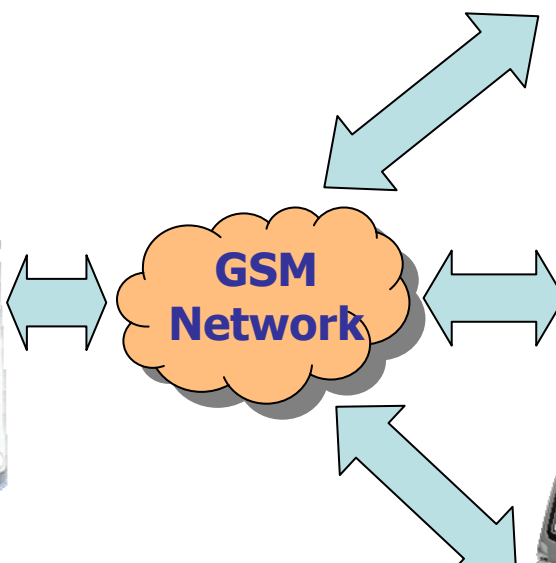Hand held terminal via serial link on IRDA port (for ECU maintenance and setup mode)

P&CD

Serial link for operator set-up of the ECU and to download all logs, alarms and events

REMOTE Interfaces:

FIO Manager is a versatile software tool to setup the FIO and to manage remotely the FIO
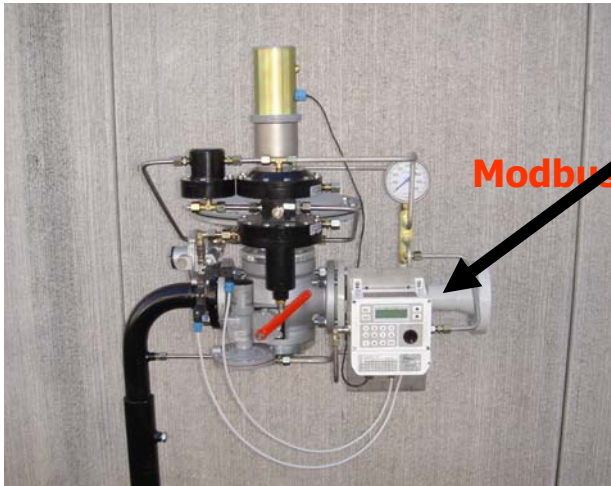

GSM Network

P&CD

Thanks to the Modbus protocol the FIO features can be easily implemented in existing SCADA system

A standard GSM mobile phone is able to query the FIO and to receive the alarms

Hazardous Area

Safe Area

P&CD

Modbus

**Battery powered GSM/GPRS
communication devices**

**On demand:
Solar Panel power supply
Power grid power supply**

Expected battery life 2 years with following configuration:
- Indirect flow measurement: ON
- Flow profiling: 2 variations a day with pressure variation +/- 50% of set-point
- Flow limitation: 1/month
- GSM communication: 1 alarm call every 2 days and 1 daily remote reading
- Wake up time for SMS check: 1 every 12 hours

A special function (optional as future implementation) of remote control that may be activated in FIO is the regulation of the regulator outlet pressure with closed loop (feedback) with the pressure measument performed in a particular point of the network.

GSM - GPRS
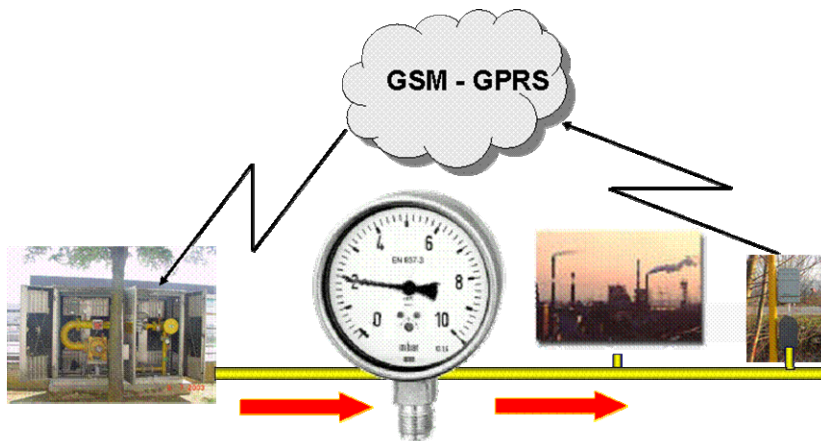
[EUM] End User Management

To remotely intervene for the disconnection of special users (Load Breaking) in precarious conditions that might compromise the network operation or in arrears conditions, allows reducing the operational costs, the intervention times and might result in an advantageous alternative for the improvement of the network when this is necessary only for cooping with occasional overloading situations.

The interruption of the supply may take place further to a specific control sent by the remote center, that is for the repeated or continuous exceeding of a configurable flow rate limit.
The interruption of the supply may be made by triggering the slam shut valve or by reducing the regulator outlet pressure to the minimum configurable value (Ps); the restoration of the supply is generally an activity to perform under safety conditions with the operator's intervention; the reset control may be generated by the FIO but require the manual reset of the slam shut valve.

The reset may be enabled either through a specific control from the remote center or/and locally by entering a password.

General specifications

- Operating temperature: -20°+60°C (On demand: extended range -25°C+65°C)

- Ambient temperature: -20°+60°C (On demand: extended range -25°C+65°C)

- Power supply: battery LYTIUM type
    – On demand: Solar panel power supply or power gird power supply

- Protection: ECU: IP65 with ABS pressure tranducers, otherwise IP55
                P&CD: IP65

- ECU Input: Inlet pressure
                    Oulter Pressure
                    Displacement transmitter (IFM function) or PT100 (EVCD function)
                    Counter (1 x LF)
                    Alarm status (2 x DI)

- P&CD Inpt: Link to ECU
                    Alarm status (2 x DI)

- ECU Output: Link to P&CD

- P&CD Output: Solenoid valves command (2 x open collector)

- Local Interfaces: ECU: keyboard + display / Irda – P&CD: serial link
    – On demand: Keyboard + display on P&CD

- Remote interfaces: GSM/GPRS/SMS modem

- Communication Protocol: Modbus

- Data Logging
    – Variables: any combination of P (1 and 2), T, Counter and Diagnostic
    – Period : 30s up to 12h (s resolution), daily, monthly
    – Strategy : Average, Statistics (min, max, σ)
    – Data Storage : > 50.000 records (Single Variable, Average Strategy)
    – Memory management : circular vs filling

- Alarms and Events
    – Analog Variables:
        - "Value" thresholds: Measured values (3 Max + 3 Min)
        - "Delta" threshold : allowed variation prior to alarm generation
    – Digital inputs variations (2 on ECU + 2 on P&CD)
    – Data Setup modifications
    – Low Battery level
    – Diagnostic events

- Alarm In-bound calls
    – Up to three telephone numbers
    – Programmable sequence

- Alarm Buffer for up to 1000 alarms and 1000 events

- Safety Approval
    – *Certificate EEx – ia IIB T4*
    – *Reference: EN 50014, EN50020*
    – *Approval Number : Ineris 01.E.5003 X - Ineris 03ATEX0017X*

- EVCD "Electronic Volume Conversion Device"
    – *Reference : CEN 12405-1, "Ijkregeling gasmeter" (NL)*
    – *Approval : NMI T5928*
    – *Certificate : NMI TC3466*