

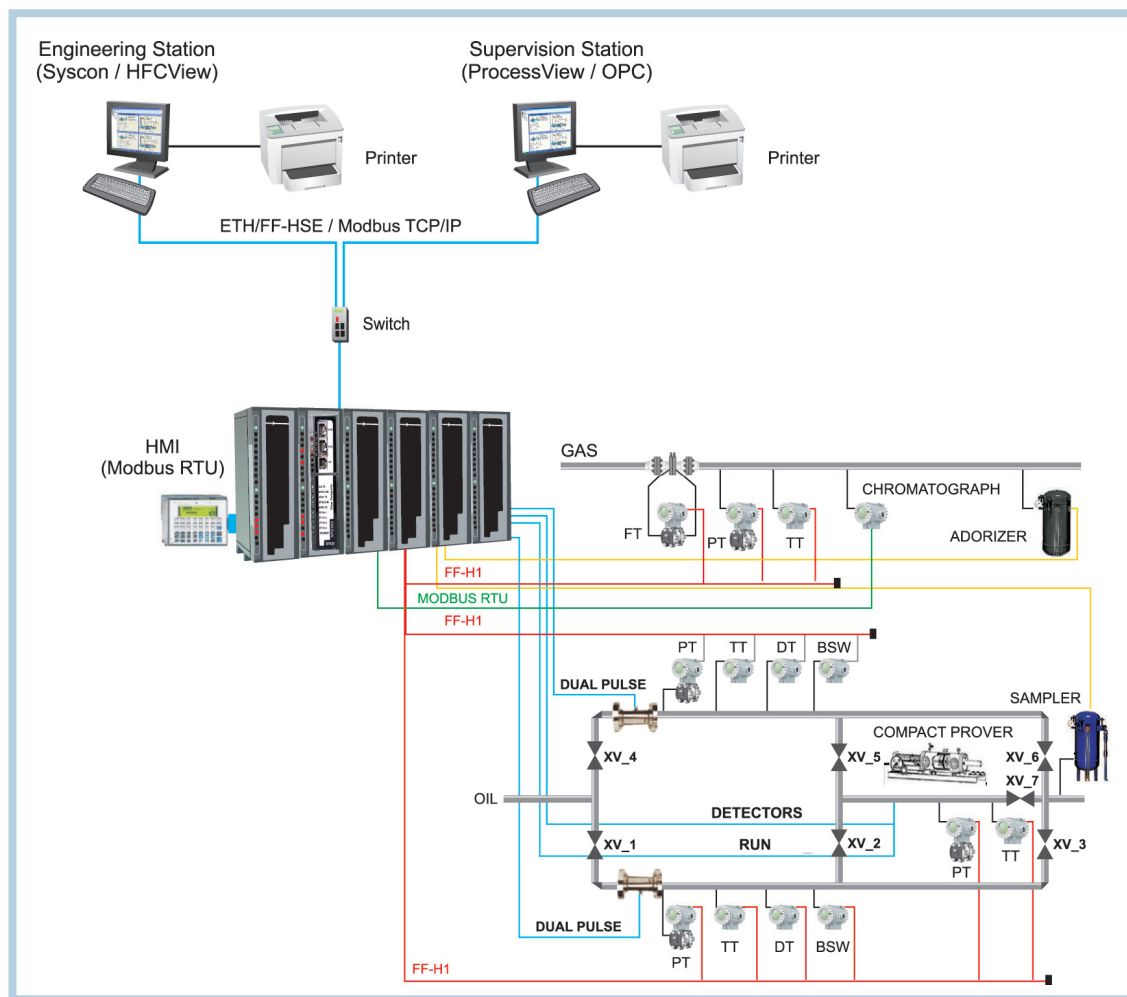
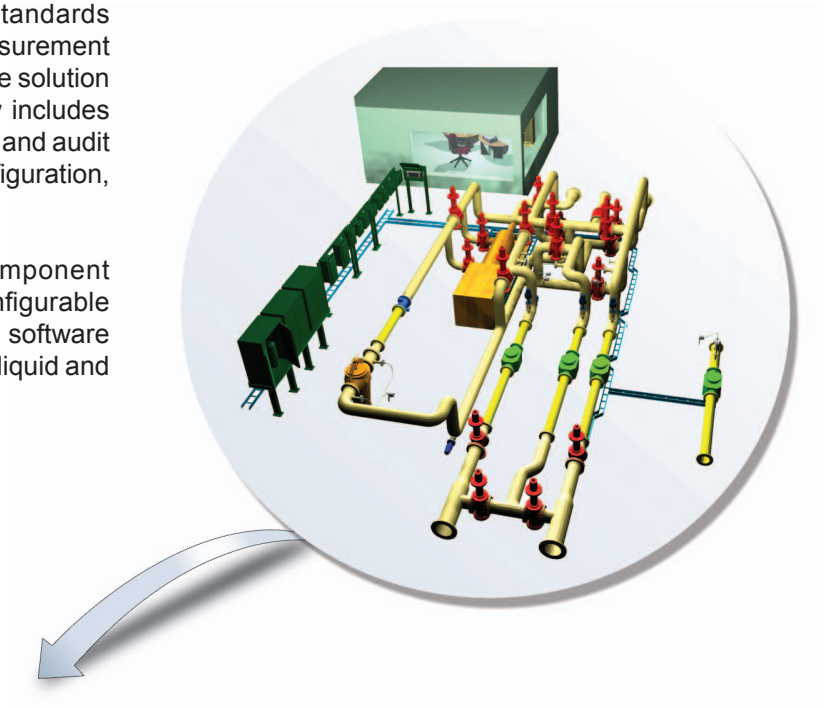
FLOW MEASUREMENT SYSTEM

- Inmetro and NMI certification for liquid and gas in fiscal measurement and allocation measurement.
- NMI Certin B.V. certification in compliance with MID 2004/22/EC (OIML R117-1:2007, EN12405-1:2010, Welmec 7.2).
- Custody transfer and fiscal measurement.
- Reduced uncertainty with the use of FOUNDATION™ fieldbus digital communication, thus eliminating the A/D and D/A conversions of conventional systems.
- In compliance with ASME, OIML, GPA, ISO, AGA, API, EN12405-1 and Welmec 7.2 standards.
- Supported flow meters: differential pressure, turbine, ultrasonic, positive displacement, Coriolis, Vcone, Wafer Cone.
- Suitable liquids: crude oil, refined products, lubricating oil, LPG, water and ethanol.
- Suitable gases: natural gas, steam, humid steam, argon, oxygen, nitrogen, carbon dioxide and ammonia.
- Supported prover types: Piston, ball, tank and master meter (operating meters can also have the function of master meter).
- Configurable in user-friendly languages as Block diagrams and ladder.
- Modular and expansible I/O system.
- Based on international digital communication standards: FOUNDATION™ fieldbus (H1 and HSE), OPC, Modbus RTU, Modbus TCP/IP, Ethernet TCP/IP and HART®.
- Report storage in SQL Server or MS Access databases.
- Remote SCADA architecture via radio or GSM/GPRS.
- Outstanding applications on exploration and production, well test, allocation measurement, transport and distribution of gas or liquids.



Compliant with the up-to-date international standards for custody transfer applications and flow measurement systems, the AuditFlow provides a comprehensive solution for electronic flow measurement. The AuditFlow includes real time flow correction calculation, data security and audit trail in order to fulfill every requirement for configuration, parametrization and field network inspection.

HFC302 flow computer module is a key component in the AuditFlow - Smar system. It is fully configurable and designed with leading edge hardware and software concepts for metering, controlling and correcting liquid and gas flow rates.



- High information reliability: audit trail in compliance with the API-21.1 and API-21.2 standards, including changes in transmitter configuration;
- Several redundancy levels;
- Linearization curve of KF/NKF/MF factors regarding liquid measurement frequency;
- Access for analyzers / chromatograph via Modbus or FOUNDATION™ fieldbus;
- Reduced and agile commissioning of field instrumentation through FOUNDATION™ fieldbus digital networks;
- Access control for up to 30 users, with username, 4-level configurable access and double password capability;
- High security information level: The writing and reading of the report in the NVRAM memory and database are checked, as well as the periodic checking of the firmware and configuration;
- Electronic seal: In case of seal violation, an event will be electronically registered by the Flow Computer;
- Increased diagnostic and status handling as only a FOUNDATION™ fieldbus based measurement system can provide;
- Engineering units selection for each physical quantity;
- High flexibility in handling the secondary variable override with five different modes;
- Orifice plate gas measurement using up to three differential pressure transmitters, avoids the use of plate holders and wrong plate installation. Besides it provides differential pressure transmitter redundancy;
- Capacity for up to 20 compositions of natural gas associated to each one of wells;
- Gas composition consistence can be verified by manual input either chromatograph;
- Liquid and gas stations: operation with measured flows, generating quantity transaction reports (QTR);
- Well test lasting up to 48 hours: evaluation of potential production for allocation in shared measurement;
- Proving request alert by the elapsed time since last proving or measured volume;

The image shows three overlapping AuditFlow report forms. The top form is a 'Quantity Transaction Report of Gases' for Flow Computer 'smar'. The middle form is a 'Quantity Transaction Report of Liquids' for Flow Computer 'smar'. The bottom form is a 'HISTORICAL ALARM / EVENT REPORT' for Flow Computer 'smar' showing a list of events with columns for Date/Time, Event, Block Tag, Var. Type, Alarm Type, Priority, and Value.

Ch	Date / Time	Event	Block Tag	Var. Type	Alarm Type	Priority	Value
1	[Thu] 26-Sep-2003 11:03:00	Specific	Initialization of loggers	None	Block Alarm/Event (occurred)	5	0
2	[Thu] 26-Sep-2003 17:33:00	Specific	Configuration download	None	Block Alarm/Event (occurred)	5	0
3	[Thu] 26-Sep-2003 17:33:00	Specific	Override temperature used	Temperature	Block Alarm/Event (occurred)	5	0
4	[Thu] 26-Sep-2003 17:33:00	Specific	Override pressure used	Pressure	Block Alarm/Event (occurred)	5	0
5	[Thu] 26-Sep-2003 17:33:00	Specific	Override density used	Density	Block Alarm/Event (occurred)	5	0
6	[Thu] 26-Sep-2003 17:33:00	Specific	Override SV used	SV	Block Alarm/Event (occurred)	5	0
7	[Thu] 26-Sep-2003 17:34:00	Specific	Override temperature used	Temperature	Block Alarm/Event (occurred)	5	0
8	[Thu] 26-Sep-2003 17:34:00	Specific	Override pressure used	Pressure	Block Alarm/Event (occurred)	5	0
9	[Thu] 26-Sep-2003 17:34:00	Specific	Override density used	Density	Block Alarm/Event (occurred)	5	0
10	[Thu] 26-Sep-2003 17:34:00	Specific	Override SV used	SV	Block Alarm/Event (occurred)	5	0
11	[Thu] 26-Sep-2003 17:35:00	Specific	Initialization of loggers	None	Block Alarm/Event (occurred)	5	0
12	[Thu] 26-Sep-2003 17:35:00	Specific	Configuration download	None	Block Alarm/Event (occurred)	5	0
13	[Thu] 26-Sep-2003 17:35:00	Specific	Flow Computer power down	None	Block Alarm/Event (occurred)	5	1
14	[Thu] 26-Sep-2003 17:35:00	Specific	Flow Computer power up	None	Block Alarm/Event (occurred)	5	0

- Event record for Flow Computer Module, such as power on/off, override value usage, correction factor out of range, configuration download, rollover of non-resettable totalizers, log initialization, daylight savings time start/end, bad flow sensor, etc;
- Three Batch Types: by quantity, by time and by liquids interface;
- Totally prepared for allocation measurement including specific calculations of correction factors and proving;
- Level A in pulse transmission fidelity and security;
- Wide control functions: advanced PID, interlocks, sampler, adozizer and batch.

The algorithms for flow calculation and procedures were based on international standards, in order to assure AuditFlow reliability. The main standards used are:

Gas

- AGA 3 / API 14.3 and ISO 5167: Calculation of flow using orifice plate;
- AGA 5: Calculation of heating value;
- AGA 7: Calculation of flow using turbine;
- AGA 8 / API 14.2: Calculation of compressibility factor (Z);
- AGA 9: Calculation of flow using ultrasonic;
- AGA 10: Calculation of isentropic coefficient;
- AGA 11: Calculation of flow using coriolis;
- ASME IAPWS-1997: Steam measurement;
- AIChE DIPPR 801: Pure substances (Ar, O₂, N₂, CO₂, Ammonia);
- API 21.1: Audit, reports, calibration, check and data security.

Liquid

- API 5.3: Measurement of liquid hydrocarbons by turbine;
- API 5.6: Measurement of liquid hydrocarbons by Coriolis meters;
- API 11.1 (versions 1980 and 2004): Correction factor for temperature;
- API 11.2.1: Correction factor for pressure;
- API 11.2.2: Correction factor for pressure – light hydrocarbon;
- API 12.2.1: Correction factor for volumetric flow;
- API 12.2.2: Measurement for ticket;
- API 20.1: Allocation Measurement;
- API 21.2: Audit, reports, calibration, check and data security;
- ISO 4267-2: Calculation of quantities for oil;
- ISO 6551/API 5.5: Fidelity and security in pulse transmission;
- GPA TP15: Calculation of equilibrium pressure;
- GPA TP25: Correction factor for temperature – light hydrocarbon;
- OIML R22 / NBR 5992: Correction factor for temperature – ethanol.

Proving

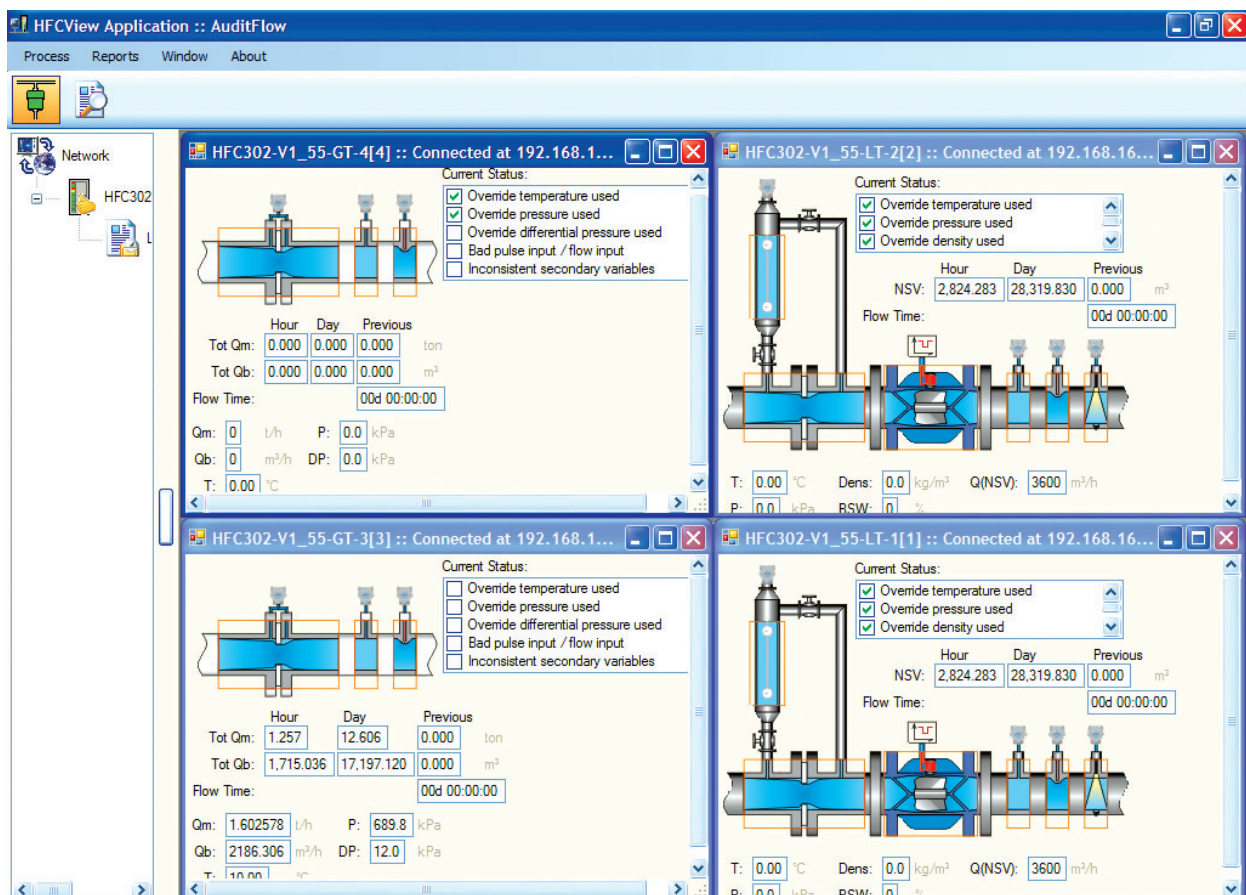
- API 4.2: Pipe Provers (uni and bidirectional)
- API 4.3: Small Volume Provers;
- API 4.5: Master Meter;
- API 12.2.3: Proving report;
- ISO 7278-1: General principles of proving systems for volume measurement;
- ISO 7278-2/API 4.2: Conventional Provers (uni and bidirectional);
- ISO 7278-3/API 4.6: Pulse interpolation.

Features

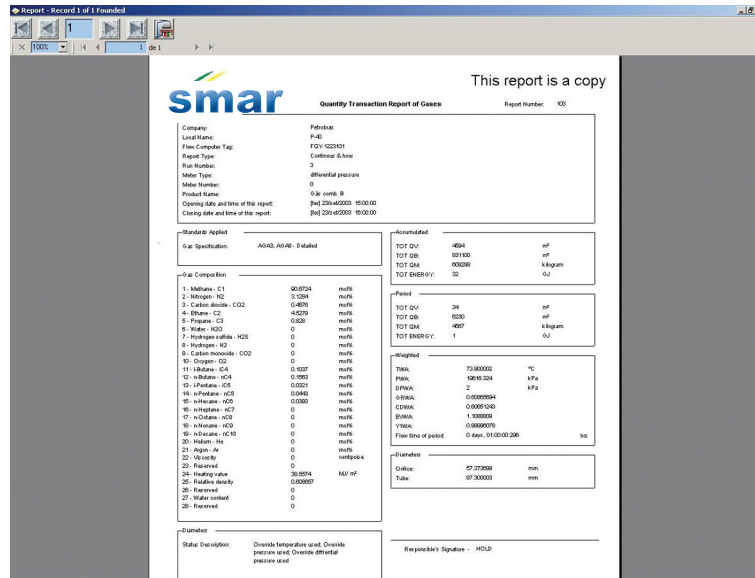
- AuditFlow shares the same renowned SYSTEM302 integrated process control software platform for measurement reports and management;
- All required information for reports are generated by the Flow Computer and stored in non-volatile memory;
- The HFCView reads this information via Modbus and stores in a database, without numeric manipulations;
- Simultaneously to the report storage in database, the HFCView can automatically send for a Windows configured printer. The reports also can be stored in PDF, TIF or other file formats;
- Comparison of Configuration Reports: indication only of the differences between two Configuration Reports, which are complete lists of the values of configuration parameters;
- Management of proving and well test procedures;
- Language selection for software and reports: English and Portuguese;
- Customization of company logo on reports;
- In case of database loss, the resident reports in the Flow Computer Module memory can be recovered using the HFCView Restore function;
- No additional configuration required for complete individual flow variables monitoring via Modbus: weight averages, totalizations, correction factors, status and process alarms;
- Atuation in every flow parameter via Modbus as in gas composition for instance;
- Alarm station: indicates active or unrecognized process alarms for each flow;
- Summary Report on a table and graph: profile of consumption / production, potential production of the well and MF monitoring over time for preventive maintenance.

New

Generating XML reports in accordance with the requirements of the ANP - National Petroleum Agency and verification of content integrity.



In compliance with API 21.1 and API 21.2 standards, the AuditFlow system establishes audit trail by the compilation and retention of enough information to check custody transfer quantities, system operation performance and data security.



Quantity Transaction Report of Gases

Report Number: 100

This report is a copy

Company: Petrobras
Local Name: P-40
Flow Computer Tag: F2V-022001
Report Type: Custody & flow
Run Number: 3
Meter Type: Differential pressure
Meter Number: 0
Product Name: n-Butane
Opening date and time of this report: [Fri] 23/04/2003 15:00:00
Closing date and time of this report: [Fri] 23/04/2003 15:00:00

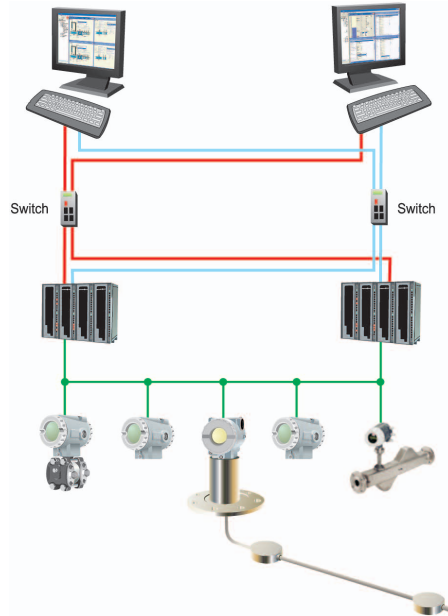
Standard Applied: API 21.1, API 21.2 - Detailed

Gas Specification:

Gas Composition	Value	Unit
1. Methane - C1	80.8754	mol%
2. Nitrogen - N2	3.3284	mol%
3. Carbon dioxide - CO2	0.4870	mol%
4. Ethane - C2	4.5279	mol%
5. Propane - C3	0.020	mol%
6. Water - H2O	0	mol%
7. Hydrogen sulfide - H2S	0	mol%
8. Hydrogen - H2	0	mol%
9. Carbon monoxide - CO	0	mol%
10. Oxygen - O2	0	mol%
11. Nitrate - NO3	0.0027	mol%
12. Nitrate - NO2	0.0003	mol%
13. Nitrate - NO	0.0003	mol%
14. Nitrate - N2O	0.0003	mol%
15. Nitrate - N2O5	0.0003	mol%
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329. Nitrate - NO308	0	mol%
330. Nitrate - NO309	0	mol%
331. Nitrate - NO310	0	mol%
332. Nitrate - NO311	0	mol%
333. Nitrate - NO312	0	mol%
334. Nitrate - NO313	0	mol%
335. Nitrate - NO314	0	mol%
336. Nitrate - NO315	0	mol%
337. Nitrate - NO316	0	mol%
338. Nitrate - NO317	0	mol%
339. Nitrate - NO318	0	mol%
340. Nitrate - NO319	0	mol%
341. Nitrate - NO320	0	mol%
342. Nitrate - NO321	0	mol%
343. Nitrate - NO322	0	mol%
344. Nitrate - NO323	0	mol%
345. Nitrate - NO324	0	mol%
346. Nitrate - NO325	0	mol%
347. Nitrate - NO326	0	mol%
348. Nitrate - NO327	0	mol%
349. Nitrate - NO328	0	mol%
350. Nitrate - NO329	0	mol%
351. Nitrate - NO330	0	mol%
352. Nitrate - NO331	0	mol%
353. Nitrate - NO332	0	mol%
354. Nitrate - NO333	0	mol%
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356. Nitrate - NO335	0	mol%
357. Nitrate - NO336	0	mol%
358. Nitrate - NO337	0	mol%
359. Nitrate - NO338	0	mol%
360. Nitrate - NO339	0	mol%
361. Nitrate - NO340	0	mol%
362. Nitrate - NO341	0	mol%
363. Nitrate - NO342	0	mol%
364. Nitrate - NO343	0	mol%
365. Nitrate - NO344		

A very important measurement system feature is its high availability. With this purpose, Smar provides redundant and advanced architectures with the following features:

- Supervision stations redundancy, Ethernet networks, switches, power supply and pulse module;
- Hot Standby Redundancy of the Flow Computer CPU, to keep the function blocks active, Modbus communication and LAS (Link Active Scheduler).



Reduced Cost

One Flow Computer Module supports up to four liquid and gas applications flows, using several types of flow meters.

It has PID control and integrated interlocking, without requiring additional dedicated hardware.

The AuditFlow modularity allows future expansion. Starting with a processor module and power supply, future I/O modules expansion is possible, according to the application requirements.

Packaging

The system can be supplied in standard panel or according to specification.



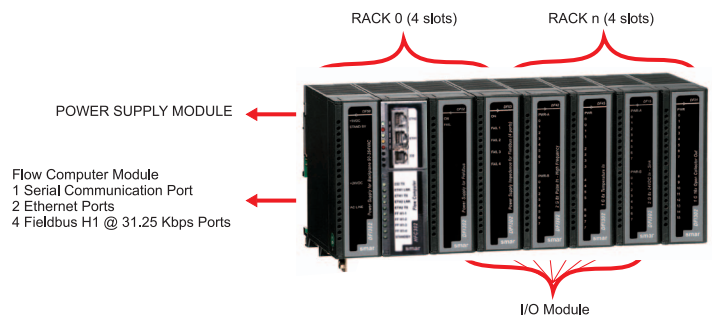
There are many types of I/O modules available for AuditFlow system, which can be connected any time according to the user requirements. Besides the conventional I/O modules, communication interface modules allow the Flow Computer Module to connect to field networks using standard industrial protocols. These modules allow Flow Computer to access diverse types of field signals, such as:

- DF77 Module: Pulse input module with level “A” in fidelity and security pulse transmission. This module is used on proving with piston prover, ball prover, tank prover and master meter.

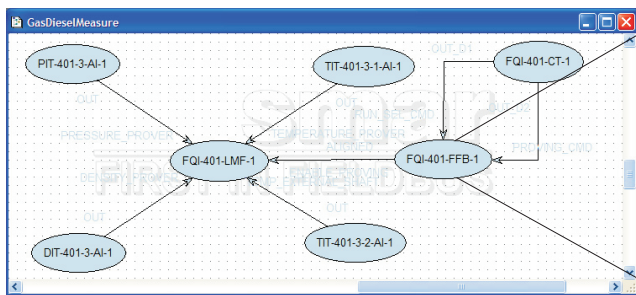
Double chronometry capability and pulse interpolation for small volume provers in compliance with API-4.6.

Level “A” fidelity and security pulse transmission with automatic detection and correction of the following errors in dual pulse mode: sequence, phase, coincident pulses, missing pulses and extra pulses.

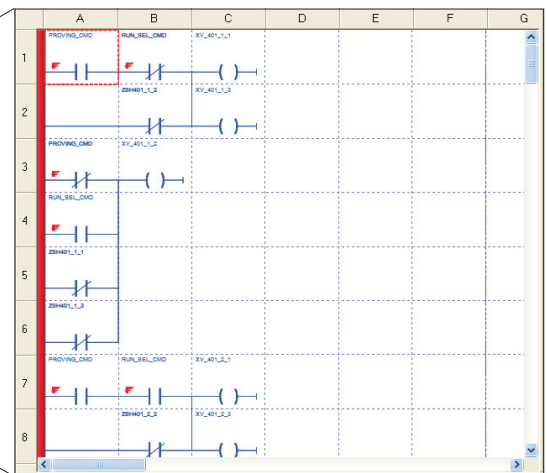
- Digital Inputs (AC and DC);
- Digital Outputs (relay, transistor, triac);
- Pulse Inputs;
- Analog Inputs (4-20 mA, 0-20 mA, 0-5 V, 1-5 V, 0-10 V, 1-10 V);
- Temperature Inputs (RTD or thermocouples);
- Analog Outputs (4-20 mA, 0-20 mA, 0-5 V, 1-5 V, 0-10V, 1-10 V);
- HART® Equipment;
- FOUNDATION™ fieldbus Equipment;
- Modbus RTU Equipment (chromatograph).



Graphic Languages for Simple Configuration



Syscon - Fieldbus System Configurator



LogicView - Ladder Configuration Tool

The AuditFlow System module is totally configured through instantiable Function Blocks via Syscon. Flow calculations data compliant with GPA, AGA, API and ISO standards, process control, reports, alarms, calculations and equations can be configured in a single environment, by using the Syscon configuration tool with Microsoft Windows technologies such as OPC, OLE, DCOM and ActiveX, providing integration with software from other manufacturers, including Microsoft Excel.

Online or offline configurations are available, besides upload and download features, that allows additional

customization at any time and the ability to download similar configurations in different flow computer modules, saving configuration time.

The system can remotely save projects and configurations, thus electronic documentation can be generated with no need of any other tool.

Monitoring, configuration and field devices calibration functions, diagnostics, identification, datasheets, device setup, quick start up and commissioning are other features provided by Syscon.

AuditFlow also provides HFC302 module to be configured for logic control, usually associated to the measurement systems as in the alignment of flow meter for proving. All is done through a user-friendly configuration using ladder language with direct integration with function blocks strategies.

Connectivity through Open Protocols

Smar's experience in connectivity is reflected in the AuditFlow offering a completely open solution for flow computation. Once it is based on standard protocols, this results in high integration with the supervision system, regardless of the selected media: cable, optical fiber, modem radio, GPRS, etc.

Some supported standards are:

- **ETHERNET + TCP/IP:** The MODBUS TCP/IP (master and slave), HSE-FF protocols and can co-exist with other Ethernet protocols, thus connecting to other systems.
- **MODBUS RTU:** (master or slave): Using the serial port and Modbus RTU protocol, it is possible to connect the Flow Computer Module to other systems or equipment, such as a chromatograph or multi-variable transmitters.
- **OPC (OLE for Process Control):** The OPC server allows the AuditFlow to be connected with the best available supervision interfaces.
- **FIELDBUS:** The FOUNDATION™ fieldbus (H1 and HSE) protocol is one of the most complete standards available in the automation industry.
- All HFC302 block parameters can be monitored and written via Modbus and OPC.
- **HART:** Recognized as the digital communication standard with a 4-20 mA signal. Most of the largest instrumentation suppliers are offering products with HART® communication.

Flow Computer Module

Based on a 32-bit RISC processor and with the program stored in flash memory, this module processes communication, calculation and control tasks.

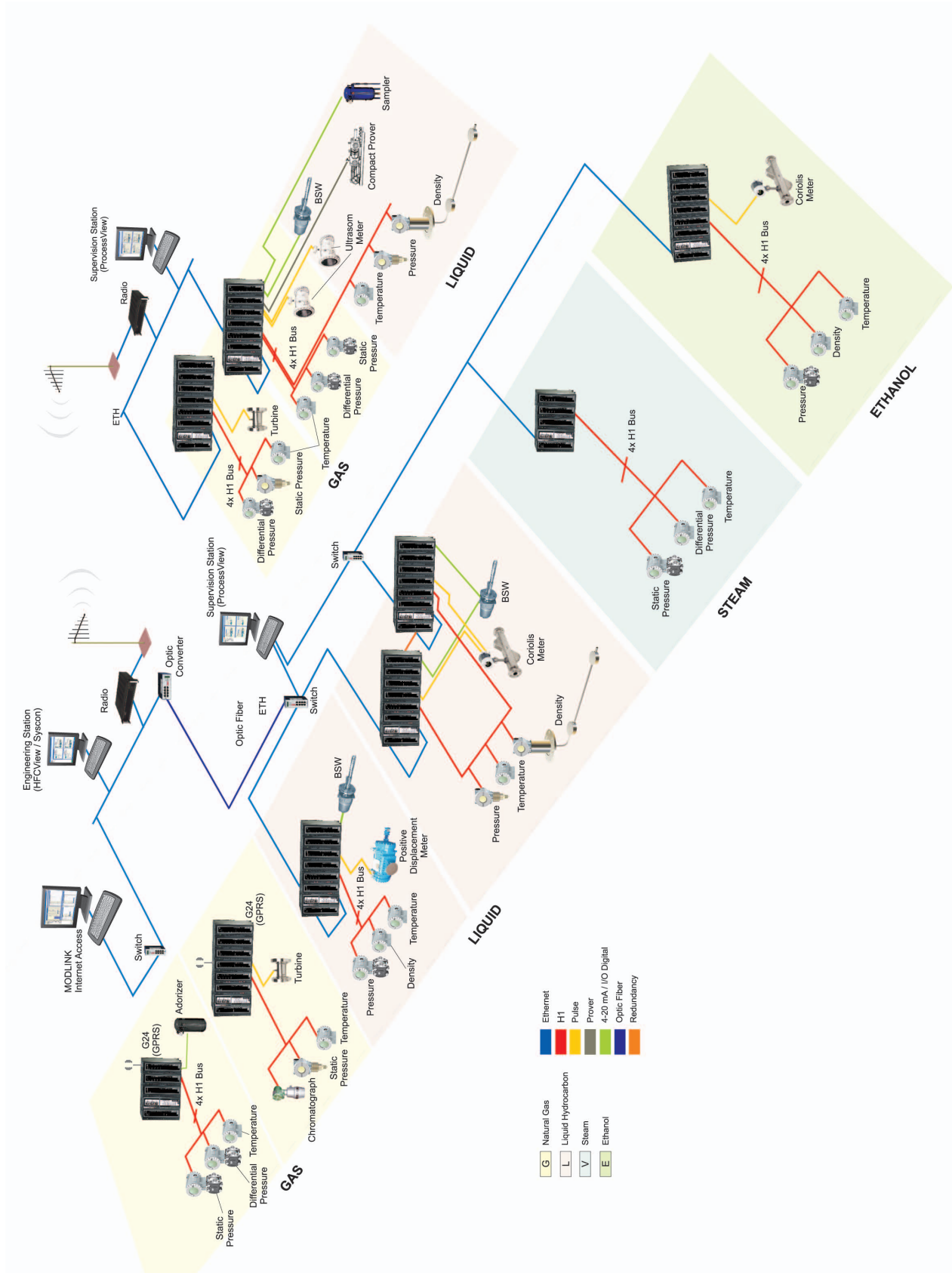
Features supported by a single Flow Computer Module:

- **ETH1 @100 Mbps port:** HSE-FOUNDATION™ fieldbus, Modbus TCP/IP (slave and master);
- **ETH2 @100 Mbps port:** HSE-FOUNDATION™ fieldbus, Modbus TCP/IP (slave);
- **4 FOUNDATION™ fieldbus Ports H1@ 31.25 Kbps;**
- **Serial Port EIA-232:** Modbus RTU (slave or master);
- **Up to four flows** in any combination of gas and liquid custody transfer measurement, or allocation measurement;
- **Supports different flow measurement devices** for natural gas in any combination.

The Flow Computer Module NVRAM memory allows the following quantity of registers/reports:

Type	Quantity
QTR (under demand, time, daily, weekly, monthly)	1000
Alarms and Events	200
Configuration changes	400
Proving Report	10
Well Test Report	2
Historic	10
Periodic Totalizers	210

The AuditFlow flexibility provides the necessary scalability to match different applications.



Open Architecture interacting with several industrial networks.

Smar acquired large experience supplying complete solutions to clients. Its proven capability to develop, project, manufacture and assemble skids for oil and gas measurement led it to master this area.

With its comprehensive knowledge, Smar offers engineering services from field data gathering, basic project, to detailed project execution, startup, commissioning, operation mentoring and training, which represents the most complete solution for skid measurement systems.

Smar also counts with local integrators in certain locations through the world which can engineer and support AuditFlow installations on behalf of Smar providing local and faster support when needed.



Application: Well Test

AuditFlow system is intended for well test in the exploration and production of crude oil and natural gas. This test is basically the separation of crude oil, natural gas, water and residue from one well and their production followup.

When performed periodically, Auditflow allows monitoring and analyzing the oil field life cycle, its variations, as well the result of different techniques applied to recover or keep the production steady through the integrated well test report.

The system can also measure injected product:

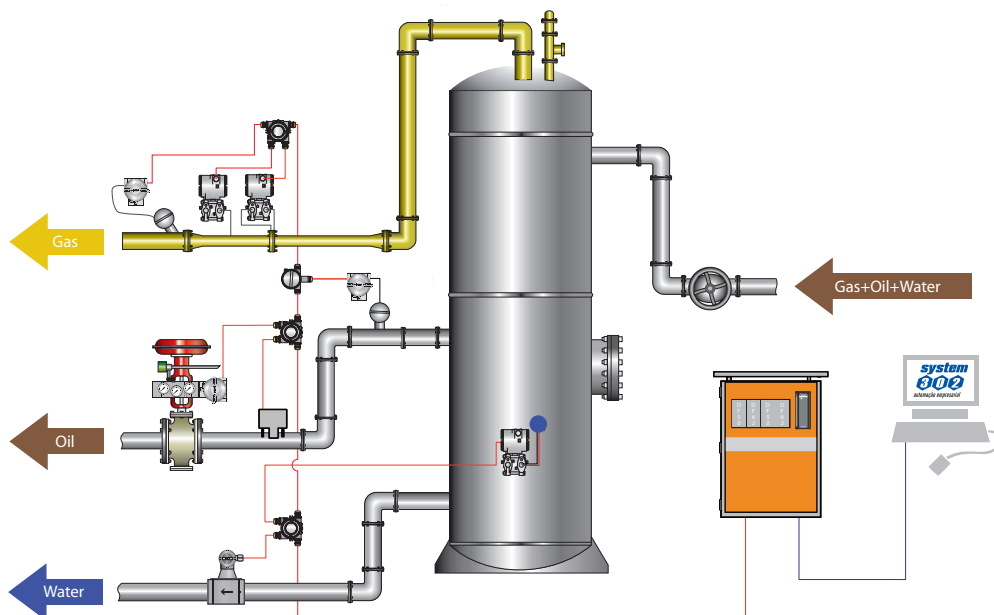
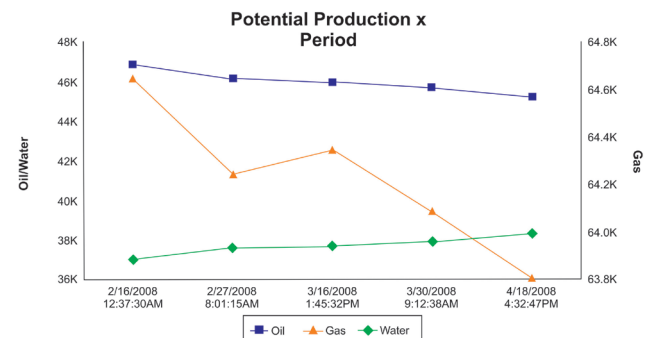
- Carbon dioxide (including super critical state);
- Steam (including super critical state);
- Wet Steam;
- Natural Gas;
- Water.

smar

Well Test Report - Summary

Flow Computer:
Flow Computer Tag: HFC302-V1 55
Field Name:
Well ID:

Date and Time	Potential Production of		
	Oil [m ³ /day]	Gas [m ³ /day]	Water [m ³ /day]
/18/2008 12:37:30AM	46,840.090	64,644.640	36,962.520
/27/2008 8:01:15AM	46,126.570	64,241.820	37,587.680
/16/2008 1:45:32PM	45,977.140	64,346.310	37,662.170
/30/2008 9:12:38AM	45,672.690	64,084.790	37,900.800
/18/2008 4:32:47PM	45,205.530	63,804.640	38,309.240



The AuditFlow-V.7.1 system has Model Approval by Inmetro for legal metrology according to the following information:

ITEM	DESCRIPTION
Notified Body	Inmetro
Country	Brazil
Type of Instrument	Flow Computer
Mark	AuditFlow
Model	HFC302-V1
Accuracy class	Class 0.3 for liquids and Class A for gases
Mechanical environment class	M2 (places with significant or high levels of vibration and shock transmitted from machines or trucks, conveyors, etc.)
Electromagnetic environment class	E2 (industrial environment)
Climatic environment class	H2 (indoors without humidity control in industrial process plants)
Approval document provides the tested hardware configuration as well the test conditions	N.º 0305 of October 13, 2011
Gas measurement - fluid type	Natural gas
Gas measurement - flow meter	Orifice plate, turbine, coriolis and ultrasonic
Liquid measurement - fluid type	Crude oil and derivatives, ethanol (anhydrous and hydrated) fuel
Liquid measurement - measurement type	Fiscal measurement and allocation measurement

The AuditFlow-V7.2. has MID 2004/22/EC Approval for flow computer issued by NMI Certin B.V. (Dordrecht - Netherlands) in accordance with WELMEC guide 8.8 "General and Administrative Aspects of the Voluntary System of Modular Evaluation of Measuring Instruments under the MID".

ITEM	DESCRIPTION
Notified Body	NMI Certin B.V (Dordrecht - Netherlands)
Countries	European Union and accepted by Notified Bodies of others countries
Type of Instrument	Flow Computer
Mark	AuditFlow
Model	HFC302-V2
Mechanical environment class	M2 (places with significant or high levels of vibration and shock transmitted from machines or trucks, conveyors, etc.) M3 (level of vibration and shock is high or very high, e.g. for instruments mounted directly on machines, conveyor belts, etc)
Electromagnetic environment class	E2 (industrial environment)
Climatic environment class	Temperature range ambient: -10°C to 55°C Humidity environment class: condensing
European legal metrology	Welmec 7.2. Software Guide - Measuring Instruments Directive 2004/22/EC

Gas measurement	Evaluation certificate provides the tested hardware configuration as well the test conditions	
	In accordance with	EN 12405-1_2005+A2_2010 "Gas meters-Conversion devices - Part 1: Volume conversion"
	Measuring Instrument	An electronic volume conversion device for use as part of a Gas Custody Transfer Measurement installation.
	Fluid type	Natural gas
	Flow meter	Orifice plate, turbine, coriolis and ultrasonic
Liquid measurement	Evaluation certificate provides the tested hardware configuration as well the test conditions	
	In accordance with	OIML R117-1 Edition 2007 (E) "Dynamic measuring systems for liquids other than water"
	Measuring Instrument	An electronic calculating device for use as part of a liquid measuring installation.
	Fluid type	Crude oil, refined products, special applications (MTBE), lubricating oils, light hydrocarbon liquids
	Flow meter	Turbine, coriolis, ultrasonic, positive displacement
	Engineering units	International system of units (SI) and US units

The AuditFlow-V.7.has other certificates according to the following information:

DOCUMENT	DESCRIPTION
TUV Rheinland 016-07-46761730000106-309	Certificate of Brazilian content for the HFC302 module.
Smar CE Label declaration for AuditFlow-V7 provides the tested hardware configuration as well the test conditions	European Conformity

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Specifications and information are subject to change without notice.
Up-to-date address information is available on our website.

web: www.smar.com/contactus.asp



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