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(54) Title: AN AID IN VALIDATING FLOW MEASUREMENT EQUIPMENT

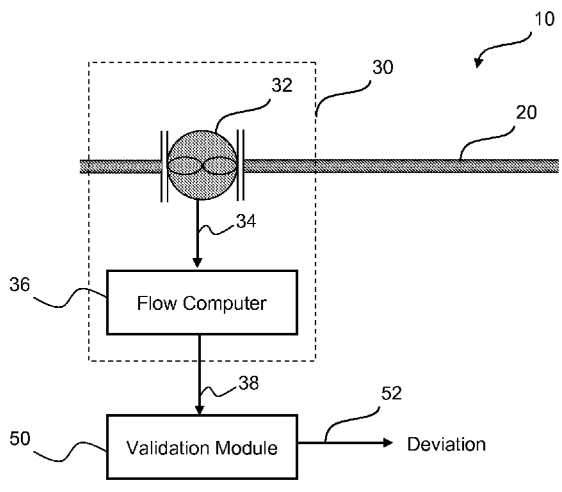

Fig.1

(57) Abstract: An apparatus is provided for aiding the validation of flow measurement equipment (30), the apparatus comprising: a validation module (50) configured to receive data representing a primary characteristic of a fluid flowing in a pipeline(20); wherein the validation module (50) is configured to calculate a descriptive statistic of the data over a batch, and to compare the descriptive statistic with another descriptive statistic calculated separately to obtain a deviation value.

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AN AID IN VALIDATING FLOW MEASUREMENT EQUIPMENT

Technical Field

The invention relates to an aid in validating flow measurement equipment. In particular, but not exclusively, the invention is of particular use in hydrocarbon flow measurement and metering, but is also useful for other applications, such as water and chemical measurement and metering.

Background

Accurate flow measurement is desired in many fields, including chemical manufacture, water supply and energy supply. Having an accurate flow measurement system allows users to be confident of the amount of material transferred, which is important for product quality, billing and taxation purposes. In some fields, particularly energy supply, high accuracy is very important due to the relative expense of the material being transferred.

In particular, hydrocarbon (oil and gas) transfer needs to be very accurately measured. In the global oil and gas market validation of metering systems is already to a high standard. Recent global CO2 emission legislation has also created a second need to require accurate metering validation to reduce commercial risk.

Commercially, a typical 850 MW combined cycle gas turbine (CCGT) power station burns USD160,000,000 of gas per year. With ± 1% uncertainty of metering this could result in around ± USD1,600,000 of gas being unaccounted for per year.

Hydrocarbon flow measurement equipment is therefore often calibrated to high standards and frequent validation is necessary to ensure the measurement equipment is reading within a permitted range and without systematic bias. Suitable validation procedures reduce the commercial risk from measurement errors caused by bias, drift and uncertainty within a flow measurement design.

It is a UK requirement for periodic validation of all measurement equipment connected to the National Grid Network and National Grid General Standards apply. These validation standards are a global bench mark and similar standards exist globally, for example within BP, Shell, Exxon Mobil (all RTMs) etc.

However, current validation procedures have some disadvantages. For example, current validation procedures:

a) require the pipeline to be put into maintenance mode (i.e. they have to be done 'off-line');
b) require specialist technicians and engineers;
c) are labour intensive;
d) require logging of validation results by hand which are prone to error;
e) require manual checking of flowcomputer parameters;
f) require manual calculation checks using keypad data, which are again prone to error;
g) require many different individual tests to meet standards.

Therefore, due to the above disadvantages, validation procedures are very intrusive, costly, raise health and safety issues in carrying them out and are prone to human error.

It is an aim of the invention to provide an improved automatic process for validating flow measurement equipment with minimum manual intervention. More particularly, the invention aims to provide one or more of a more accurate, more reliable, cheaper and more frequently used process for validating flow measurement equipment without having to put the metering stream into an off-line status.

Summary of the Invention

According to the invention, there is provided an apparatus and method as set forth in the attached claims. Further optional features are seen in the dependent claims and the description which follows.

In one aspect, there is provided an apparatus for validating flow measurement equipment, the apparatus comprising: a validation module configured to receive data representing a primary characteristic of a hydrocarbon fluid such as oil or gas flowing in a pipeline; wherein the validation module is configured to calculate a descriptive statistic of the data over a batch, and to compare the descriptive statistic with another descriptive statistic calculated separately to obtain a deviation value.

In this way, a validation process is aided by the use of 'on-line' measurements and the frequency of 'off-line' validation processes may be reduced, saving time and money, and improving accuracy and reliability.

In one example, wherein the descriptive statistic and the another descriptive statistic are each an arithmetic mean of the data over the batch. Preferably, wherein the arithmetic mean is one of a time-weighted mean, a flow-weighted mean and a time-flow weighted mean. In this way, the accuracy of the validation is improved.

The validation module may be configured to receive other data separately representing the primary characteristic of the fluid; and to calculate over the batch a second descriptive statistic of the primary characteristic which acts as the another descriptive statistic.

Preferably, wherein the validation module is arranged to receive the data representing a primary characteristic of a fluid flowing in a pipeline from first measurement equipment and is arranged to receive data separately representing the same primary characteristic of the fluid from second measurement equipment. Preferably, wherein the second measurement equipment is calibrated against standards higher than standards used to calibrate the first measurement equipment so that the second meter is a master meter and the another descriptive statistic is used as a standard by which to judge the first descriptive statistic.

In one example the validation module is configured to receive data representing at least two primary characteristics of the fluid, and the validation module is arranged to determine a descriptive statistic for each primary characteristic and to compare each descriptive statistic with a corresponding other descriptive statistic derived separately to create corresponding deviation values and to compare each deviation value against a corresponding benchmark value.

A secondary characteristic of the fluid may be derived from the or each primary characteristic, and the validation module is arranged to determine a descriptive statistic for the or each secondary characteristic and to compare the or each descriptive statistic with another corresponding descriptive statistic derived separately to create corresponding deviation values and to compare each deviation against a corresponding benchmark value.

Preferably, wherein the or each primary characteristic of the fluid comprises one or more of a turbine frequency, a temperature and a pressure. Preferably, wherein the or each secondary characteristic of the fluid comprises one or more of a flow rate and an energy content.

In another aspect, there is provided a method of validating flow measurement equipment, the method comprising:

(a) receiving data describing a primary characteristic of a fluid flowing in a pipeline;

(b) calculating a descriptive statistic from the data describing the primary characteristic over a batch;

(c) comparing the descriptive statistic with another descriptive statistic to obtain a deviation value.

Preferably, wherein the method comprises receiving other data separately representing the primary characteristic of the fluid; and calculating a second descriptive statistic of the primary characteristic over the batch which acts as the another descriptive statistic.

In another aspect, there is provided a computer readable recording medium having recorded thereon instructions for performing the method of the paragraphs immediately above.

In the ways mentioned above, a fuller validation is achieved, potentially reducing the need for any ‘off-line’ validation or reducing the frequency thereof significantly.

Brief Description of the Drawings

For a better understanding of the invention, and to show how example embodiments may be carried into effect, reference will now be made to the accompanying drawings in which:

Fig.1 is a schematic view of a system in accordance with a first embodiment of the invention;

Fig.2 is a schematic view of a system in accordance with a second embodiment of the invention;

Fig.3 is a schematic view of a system in accordance with a third embodiment of the invention;

Fig.4 is a schematic view of a system in accordance with a fourth embodiment of the invention;

Fig.5 is a flow chart outlining a method in accordance with the invention; and

Fig. 6 is a graph showing deviations plotted for multiple batches.

Detailed Description of the Example Embodiments

Several example embodiments of the invention are now described with reference to the above-listed figures.

Fig.1 is a schematic view of a system 10 for validating flow measurement equipment 30 in accordance with a first embodiment of the invention.

The system 10 comprises a pipeline 20 though which natural gas flows into a power station. Measurement equipment 30 is installed in the pipeline 20 to measure the amount of natural gas, and hence energy, flowing through the pipeline 20 into the power station.

The measurement equipment 30 comprises a flow metering system, or flow meter, 32 arranged to measure primary characteristics of the amount of natural gas flowing in the pipeline 20. In this example, the flow meter 32 is a turbine flow meter and measures turbine frequency (Hz) and additional instrumentation measures the temperature (degC) and pressure (barg) of the natural gas. The flow meter system 32 is configured to output the three main primary characteristics via a data connection 34, which may be a discrete or digital data connection or a combination of both. Temperature and pressure are measured and output via a discrete 4-20 mA or digital data connection 34. Other gas characteristics (i.e. gas composition) may also be available over the data connection 34.

In this embodiment, the flow metering system comprises the following components:

- Turbine Meter: Vemmtec G1600
- Pressure Transmitter: Rosemount 3051TG
- Temperature Transmitter: Rosemount 3144PD
- Gas Chromatograph: Daniel GC700

The measurement equipment 30 also comprises a flow computer 36 arranged to receive the primary characteristics via the data connection 34. Here, the flow computer is arranged to translate the primary characteristics into secondary characteristics representative of the amount of gas flowing through the pipeline 20. For this purpose, the flow computer 36 is programmed with one or more algorithms using equations and constants to create the secondary characteristics as would be known to a person skilled in the field of flow measurement. The flow computer 36 is configured to output the primary and secondary characteristics, collectively referred to as measurement equipment outputs, via a flow computer output data connection 38, which may be a discrete or digital data connection.

In this example, the flow computer 36 is a FloBoss S600 by Emerson Process Management.

The flow computer is programmed to calculate and output the following secondary characteristics relating to the instantaneous properties of natural gas flowing in the pipeline, as an example:

- fluid density at the operating conditions (kg/m3);
- standard density at standard conditions (kg/Sm3);
- heating value, calorific value (MJ/m3);
- uncorrected volumetric flow rate (m3/hour);
- corrected volumetric flow rate (Skm3/h);
- mass flow rate (tonnes/hour);
- energy flow rate (GJ/hour);
- carbon dioxide (CO_2) flow rate (tonnes/hour);
- uncorrected total volume of gas (m3);
- corrected total volume of gas (Sm3);
- mass total volume (tonne);
- energy total (GJ); and
- carbon dioxide (tonne).

For the avoidance of doubt, secondary characteristics are characteristics derived using one or more primary characteristics.

However, according to the invention, the system 10 comprises a validation module 50 which is arranged to receive data representing the measurement equipment outputs from the flow computer 36 via the flow computer output data connection 38. Here, in this example, it is important that at least one primary characteristic or secondary characteristic which represents the natural gas flowing in the pipeline 20 is received by the validation module 50. In this example, all of the primary and secondary instantaneous values are included in the data received by the validation module 50.

The validation module 50 is configured to calculate a descriptive statistic, in this case an arithmetic mean of the data over a batch, and to compare the arithmetic mean with another descriptive statistic, again in this case an arithmetic mean, calculated separately to obtain a deviation value. The deviation value may be subsequently compared against a benchmark value to determine a validation state of the measurement equipment 30.

Here, batch means a time period over which fluid flow is measured in the pipeline 20 while still online.

In this example, the another descriptive statistic is calculated by the validation module 50 over the same batch period using the output data received over connection 38. The difference between the arithmetic means calculated respectively by the flowcomputer 36 and the validation module 50 is used as the deviation value over the same batch period.

The validation module 50 is configured to output the deviation value via data connection 52 and/or via a user interface (not shown). The validation module 50 may also output the comparison result of the deviation and the benchmark, and also the measurement equipment outputs.

The deviation value can be used to determine any drift in the performance of the measurement equipment 30. In this way, the system 10 is able to perform in whole or part a validation procedure while online, reducing disruption to the supply of natural gas flowing through the pipeline 20, reducing labour costs, reducing reliability issues, and allowing for validation to be conducted more frequently, thereby increasing confidence in the accuracy of the measurement equipment and increasing certainty as to the amount of fluid transferred.

For example, in a test, the turbine frequency of the flow meter 32 was measured over a batch starting on 17 March 2011 at 15:52:42 and finishing on 28 March 2011 at 13:32:01 and the arithmetic mean was calculated to be 141.838 Hz over the batch. The arithmetic mean of the turbine frequency derived at the flowcomputer 36 was compared with an equivalent arithmetic mean of the turbine frequency taken at the validation module 50 during the same batch period. In this case, the arithmetic mean was 141.310 Hz, giving a deviation value of -0.372 %. The benchmark value in this case was +- 1.000 % and so the measurement equipment 30 was deemed to pass the validation procedure.

The arithmetic mean may be flow-weighted so that changes in flowrate during the batch are taken into account.

Fig.2 is a schematic view of a system in accordance with a second embodiment of the invention. Fig.2 shows a modified version of the system 10 of Fig.1 and like reference signs have been used for like components. Only the differences are described.

In this second embodiment, the flow meter 32 is able to produce two separate and independent measurements of one or more primary characteristics of the fluid. For this reason, there are two outputs from the flow computer 32 which are output over separate discrete or digital data connections 34a, 34b. Data connections 34a, 34b replace the single data connection 34 of Fig.1 for illustrative purposes and a single data connection could be used.

The flow computer 36 is arranged to receive both sets of independent primary characteristics and is configured to produce secondary characteristics for each in the same way as described in relation to Fig.1.

In this second embodiment, the validation module 50 is configured to receive data representing the measurement equipment outputs from the flow computer 36 which separately represent the two independently measured primary characteristics of the fluid, and is arranged to calculate over the same batch a first descriptive statistic and a second descriptive statistic of the data which acts as the another descriptive statistic mentioned previously in relation to Fig.1.

The deviation value is calculated by comparing the first descriptive value and the second descriptive value.

For example, in a test, the mass flow rate of the flow meter 32 was measured over a batch starting on 17 March 2011 at 15:52:42 and finishing on 28 March 2011 at 13:32:01 and the first arithmetic mean was calculated to be 44.862 tonnes/hour over the batch. The arithmetic mean of the mass flow rate was compared with the second arithmetic mean of the mass flow rate taken during the same batch. In this case, the second arithmetic mean was 44.814 tonnes/hour, giving a deviation value of -0.107 %. The benchmark value in this case was +-0.700 % and so the measurement equipment 30 was deemed to pass the validation procedure.

Fig.3 is a schematic view of a system in accordance with a third embodiment of the invention. Fig.3 shows a modified version of the system 10 of Figs.1 and 2 and like reference signs have been used for like components. Only the differences are described.

In this third embodiment, there are two flow computers 36a, 36b which are each arranged to receive the primary characteristics of the fluid in the pipeline 20 from the flow meter 32 via data connection 34 in the same way as described with reference to Fig.1. The flow computers 36a, 36b are configured to produce two separate and independent sets of secondary characteristics from the same set of primary characteristics. Each flow computer has a respective flow computer data output connections 38a, 38b.

The validation module 50 is configured to receive data representing the measurement equipment outputs from each flow computer 36a, 36b which separately represent the two independently calculated secondary characteristics of the fluid, and is arranged to calculate over the same batch a first descriptive statistic and a second descriptive statistic of the data which acts as the another descriptive statistic mentioned previously in relation to Fig.1.

For example, in a test, the total mass of natural gas flowing through the flow meter 32 was calculated from arithmetic mean values of the primary characteristics measured over a batch starting on 17 March 2011 at 15:52:42 and finishing on 28 March 2011 at 13:32:01 The first total mass was calculated based on data from the first flow computer 36a and was 847.77 tonnes over the batch. The second total mass was calculated based on data from the second flow computer 36b and was 847.07 tonnes over the same batch. The first total mass was compared with the second total mass taken during the same batch to give a deviation value of -0.08 %. The benchmark value in this case was +- 0.07 % and so the measurement equipment 30 was deemed to fail the validation procedure.

Fig.4 is a schematic view of a system in accordance with a fourth embodiment of the invention. Fig.4 shows a modified version of the system 10 of Figs.1, 2 and 3 and like reference signs have been used for like components. Only the differences are described.

In this fourth embodiment, the system further comprises a second measurement equipment 40 in addition to the measurement equipment 30 described earlier. The second measurement equipment 40 comprises a second flow meter system 42 arranged in series with the flow meter 32 in the pipeline 20. The second flow meter system 42, in this example is also a turbine meter of the same type (but does not need to be the same type) as the flow meter 32 of Fig.1 and is arranged to measure primary characteristics of the natural gas flowing in the pipeline 20. The second measurement equipment 40 comprises a data connection 44, flow computer 46 and flow computer output data connection 48 arranged in the same way as the measurement equipment described with reference to Fig.1.

The validation module 50 is configured to receive data representing the measurement equipment outputs from each flow computer 36, 46 which each represent the two independently measured primary characteristics and two independently calculated secondary characteristics of the fluid, respectively. The validation module is configured to calculate first and second descriptive statistics from each of the two data sets and to compare the results to obtain one or more deviation values.

For example, in a test, the averages (arithmetic mean) and totals shown in Table I were measured over a batch starting on 17 March 2011 at 15:52:42 and finishing on 28 March 2011 at 13:32:01:

Table I

Type	Batch Data Type	ME 30	ME 40	Unit	Deviation
Primary Average	Turbine Frequency	141.838	141.310	Hz	-0.372
Primary Average	Temperature	6.618	6.392	Deg.C	-3.415
Primary Average	Pressure	56.350	56.367	barg	0.030
Secondary Average or Constant	Density	53.710	53.804	kg/m3	0.175
Secondary Average	Volumetric Flow Rate	833.706	831.181	m3/hour	-0.303
Secondary Average	Volumetric Flow Rate	57.570	57.507	Skm3/hour	-0.108
Secondary Average	Mass Flow Rate	44.862	44.814	tonnes/hour	-0.109
Secondary Average	Energy Flow Rate	2304.473	2301.961	GJ/hour	-0.109
Secondary Average	CO2 Flow Rate	0.118	0.118	tonnes/hour	-0.109
Secondary Total	Volume	15788.98	15748.33	m3	-0.26
Secondary Total	Volume	1089.36	1088.46	Skm3	-0.08
Secondary Total	Mass	847.77	847.07	tonne	-0.08
Secondary Total	Energy	43440.84	43404.87	GJ	-0.08
Secondary Total	CO2	2.23	2.22	tonne	-0.45

Also, in this example, the second measurement equipment 40 is calibrated against standards higher than standards used to calibrate the first measurement equipment 30 so that the second measurement equipment is a master. In this case, the deviation from the master can be calculated. Also the master can be switched into and out of the pipeline 20, in this case a production pipeline, without stopping flow.

The benchmark value or values are determined from overall uncertainty requirements, and include the performance of the relevant ones of the primary meter, secondary instrumentation, signal interface to electronics, flow computer signal conversion and flow computer calculations.

In this example, an overall system uncertainty requirement is +/- 1% for volume and mass, and +/- 1.1 % for energy and is derived from ISO 5168 R.S.S (root sum squared) developed by the applicant for pulse/frequency primary meters. The validation module 50 of the above embodiments is arranged to output validation reports and to store a data base of validation reports, trends and other results. Reports are generally stored in the comma-separated value (CSV) file format or other suitable format.

Fig.5 is a flow chart outlining a method in accordance with the invention. The method comprises the following main steps:

S500: receiving data describing a primary characteristic of a fluid flowing in a pipeline.

S510: calculating a descriptive statistic from the data describing the primary characteristic over a batch.

S520: comparing the descriptive statistic with another descriptive statistic, to

S530: obtain a deviation value.

In accordance with the second, third and fourth embodiments described above in relation to Figs. 2 to 4, the method comprises receiving other data separately representing the primary characteristic of the fluid; and calculating a second descriptive statistic of the primary characteristic over the batch which acts as the another descriptive statistic.

The method also comprises comparing the deviation value against a reference value.

The method is intended to be executed by a microprocessor having inputs, outputs and memory and arranged to run machine-executable code embodying the method.

Fig. 6 is a graph showing deviations plotted for multiple batches.

Here, the *x*-axis is representative of each batch number ranging from 1 to 11, and the *y*-axis is representative of the percentage error between the energy flow rate calculated by the first measurement equipment 30, or a meter under test, when compared against the same measurement from the second measurement equipment 40, or master meter. In this example, two flow computers are used to process the primary data from the first measurement equipment 30, namely first flow computer FC-A and second flow computer FC-B. As can be seen in the graph, there is a tight correlation between the deviation between the energy flow rate derived from the second measurement equipment 40, or master meter, and respectively each of the derived energy flow rates from the first flow computer FC-A and the second flow computer FC-B. However, there is a deviation at batch 9 and batch 11, and to a much lesser degree at batch 6 which can be explained by differences in the algorithms or constants used to derive the energy flow rate in each of the two flow computers FC-A and FC-B. As will be appreciated, the primary data fed to each flow computer is identical and two flow computers are used here to provide redundancy. This result is useful as it highlights where there may be issues with either the measurement equipment 40 itself, or one of the flow computers FC-A and FC-B.

Also, it can be seen that the percentage error between the first measurement equipment 30 and the second measurement equipment 40 is no worse than -0.2% for batches 2 to 11. The first batch has an error of -0.5% which is probably explained by the need to set up the equipment.

This information was repeated for all of the primary characteristics and secondary characteristics, but that information has not been shown here for brevity. Suffice to say equivalent results were achieved.

The trend shown in Fig. 6 can be very useful for setting appropriate benchmarks when comparing deviation between a meter under test, in this example the first measurement equipment 30, and a master meter, in this example the second measurement equipment 40. In this example, a benchmark setting of an error percentage of -0.2% would seem appropriate as a maximum limit which if exceeded would trigger some remedial action, such as the calibration of the system.

Final Statements

While the embodiments are described in the context of a natural gas pipeline (20), the invention is applicable to other types of hydrocarbon fluid flow or another chemical fluid flow. For example, the invention could be applied to the measurement of flow of oxygen or other gaseous substances, oil, water, chemicals and other liquid substances. At present, the invention is particularly desirable for hydrocarbon measurement due to the relative high value and taxation status of hydrocarbons.

Also, while the embodiments are described in the context of a turbine flow meter, the principles are applicable to other types of flow meter including mechanical type flow meters, pressure-based flow meters, optical flow meters, thermal mass flow meters, vortex flow meters, electromagnet, ultrasonic and Coriolis flow meters and laser Doppler flow meters. Of those listed, ultrasonic flow meters are particularly useful for measuring gas at high accuracy.

Also, while the embodiments are described in the context of a turbine flow meter, pressure transmitter and temperature transmitter as direct measurement components installed in a pipeline (20), the principles are applicable to other additional types of direct measurement from a pipeline, as an example but not limited to: Gas Chromatograph, CV Analyser, H2S analyser etc.

It will also be understood that the validation module (50) may be implemented in hardware or software and may be located within one or more flow computers (36,46) or within a process control system such as a human machine interface (HMI) of a SCADA (supervisory control and data acquisition). The specific location of the validation module (50) shown and described with reference to the figures is a convenient example but is not intended to be limiting. Also, the validation module (50) is particularly suited to implementation as a PC based software package written in C++ or other suitable programming language, sitting on an industrial PC hardware platform running Microsoft Windows (RTM) or equivalent. The validation module (50) is designed to interface with the measurement equipment via suitable communication protocols and standards such as Ethernet, Modbus and TCP/IP.

In the example embodiments, the arithmetic mean has been used to summarise the data for the purposes of deviation analysis. However, other descriptive statistics could be used, such as the median and the mode, or other statistics such as standard deviation.

Also, the arithmetic mean may be one of a time-weighted mean and a flow-weighted mean The time-weighted mean ensures that the concentration in each sample (if different) is weighted by the period of time the sample represents. The flow-weighted mean ensures that the concentration in each sample is weighted by both the time and the flow that accompanied the sample.

The described system ensures that only few changes are made to existing metering systems and is very easy to install. The described system also allows the meter calibration methodology to remain the same as before. Existing metering system is also ring-fenced and independent from the validation system. Live on-line flow metering validation data is available from the described system.

The described system also assumes that the measurement systems are correctly designed and adhere to the relevant measurement standards, such examples being, but not limited to: ISO 5167, ISO 9951, AGA 3, PMM Ch 14.3, IGE/GM/1, API and IP "Petroleum Measurement Standards".

Although a few preferred embodiments have been shown and described, it will be appreciated by those skilled in the art that various changes and modifications might be made without departing from the scope of the invention, as defined in the appended claims.

Claims:

1. An apparatus for validating flow measurement equipment (30), the apparatus comprising:

a validation module (50) configured to receive data representing a primary characteristic of a hydrocarbon fluid, such as oil or gas, flowing in a pipeline (20);

wherein the validation module (50) is configured to calculate a descriptive statistic of the data over a batch, and to compare the descriptive statistic with another descriptive statistic calculated separately to obtain a deviation value.

2. The apparatus of claim 1, wherein the descriptive statistic and the another descriptive statistic are each an arithmetic mean of the data over the batch.

3. The apparatus of claim 2, wherein the arithmetic mean is one of a time-weighted mean, a flow-weighted mean and a time-flow weighted mean.

4. The apparatus of any of claims 1 to 3, wherein the validation module (50) is configured to receive other data separately representing the primary characteristic of the fluid; and to calculate over the batch a second descriptive statistic from the other data which acts as the another descriptive statistic.

5. The apparatus of claim 4, wherein the validation module (50) is arranged to receive the data representing a primary characteristic of a fluid flowing in a pipeline (20) from first measurement equipment (30) and is arranged to receive the data separately representing the same primary characteristic of the fluid from second measurement equipment (40).

6. The apparatus of claim 5, wherein the second measurement equipment (40) is calibrated against standards higher than standards used to calibrate the first measurement equipment (30) so that the second meter (40) is a master meter and the another descriptive statistic is used as a standard by which to judge the first descriptive statistic.

7. The apparatus of any preceding claim, wherein the validation module (50) is configured to receive data representing at least two primary characteristics of the fluid, and the validation module (50) is arranged to determine a descriptive statistic for each primary

characteristic and to compare each descriptive statistic with a corresponding other descriptive statistic derived separately to create corresponding deviation values and to compare each deviation value against a corresponding benchmark value.

8. The apparatus of any preceding claim, wherein a secondary characteristic of the fluid is derived from the or each primary characteristic, and the validation module (50) is arranged to determine a descriptive statistic for the or each secondary characteristic and to compare the or each descriptive statistic with another corresponding descriptive statistic derived separately to create corresponding deviation values and to compare each deviation against a corresponding benchmark value.

9. The apparatus of claim 8, wherein the or each secondary characteristic of the fluid comprises one or more of a flow rate and an energy content.

10. The apparatus of any preceding claim, wherein the or each primary characteristic of the fluid comprises one or more of a turbine frequency, a temperature and a pressure.

11. The apparatus of claim 1, wherein the another descriptive statistic is calculated separately over the same batch as the descriptive statistic.

12. A method of validating flow measurement equipment in a validation module, the method comprising:

(a) receiving data describing a primary characteristic of a fluid flowing in a pipeline;

(b) calculating a descriptive statistic from the data describing the primary characteristic over a batch;

(c) comparing the descriptive statistic with another descriptive statistic to obtain a deviation value.

13. The method of claim 12, wherein the method comprises receiving other data separately representing the primary characteristic of the fluid; and calculating a second descriptive statistic of the primary characteristic over the batch which acts as the another descriptive statistic.

14. The method of claim 13, wherein the method is repeated for a plurality of batches and the deviation value is plotted for each batch to determine whether recalibration is required.

15. A computer readable recording medium having recorded thereon instructions for performing the method of claims 12 or 14.

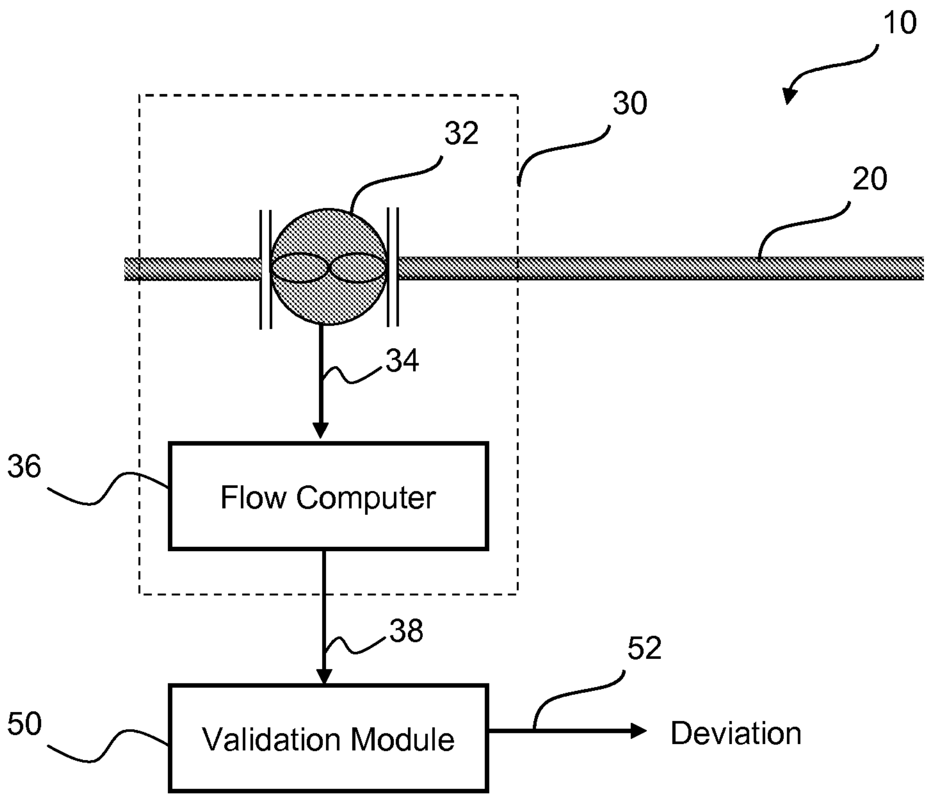
10
30
32
20
34
36
Flow Computer
38
52
50
Validation Module
Deviation

Fig.1

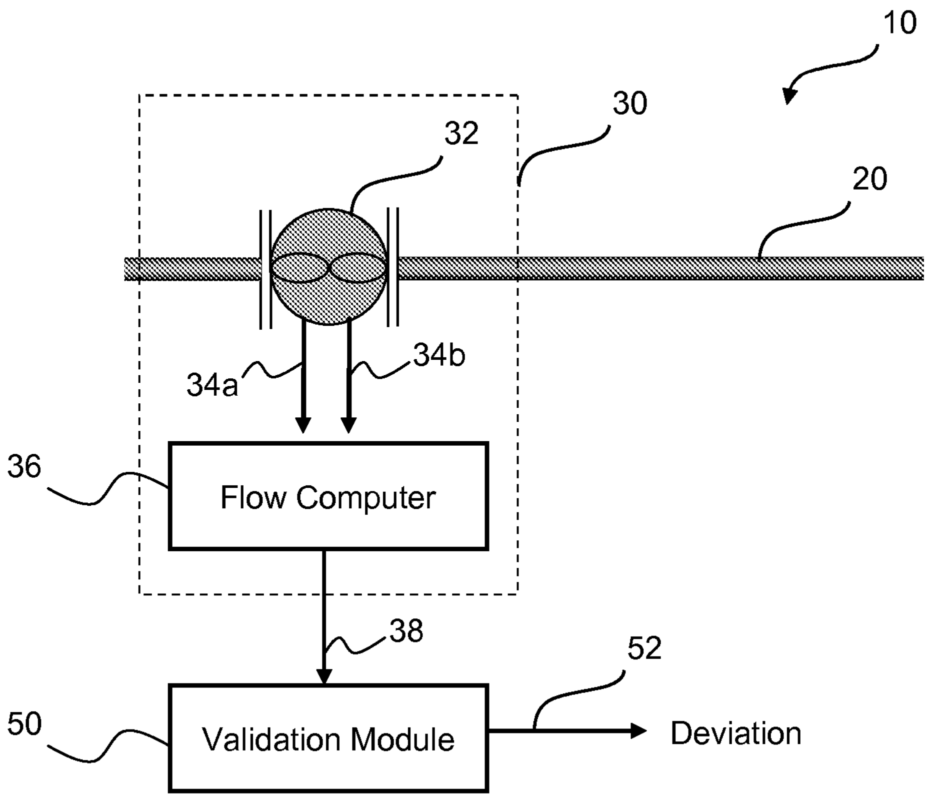
10
30
32
20
34a
34b
36
Flow Computer
38
52
50
Validation Module
Deviation

Fig.2

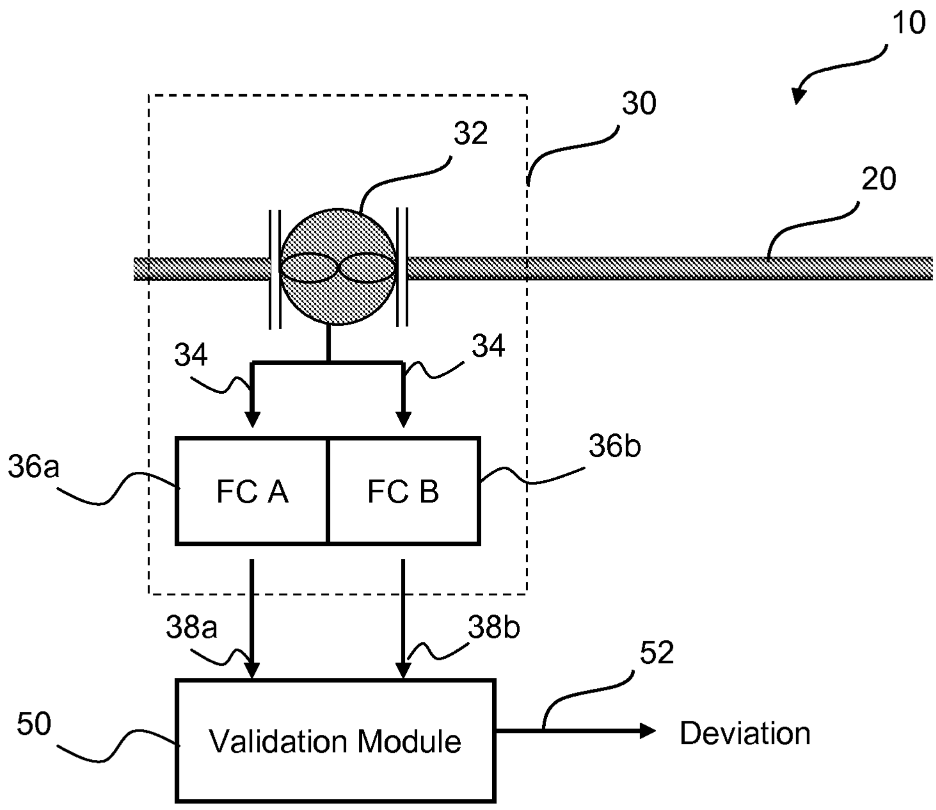
10
30
32
20
34
34
36a
FC A
FC B
36b
38a
38b
52
50
Validation Module
Deviation

Fig.3

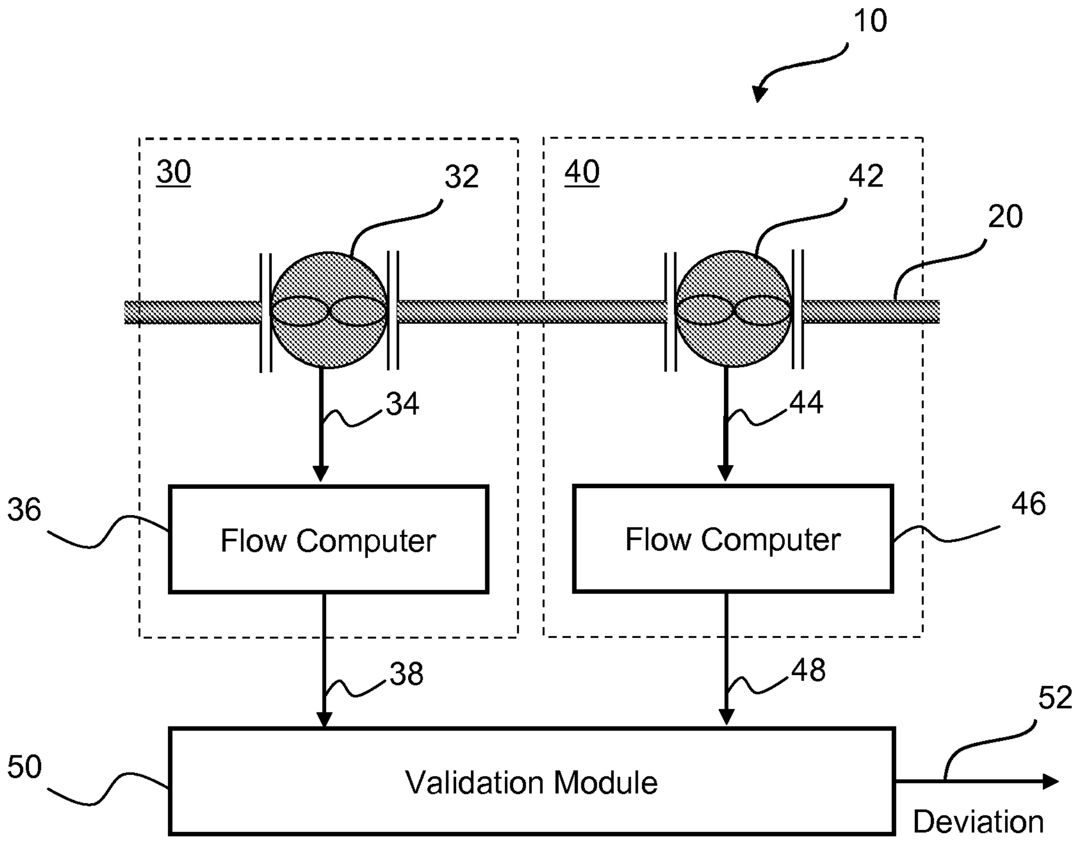
10
30
32
40
42
20
34
44
36
Flow Computer
Flow Computer
46
38
48
52
50
Validation Module
Deviation

Fig.4

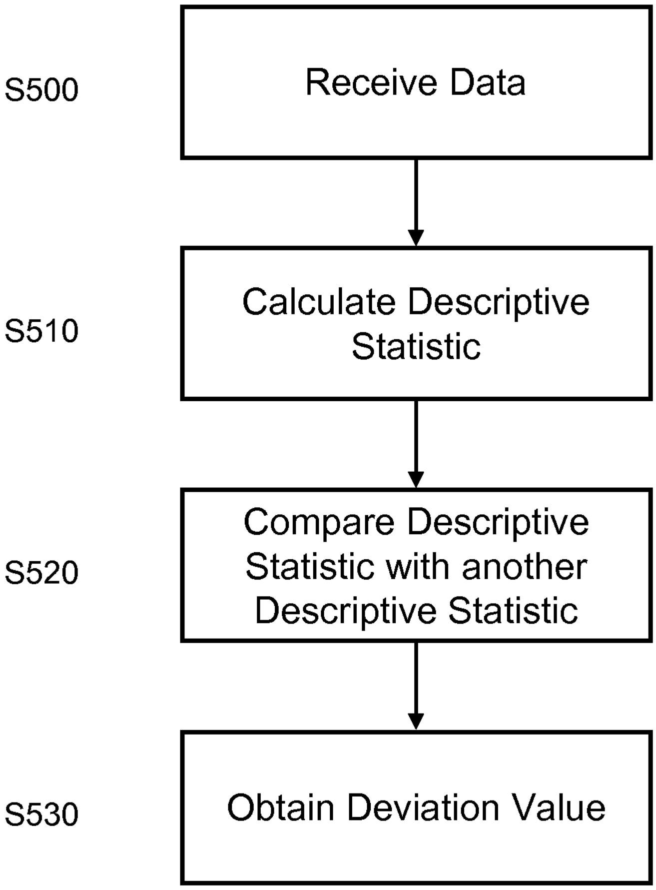
S500
Receive Data
S510
Calculate Descriptive Statistic
S520
Compare Descriptive Statistic with another Descriptive Statistic
S530
Obtain Deviation Value

Fig.5

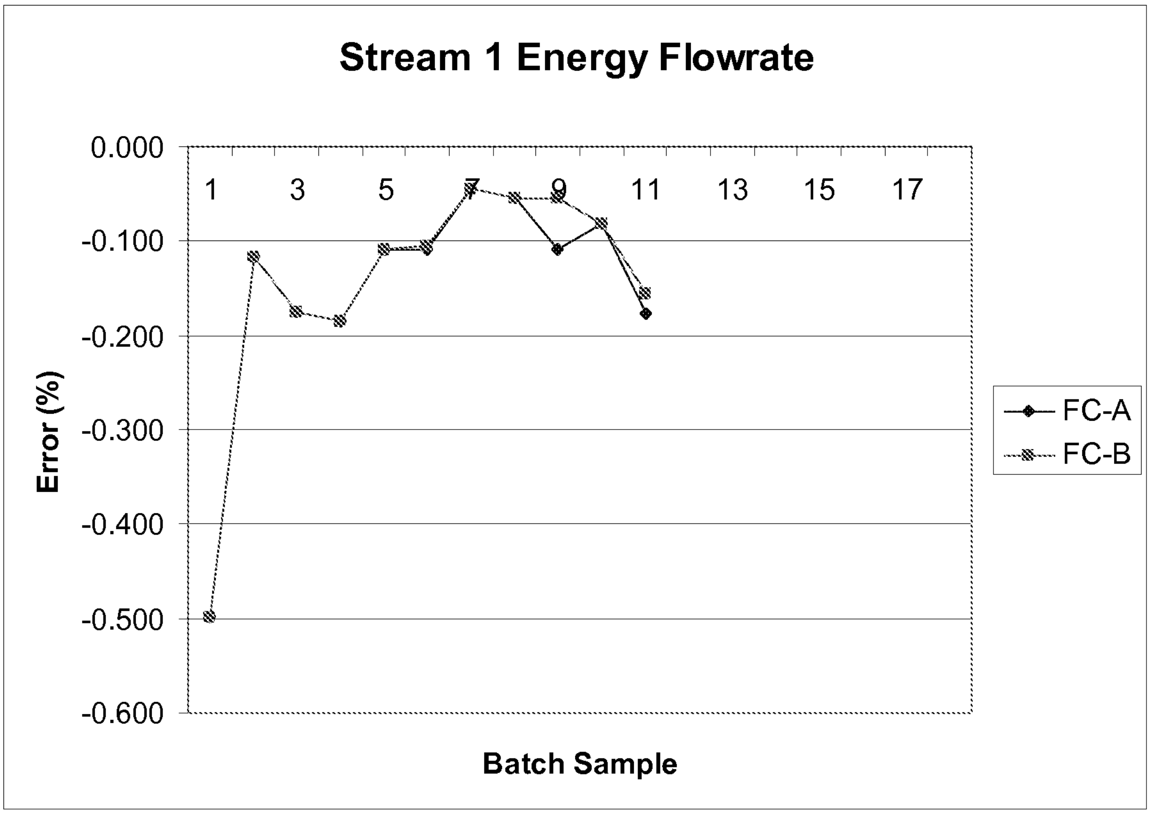
Stream 1 Energy Flowrate
0.000
-0.100
-0.200
-0.300
-0.400
-0.500
-0.600
1
3
5
7
9
11
13
15
17
Error (%)
Batch Sample
FC-A
FC-B

Fig.6

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/051861

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01F25/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 98/33043 A1 (AMERICAN METER CO [US]; SCHIEBER WILLIAM M [US]) 30 July 1998 (1998-07-30) page 13, line 9 - page 85, line 10; figures	1-15
X	WO 00/58696 A1 (MICRO MOTION INC [US]) 5 October 2000 (2000-10-05) page 7, line 24 - page 15, line 5; figures	1-15
A	DE 103 12 620 A1 (IMETER B V [NL]) 7 October 2004 (2004-10-07) paragraphs [0046] - [0071]; figures	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 December 2012	13/12/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Politsch, Erich

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2012/051861

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