# FOCUS DISCUSSION GROUP B

MFI Multiphase Metering Verification at the Agip Trecate Test Loop.

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# MFI MULTIPHASE METERING VERIFICATION AT THE AGIP TRECATE TEST LOOP

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## SUMMARY

AGIP has during the last few years built a comprehensive test facility at their Trecate field near Milan in Italy, which is particularly suited for testing multiphase meters. As part of AGIP's long term strategy, the MFI MultiPhase Meter (LP) has been extensively tested at Trecate, during a period from December 1995 to April 1996. The result from the tests have shown the following performance of the MFI Meter:

- The relative error in the oil, gas and water flow rates are basically inside the 10% uncertainty band in the operative range.
- The accuracy of the meter, when applied to the wells in area TR2, is consistent with the well testing performed with the test separator.
- The MFI LP meter already installed in the Trecate field is used to perform the standard well testing.
- The MFI MultiPhase Meter is recommended for on-shore and offshore applications, and it can also be recommended for subsea applications.

## 1. INTRODUCTION

This paper describe the experience that AGIP and MFI gained during testing of the MFI MultiPhase Meter at the Trecate Test Loop in Italy. Results showing the performance of the MFI MultiPhase Meter in real field conditions, covering a wide range of flow rates, pressure and temperatures are presented. Instantaneous and endurance test results are included.

The first section describes the test loop configuration and the test procedures used to verify the multiphase metering. The reference measurements are also described in this section. In the second section the MFI MultiPhase Meter is described, and in the third section the main results of the tests are reported, with comparison between the reference measurements (flow rates) and the MFI measurements.

# 2. TEST CONFIGURATION

## 2.1 Loop Description

The Trecate test loop is very flexible, and allows for comprehensive testing of the MFI MultiPhase Meter, with a large variety of flowing conditions and flow regimes. Wells from two different areas of the field can be routed through the test section, and combined in a number of different ways. Oil, water and gas can be added to the natural well flows.

The loop can be configured in several ways, and this paper describes tests with flow through the MFI MultiPhase Meter in two ways:

- First through the test separator, with the possibility to add one or several wells directly, and then through the MFI MultiPhase Meter.
- First through the MFI MultiPhase Meter, and then through the test separator.

Both options are shown in Fig 2.

## 2.2 Reference Instrumentation

The MFI MultiPhase Meter could be fed directly from the wells and/or through the MultiPhase Metering Unit, skid 412, connected to the field test separator. The service company's well testing separator was used to verify the reference measurements, using positive displacements for the oil flow rates and orifice for the gas flow rates, respectively. The consistency of the oil flow rate measurements was very good and the specified error (±1%) on the reference meters can be considered correct. For the gas flow rate measurements, the consistency was quite good at high flow rates (actual flow rates > 15-20 m3/h), but at low flow rates, it was less good. On the base of these results the errors on the gas flow rate measurement performed can be considered to be in the order of ±5%.

The MultiPhase Metering Unit, skid 412, uses two turbine meters for the gas flow rates, two positive displacement meters for the oil flow rates, and two magnetic water flow meters for the water flow rates. The double set of flow meters are for low and high range.

The Water Injection Unit was also used to measure the injected water flow rate, and this unit, skid 410, uses two magnetic water flow meters.

## 2.3 Logging System

The measurements from the MFI MultiPhase Meter was presented by MFI's Graphical User Interface, and data logged to file. Reference measurements were logged by AGIP's DCS. Also, analog signals from the MFI MultiPhase Meter were available in the control room, but these signals are, at the moment, not connected to AGIP's DCS system.

## 2.4 Test Matrix

| | |
|---|---|
| Max. gas void fraction (GVF): | 81% |
| Max. water cut (WC): | 45% (coincident with the transition to water continuos phase) |
| Mixture velocity range: | 2 - 12 m/sec |
| Max. oil flow rate: | 110 m3/h |
| Max. gas flow rate: | 60 m3/h (actual conditions) |
| Water flow rate range: | 2 - 45 m3/h |
| Pressure range: | 50 - 70 bar |
| Temperature range: | 30 - 90 °C |
| Flow regimes: | mixed and intermittent flow |

## 3. MFI METER DESCRIPTION

The MFI Meter calculate continuously flow rates of oil, water and gas. Two measurements are performed: 1) composition and 2) velocity, which are combined to yield flow rates. Fig 1 shows a photo of the meter installed in the loop.

### 3.1 MFI Composition Meter

Instantaneous oil, water and gas fractions are measured by using 1) a commercial Cs 137 gamma densitometer for measuring mixture density and 2) a patented microwave measurement device for measuring mixture dielectric constant.
The micro wave sensor works by measuring a characteristic microwave frequency that is inversely proportional to the square root of the mixture dielectric constant. A change from 100% gas to 100% water can result in a change in the measured micro wave frequency from 100 to 1.

The MFI LP MultiPhase Meter used in this test is not able to measure the characteristic microwave frequency in a water continuos mixture, but the MFI FullRange MultiPhase Meter, already developed and tested, are able to do measurements in the whole range from 0% to 100% water.

### 3.2 Velocity Device

The system tested in Trecate was equipped with two devices to measure the flow velocity. The primary element for measuring the multiphase flow velocity is the MFI Cross (X) -Correlation meter. This device uses two identical microwave sensors (such as used in the composition sensor) separated by a known distance to measure the velocity at which the multiphase flow is moving through the pipe. The secondary element for measuring the flow velocity is a standard Venturi cell. This device was used very few times in the Trecate tests.

## 4. RESULTS

### 4.1 Two Phase Flow Test

These tests were performed using the wells TR2, TR20 and TR17 which arrive in the area where the multiphase meter is installed. Ordinary well testing and tests with additional oil and/or gas were performed. In this paper, only one test series will be described: gas added to the flow of the well TR17. Two phase Flow Test refer to oil and gas.

The gas flow from the test separator was added to the flow of well TR17 through skid 412, see Fig 3 for configuration. Two of the gas flow rates were measured only with the turbine working in the low flow range, two with the high flow range turbine, and one gas flow rate were measured with both turbines. As seen in Fig 4, only one point has a relative error higher than 5%, all other points are inside ±5%. Fig 5 describe the trend of the gas flow rates measured by the MFI MultiPhase Meter.

### 4.2 Three Phase Flow Test

These tests were performed adding water form the injection system of the loop to the flow coming directly from the wells. Several tests were performed, with water injected in the main flow just before the multiphase meter to create a homogenous mixture, and water injected far from the multiphase meter to see the effect of the water separation along the line upstream the meter. But in this paper, only the test with water added to well TR17 will be described.

In this series of tests, water was injected in the main flow of well TR17, and the reference water measurement used was the MultiPhase Metering Unit, skid 412. The water flow rate was increased step by step, as shown in the global transient of Fig 6. In Fig 7, the water trends are reported along with the oil and gas trends. It is possible to see form this figure, that the oil and gas flow rates are hardly affected by the changing of the water flow rates, as it should be. A detail of these trends, where the fluctuations are bigger, are reported in Fig 8.

Another test series done on the same well (TR17) but using the reference measurements on the Water Injection Unit, skid 410, were performed. Fig 9 shows the water flow rate errors, and as seen, all points are inside ±5%. Fig 10 give the global trends of the flow rates measured by the meter (oil, water and gas) and of the reference water flow rates. Fig 11 reports only the water flow rate trends in the steady state periods.

## 5. CONCLUSIONS

- The Trecate test loop has proved to be very efficient for testing multiphase flow meters. It provides lots of flexibility, and covers a large variation in operating range.
- On the basis of the tests performed in Trecate, AGIP concludes that the MFI MultiPhase Meter can be used to perform standard well testing. The accuracy obtained with the meter is consistent with that which is obtained by a test separator.
- AGIP considers the MFI MultiPhase Meter ready for on-shore and offshore applications, and it is recommended also for subsea applications.

## 6. REFERENCES


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3 H. Berentsen/O. Økland Experience from water-in-oil monitors and multiphase meters

4 S. Gaisford/H.O. Hide A report of the field testing of the Multi-Fluid LP MultiPhase Meter

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6 O. Økland/H. Berentsen/J. Bruun-Olsen MultiPhase Meters, ready for field applications: Results from full scale qualification testing

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8 M. Scruton Microwave technique solves metering problems

9 H.O. HIDE MFI MultiPhase Meter Development Field testing of industrial prototype

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11 Multi-Fluid MFI MultiPhase Meter, Brochure

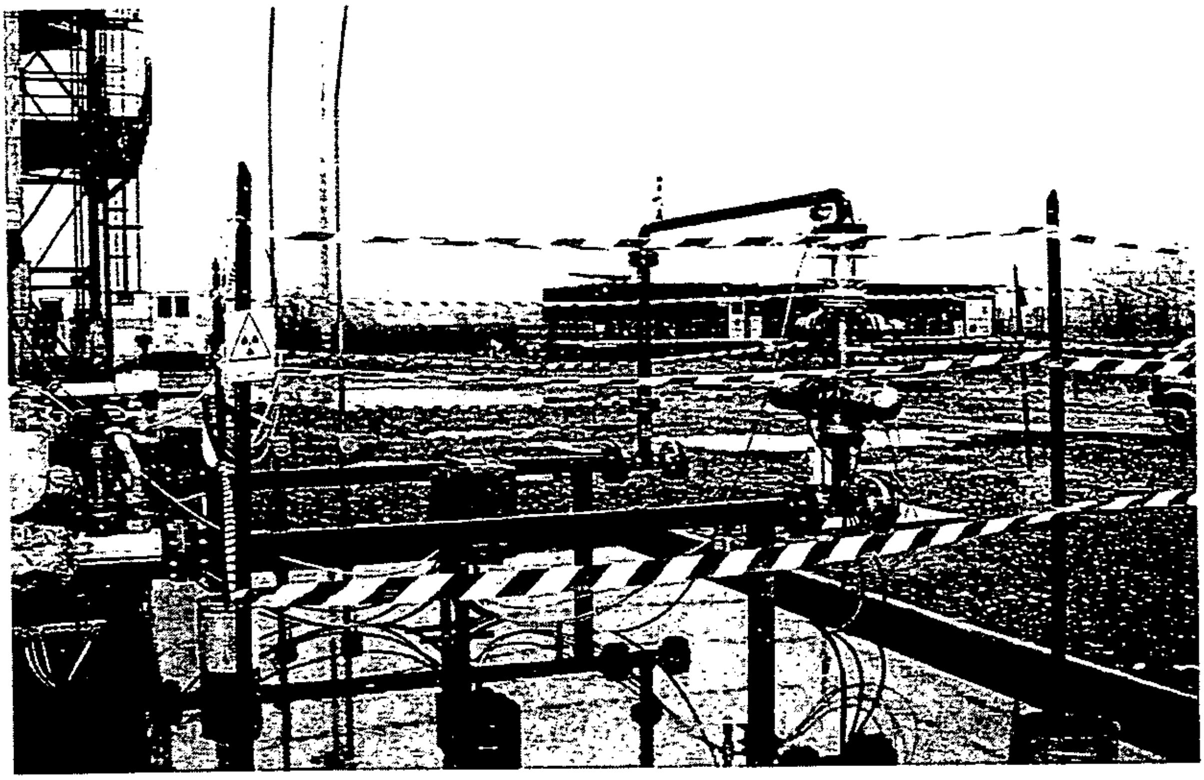
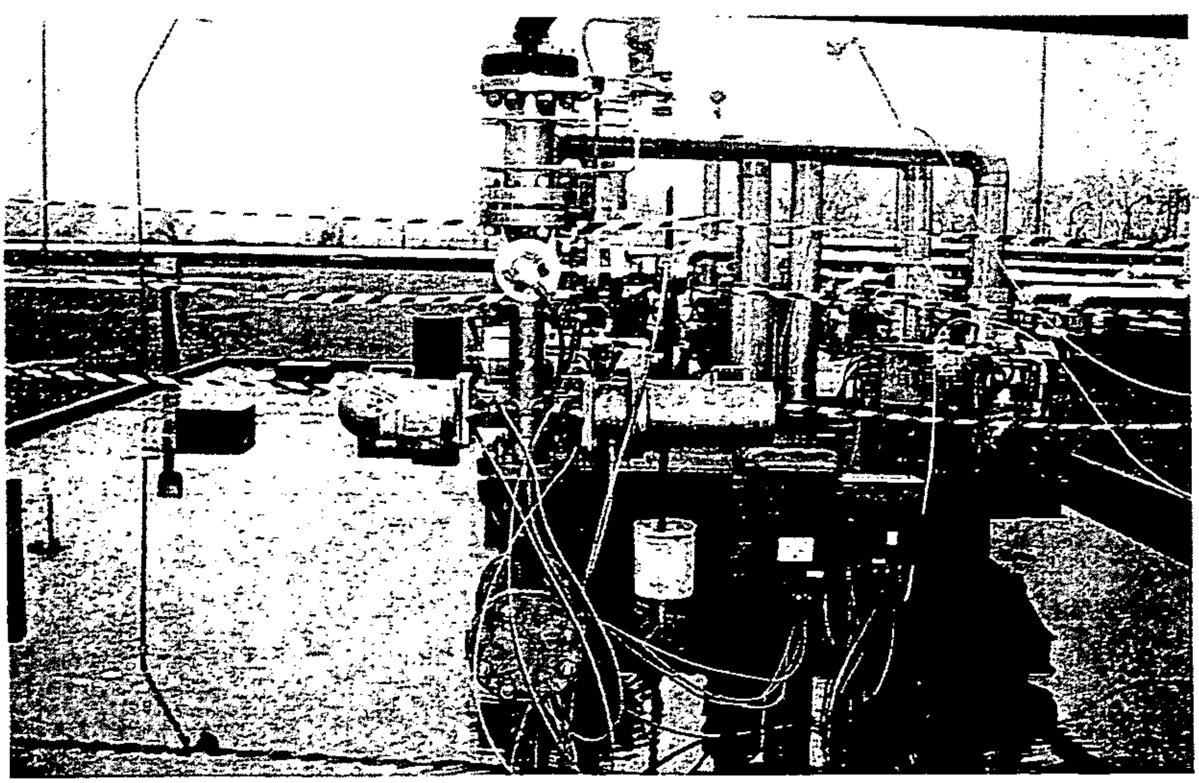


**Fig. 1: MFI-LP multiphase meter installed in the Trecate Test Loop**



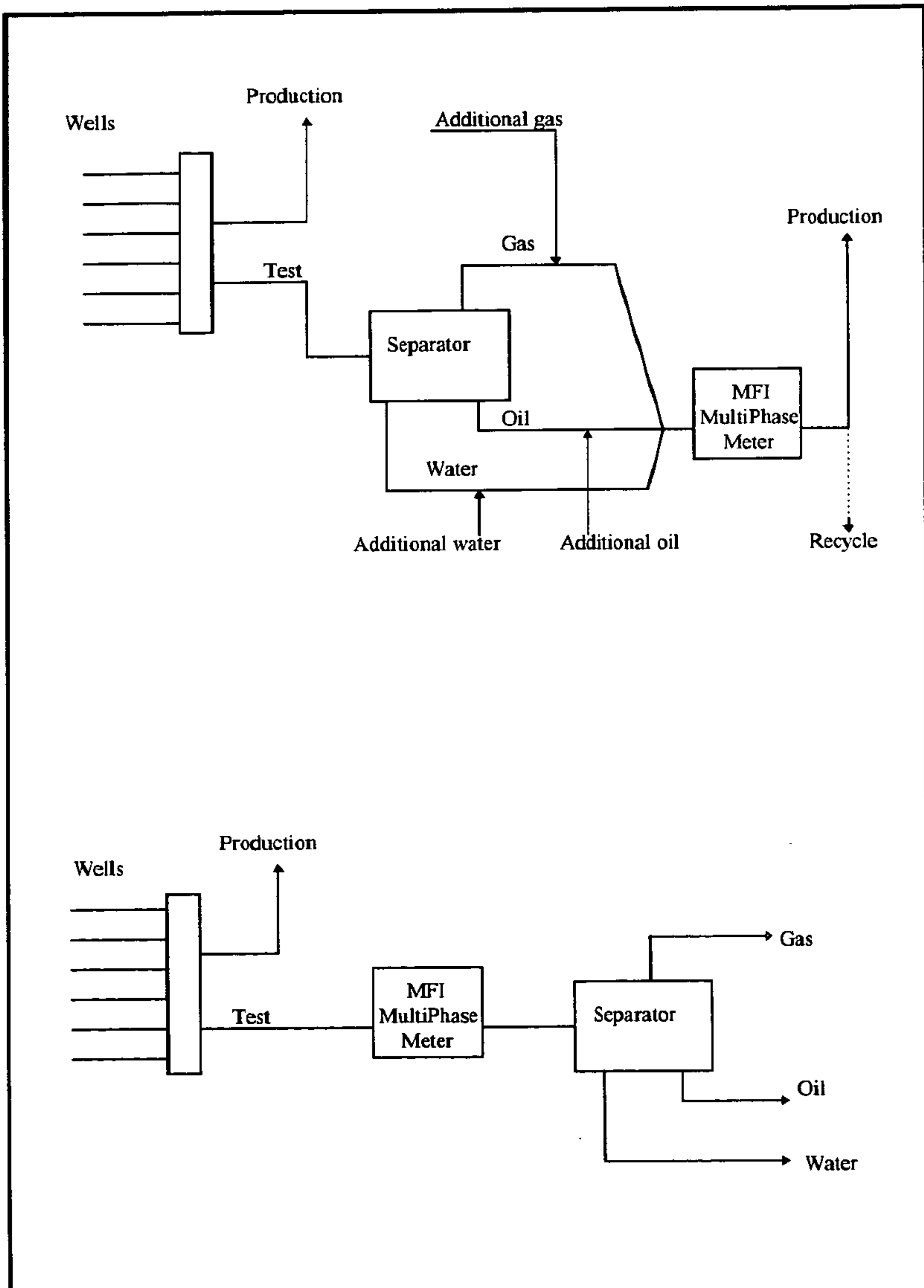



**Fig. 2: Two different configurations of the loop.**

**Fig. 3 Trecate Test Loop over all flow diagram.**

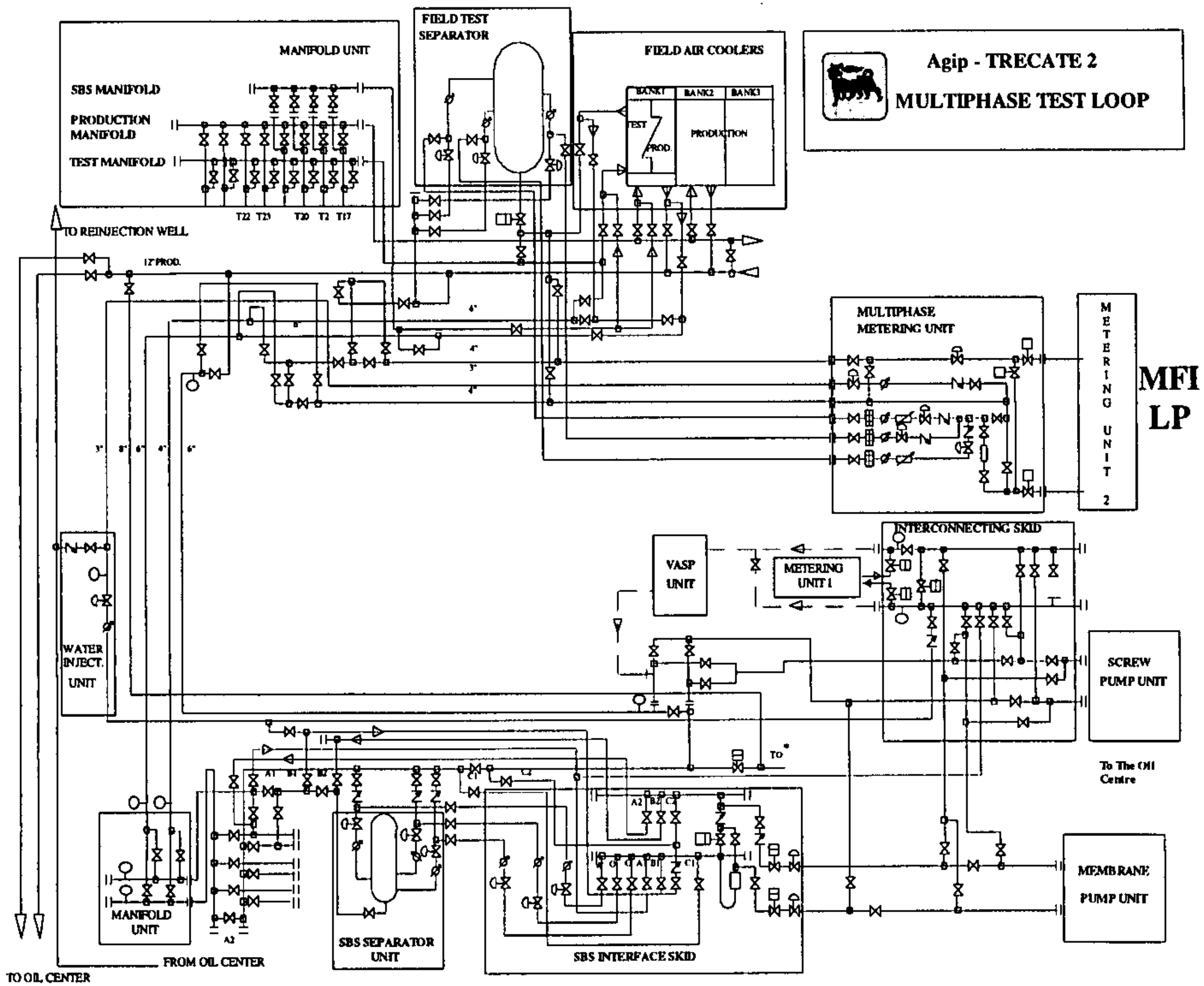


Fig.4: MFI-LP meter gas flow rate errors adding gas to the TR17 well

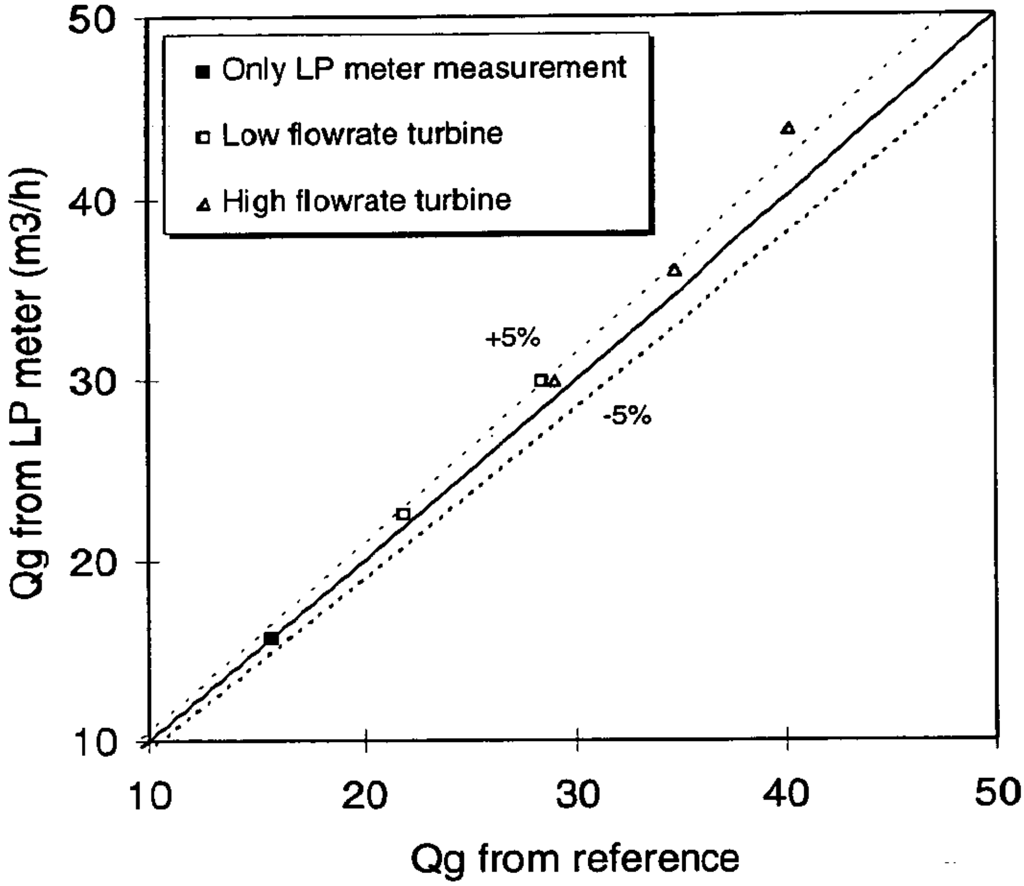


**Fig. 5: Test with gas added to the TR17 well.**

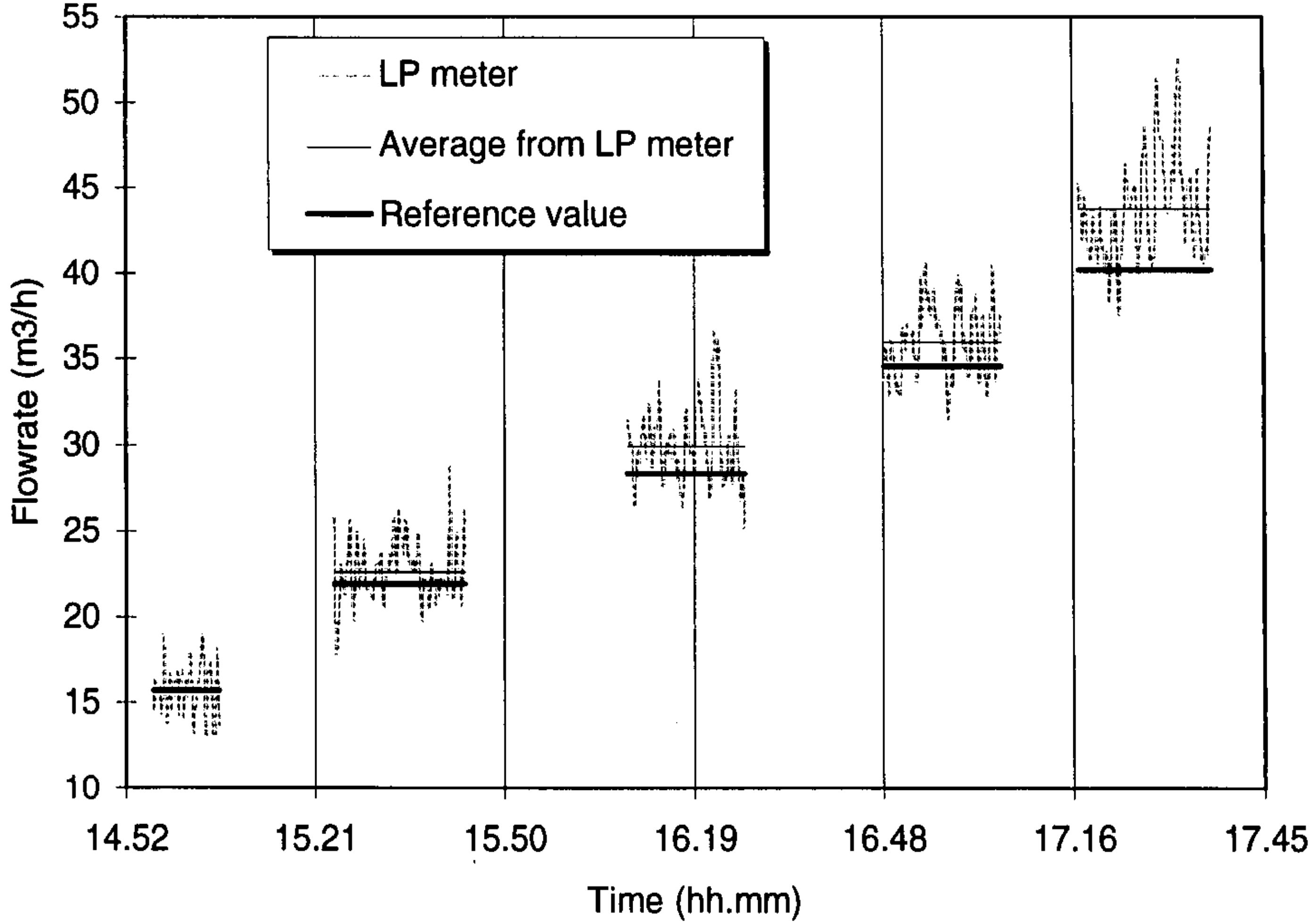


**Fig. 6: MFI-LP meter water flowrate during the tests with mixed flow and water injected through the skid 412 using TR17.**

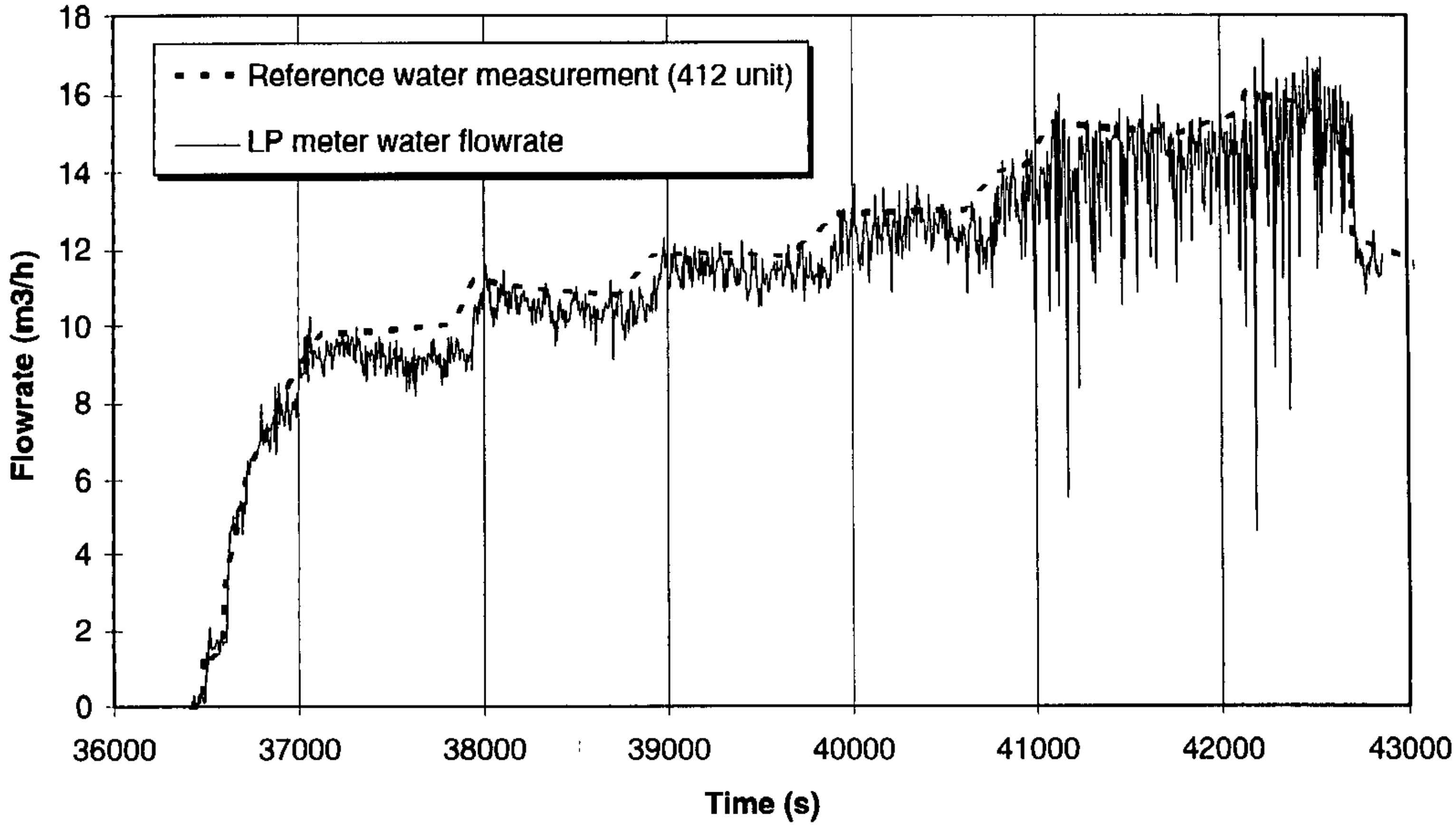


**Fig. 7 MFI- LP meter flowrates during the tests with mixed flow and water injected through the skid 412 using TR17.**

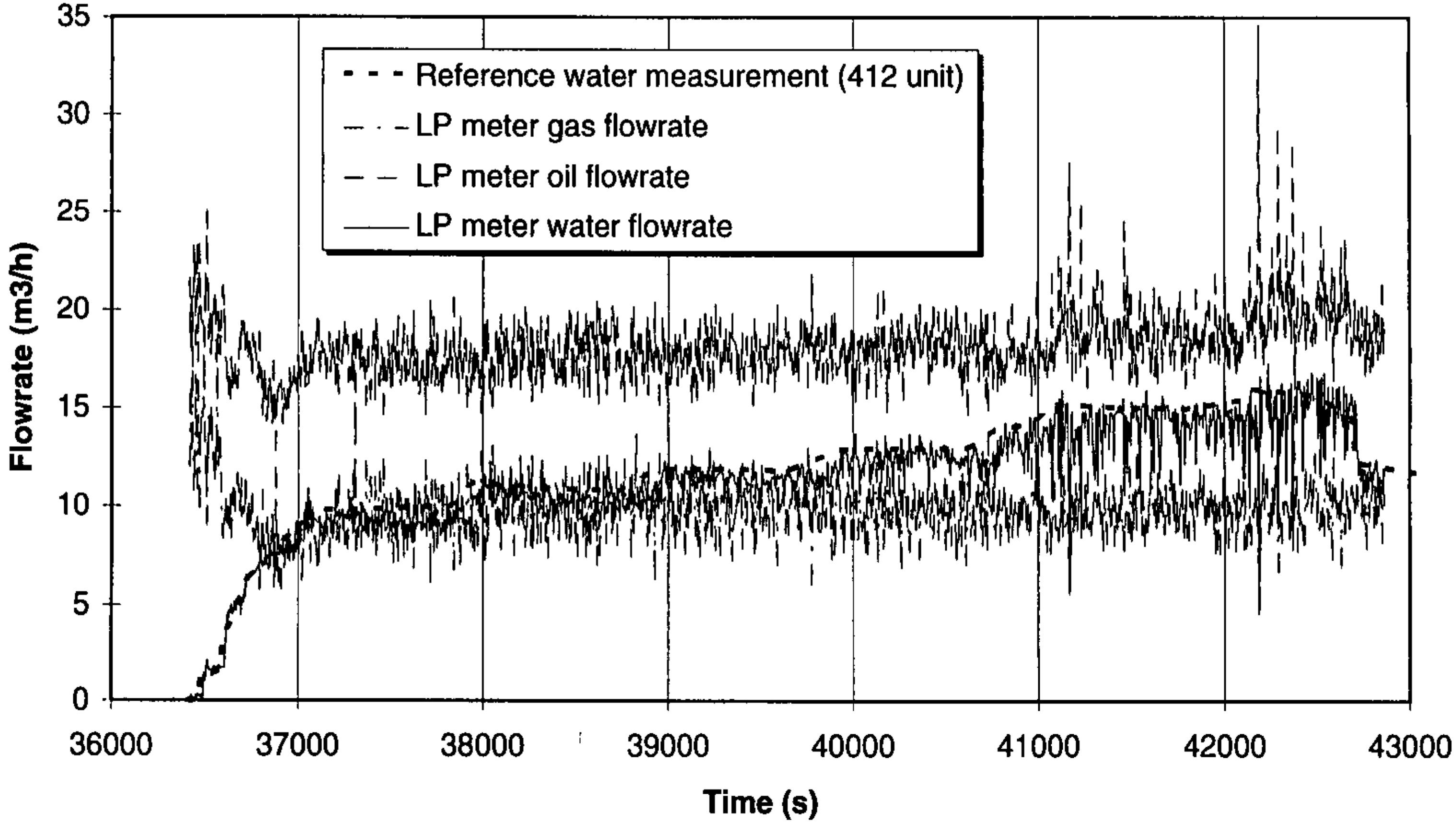


**Fig. 8: MFI-LP meter flowrates during the tests 6-7 with mixed flow and water injected through the skid 412 using TR17.**

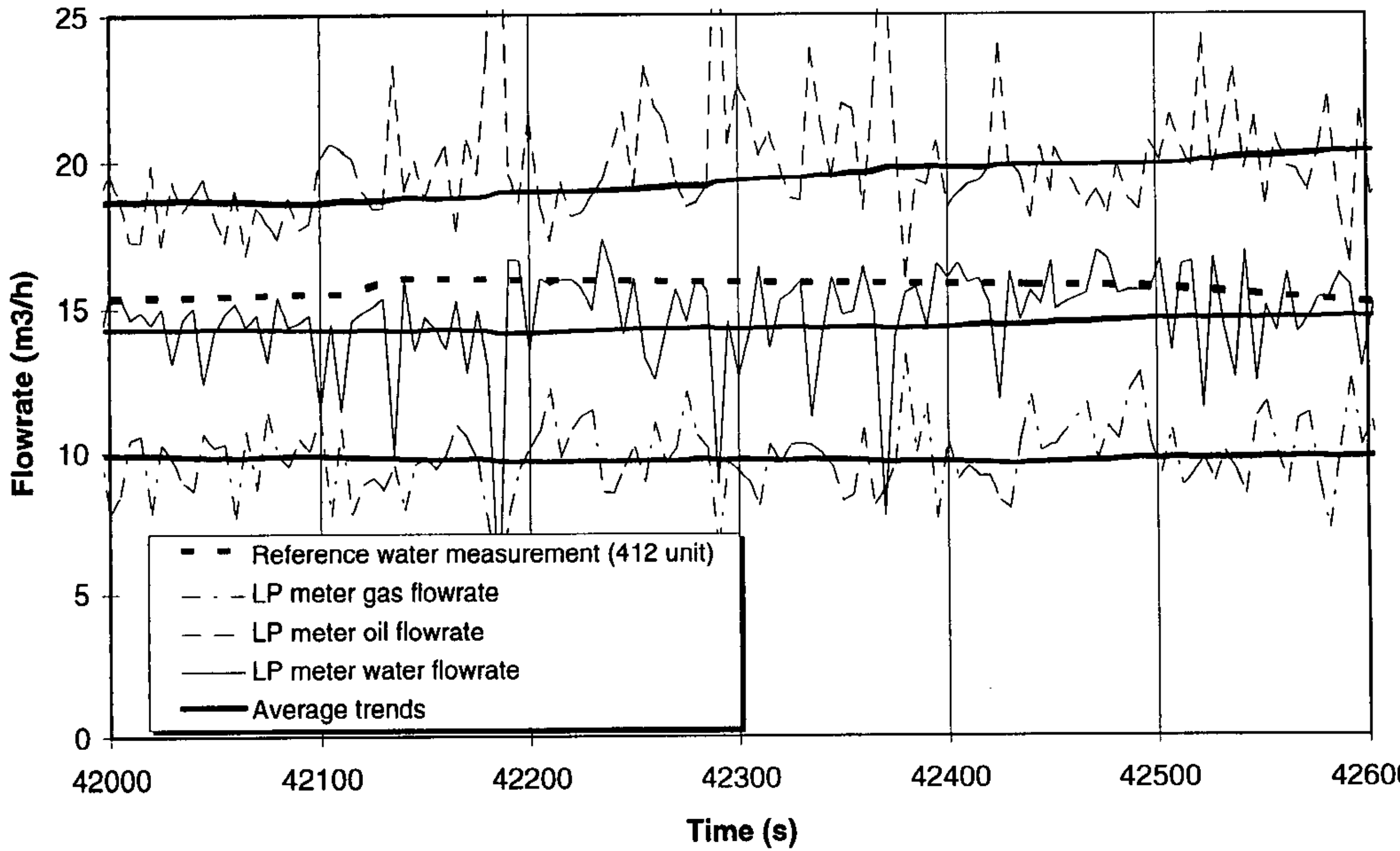
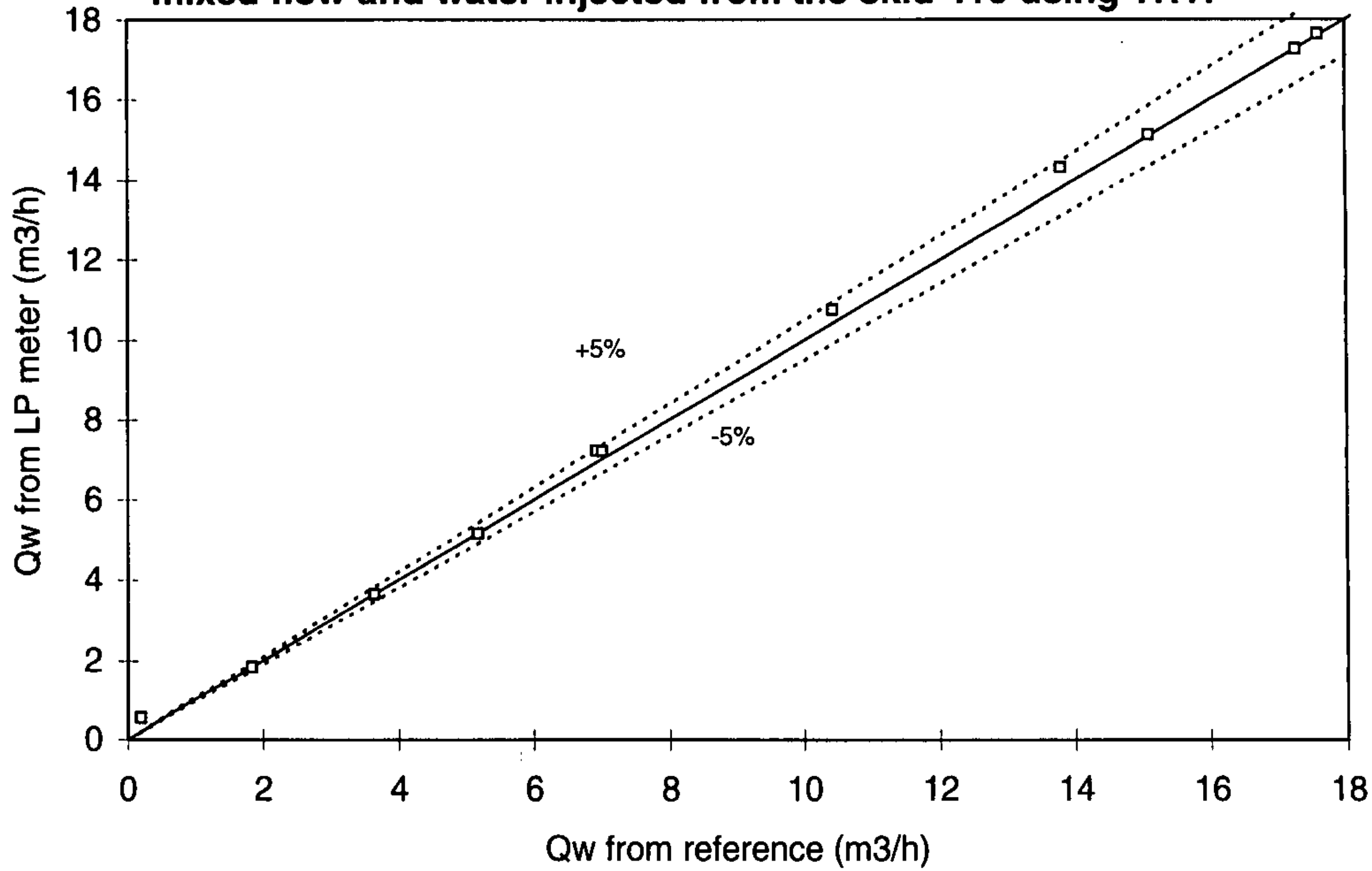


**Fig. 9: MFI-LP meter water flowrate errors during the test with mixed flow and water injected from the skid 410 using TR17**



## Fig. 10: MFI-LP meter flowrates during the tests with mixed flow and water injected from the skid 410 using TR17

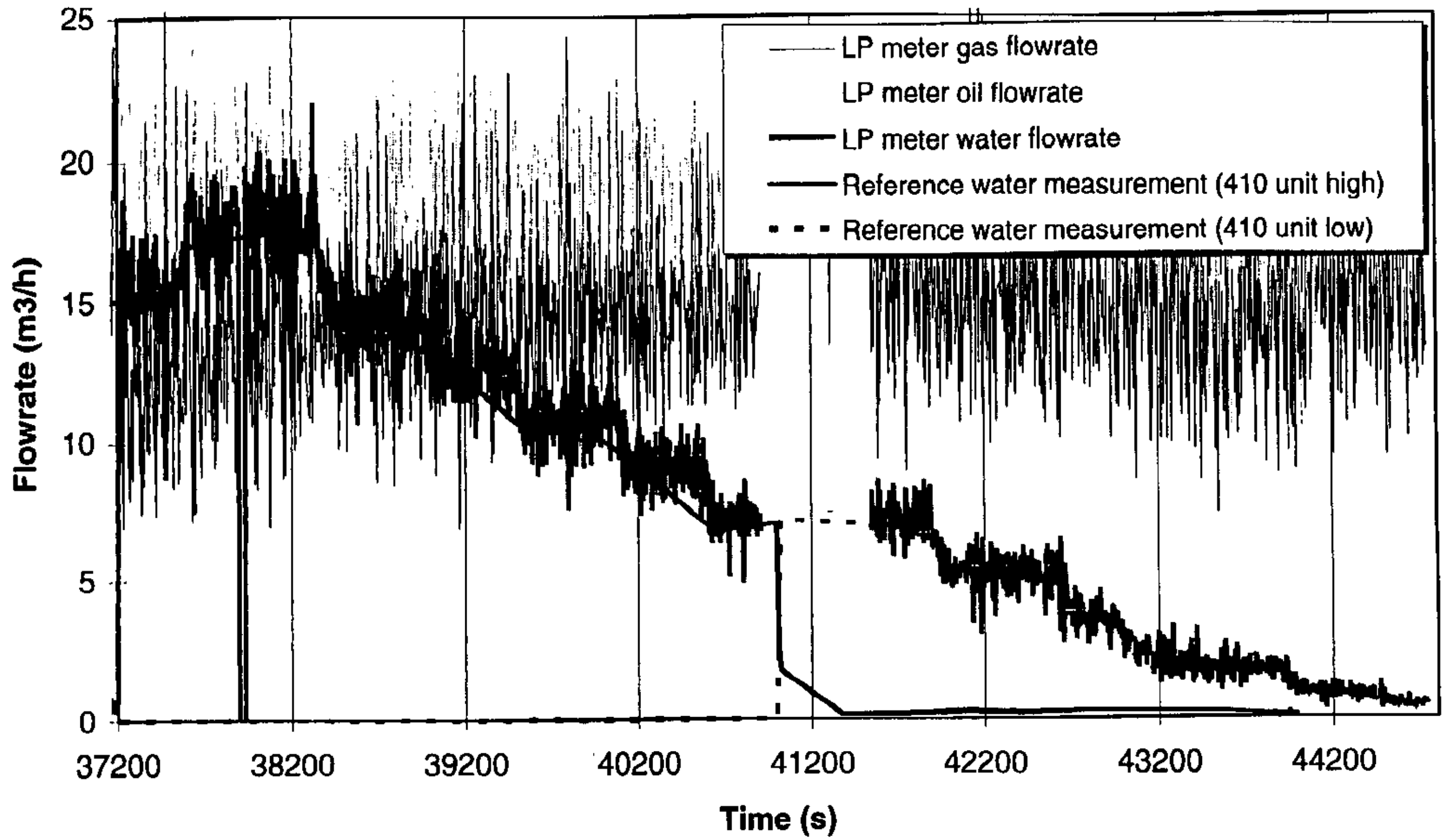


**Fig. 11: MFI-LP meter water flowrate during the test with mixed flow and water injected from the skid 410 using TR17**