AGIP-TRECATE MULTIPHASE TEST LOOP TEST FACILITY DESCRIPTION AND SPECIFICATION

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SUMMARY

The test loop is located in the Trecate-Villafortuna on shore oil field that is at about 60 Km from Milan and is fed with crud oil coming directly from the wells. This is obtained through two test separators connected respectively to two interface skids, which allow to change and to meter the flow rates of each phase (oil, water, gas), feeding the loop, in the full range (0-100 % of the test separators flows). Two test sections, interconnected mainly by three flow lines (Φ=4",6",6"; L≅450 m), are available for the tests. These flow lines can be used as single lines, or in parallel and series; in this last case the total length of the flow lines , before the test section, becomes of about 1 Km. This allows to obtain developed flow and all the main flow regimes at the test sections. The loop is working normally at the local pressure of the main transportation line (≅ 55 bar) but is possible also to perform tests at different pressures, directly in line or in close loop, using a multiphase pump.

1 INTRODUCTION

The Trecate Multiphase Test Loop (TMTL) has been built by AGIP with the EEC support in order to test in real conditions a multiphase metering developed by ENEA and CPR, which are two Italian Research Institutes involved in the multiphase technology development.
The loop being an upgrading of an existing test facility, built in order to test multiphase pumps, has the capacity to test not only multiphase flow metering but also other multiphase components as pumps, ejectors, valves and separators. Being the loop full integrated with the field flow lines, it also allows to perform specific fluid dynamic tests to qualify the multiphase computer codes. Since the main objective of the loop was to qualify multiphase metering, considerable effort has been put in the selection of the reference single phase flow meters and in the selection of the control and data acquisition system. Two consoles to control independently the overall test loop (only the ON/OFF valves are operated manually) are used. The two consoles also allow the generation on the screenings of the tests configurations and their memorisation. These configurations are then printed and given to the operators to set up the tests. For the long time period a PC-486 to store (for several weeks) the data is used. The control room of the loop is located in a cabin where other two rooms are available to install the computers of the systems to be tested. Instead 4 junction boxes (2 for each test sections), are already installed close to the two test sections, to connect the systems to be tested. Because the complexity of the loop and the strong interface with the production plant a crew of at least four people is need to run the tests. Fig. 12 shows same main components of the test loop.

2 TEST LOOP DESCRIPTION

The test loop (see fig. 5) is located in the TR2. satellite area of the Trecate-Villafortuna field. Fig 1 shows schematically the configuration of the transportation lines and the location of the loop. In fig. 2, 3 and 4 are shown respectively the typical configurations of the well and satellite areas and of the slugcatchers in the oil centre. The field, till under development, is presently producing by 19 wells. At the cluster in the TR2 satellite area, where the loop is connected, there are 9 producing wells. The field is producing from two reservoirs but the characteristics of the oils are very similar. The oil is light with a density of 700-750 Kg/cm and a viscosity ranging between 1 and 3 cp. The GOR is about 70 and the gas oil ratio at the actual conditions (55 bar, 60 °C) is about 0.6. The water cut of the producing wells is normally lower then 3%. The loop is connected through a manifold (SBS) to 4 wells upstream the production manifold (see fig. 5). In order to perform the tests a selected number of these 4 wells are bypassed from the production manifold to the SBS manifold. The flow then is delivered to the test sections(2) through the field test separator or the test loop separator or through both the test separators and the respective interface skids at which the test separators are connected. The maximum measured hydrocarbon flow (about 100 cm/hr of oil; 60 cm/hr of gas) is obtained using both the test separators. The flow limits are connected to the maximum separation capacity of the two equal test separators. If is not required to measure all the test flow in real time, but the well testing data are enough, two additional wells can be deliver to the test loop, bypassing the test separators. In this case it is possible to reach about 150 cm/hr of oil and 90 cm/hr of gas. In the interface skids (MULTIPHASE METERING UNIT; SBS INTERFACE SKID) three control valves are installed (one for each line) to control the single phase flows and single phase flow meters to measure the flow rates. The test flow conditions are obtained fixing the flow rates set points of each phase (oil, gas, water) at the required test values, then the flow controllers act on the control valves in order to meet, with the actual flow rates, the set points values. Since the water flow coming directly from the wells is presently to low for the tests, an outside system is used to inject additional water into the loop. This is obtained by using the reinjection system of the oil centre (see fig. 6). The maximum water flow rate that is possible to obtain with this system is about 50 cm/hr. This limit is connected to the maximum capacity of the reinjection pumps(2) used to boost the water from the storage tank into the reservoir. The well flow ,before to be delivered into the loop and at the oil centre, must be cooled through air coolers. For this, dedicated air coolers which can be used independently by the production are installed in the loop. In addition, the loop is connected to an air cooler bank of the production plant (one air cooler for the test , two for the production). The temperature of the crud at the manifolds is normally about 120 °C and the delivery temperature must be bellow 80 °C. The flow from the SBS manifold is delivered first to the air coolers and then to the test separator(s). If all the flow delivered to the test separator(s) is used for the tests, the single phase flow rates are measured in the test separators and also in the interface skid, otherwise (test flow lower than the test separator flow) the single phase flow rates (oil, water, gas) are measured only in the interface skids. The SBS interface skid was built in the 1987 in order to test only multiphase pumps, instead the new interface skid (MULTIPHASE METERING UNIT), just completed, has been built in order to test mainly multiphase metering. For this reason particular effort has been put to design this last skid, in order to have a stable flow at the test sections and to measure the single flow rates with the best accuracy. In the loop there are two test sections, (shown in fig. 5 with the connections of the METERING UNIT 1 and 2), which allow to test more than one multiphase flow meter in the same time. Having two test sections, interconnected by sufficient long flow lines, is possible to use one of them to meet the test conditions and the second one to test the components. This allows the generation of several flow regimes at the second test section, including the slug flow. The INTERCONNECTING SKID also allows to test multiphase pumps. The connections of the SCREW PUMP UNIT (not in field actually) and of the MEMBRANE PUMP UNIT (see fig. 5)

show the two positions where the pumps can be tested. The two positions are interconnected allowing also to test systems of pumps in series or in parallel. The tests in the loop may be performed mainly with three test loop configurations:

- in line
- in line with multiphase pump
- in close loop with multiphase pump

2.1 Tests in line

These tests are performed at the local main flow lines pressure, which is defined by the pressure set point of the slugcatcher (see fig. 4) and by the pressure drop through the flow line used to perform the tests. The flow at the outlet of the loop may be delivered to the slugcatcher through a 10" or 12" line (see fig 5). The actual set point of the slugcatcher at the oil centre is set at 50 bar and the pressure drop through the 12" flow line is about 5 bar. This brings to have in the loop a pressure of about 55 bar. This pressure may be increased up about 70 bar increasing the pressure drop through the control valves at the outlet of the loop. This upper limit is due to the blocks, for high pressure, of the wells feeding the test loop. The pressure in the loop may be also decreased down to about 45 bar decreasing the set point pressure of the slugcatcher at 40 bar. This operation can be done only for short time and in agreement with the exercise requirements. A typical configuration of the loop for these tests is shown in fig. 7. Collecting field data through the lines upstream the loop (well heads, manifolds) and downstream (slugcatcher), it is possible also to perform fluid dynamic tests for the multiphase computer codes qualification. In this case all the test loop becomes a test section where is possible to measure the pressures and temperatures in several points of the loop and to verify, using multiphase metering, the flow regimes in two points (test sections) of the line. Figure 8 shows a very schematic configuration of the transportation system involved in these tests.

2.2 Test in line with multiphase pump

These tests are performed using the diaphragm pump (MEMBRANE PUMP UNIT) that has been already tested and is till installed in the field. A typical configuration for these tests is shown in fig. 9. The pump allows to decrease the loop pressure down to 20 bar, that is the minimum inlet pressure accepted by the pump. The pump then increase again the fluid pressure up to the flow line pressure (55 bar) required to deliver the flow to the oil centre. With this loop configuration it is possible to perform tests in a wide range of pressure (20-70 bar), allowing also to test choke and control valves in critical and sub critical conditions. In this case the maximum test flow rate is about 120 cm/hr correspondent to the maximum capacity of the pump.

2.3 Tests in close loop with the multiphase pump

These tests are performed in close loop using the test loop separator (see fig. 10) or using the field test separator (see fig. 11). In this case the multiphase pump must supply the differential pressure required for the flow recirculation. The tests can be done in the pressure range of operability of the pump (20-65 bar),with a temperature variable in the range (20-80 °C). With these configurations is possible also to replace the oil in the separator(s) with more heavy oil and to verify the fluid effects (specially the viscosity) on the multiphase components and on the fluid dynamic of the transport. This can be done replacing, at low pressure, the Trecate oil with stabilised oil and adding then field gas in order to obtain a live oil.

3 TEST LOOP SINGLE PHASE FLOW METERING STATIONS

In the loop there are mainly four single phase flow metering stations:

-test field separator
-test loop separator
-SBS interface skid
-multiphase metering unit

The two test separators have the same capacity and are used as reference stations for the flow measurement when all the test separator flow is delivered to the test section(s). In these conditions they are also used to verify the accuracy of the flow meters in the interface skids, since the test separators flow meters are in series with those in the skids and the same flows are passing through them. The reference flow meters in the test separators are:

-oil flow rate: positive displacement
-gas flow rate: orifices
-water flow rate: positive displacement

The single phase flow meters in the SBS interface skid (orifices) are not used as reference , since their accuracy is presently considered not acceptable to test multiphase flow metering. For this scope, at partial flow (not all the separator flow), only the multiphase metering unit is used as single phase metering station. In order to verify the PVT package (used normally in the multiphase metering to calculate the oil and gas densities versus the measured pressures and temperatures), in this skid the oil and gas densities also are measured. The reference meters are:

-oil flow rate: positive displacements
-gas flow rate: turbines
-water flow rate: magnetic meters
-oil density: resonance densitometer
-gas density: resonance densitometer

The overall accuracy on the single phase flow rates (oil, water and gas) and on the densities is:

-flow rates: $\geq 1\%$
-densities: ± 0.5 kg/cm for oil
± 0.04 kg/cm for gas

4 CONCLUSIONS

The Trecate multiphase test loop is now available to test the following multiphase components or multiphase systems:

- flow metering,
- pumps and systems of pumps,
- ejectors,
-choke and control valves,
-novel separators and

-to perform fluid dynamic tests for the multiphase computer codes qualification.

The operating conditions of the loop are:

-pressure: 20-70 bar
-temperature: 40-70 °C
-oil flow rate: 0-150 cm/hr
-gas flow rate: 0-90 cm/hr
-water flow rate: 0-50 cm/hr
-oil viscosity: 1-3 cp (1)
-all flow regimes

Given the wide range of variation of the operative parameters the loop is particularly indicated for the characterisation of the multiphase components especially for the multiphase flow metering.

(1) replacing the Trecate oil is possible to perform tests also at higher viscosity

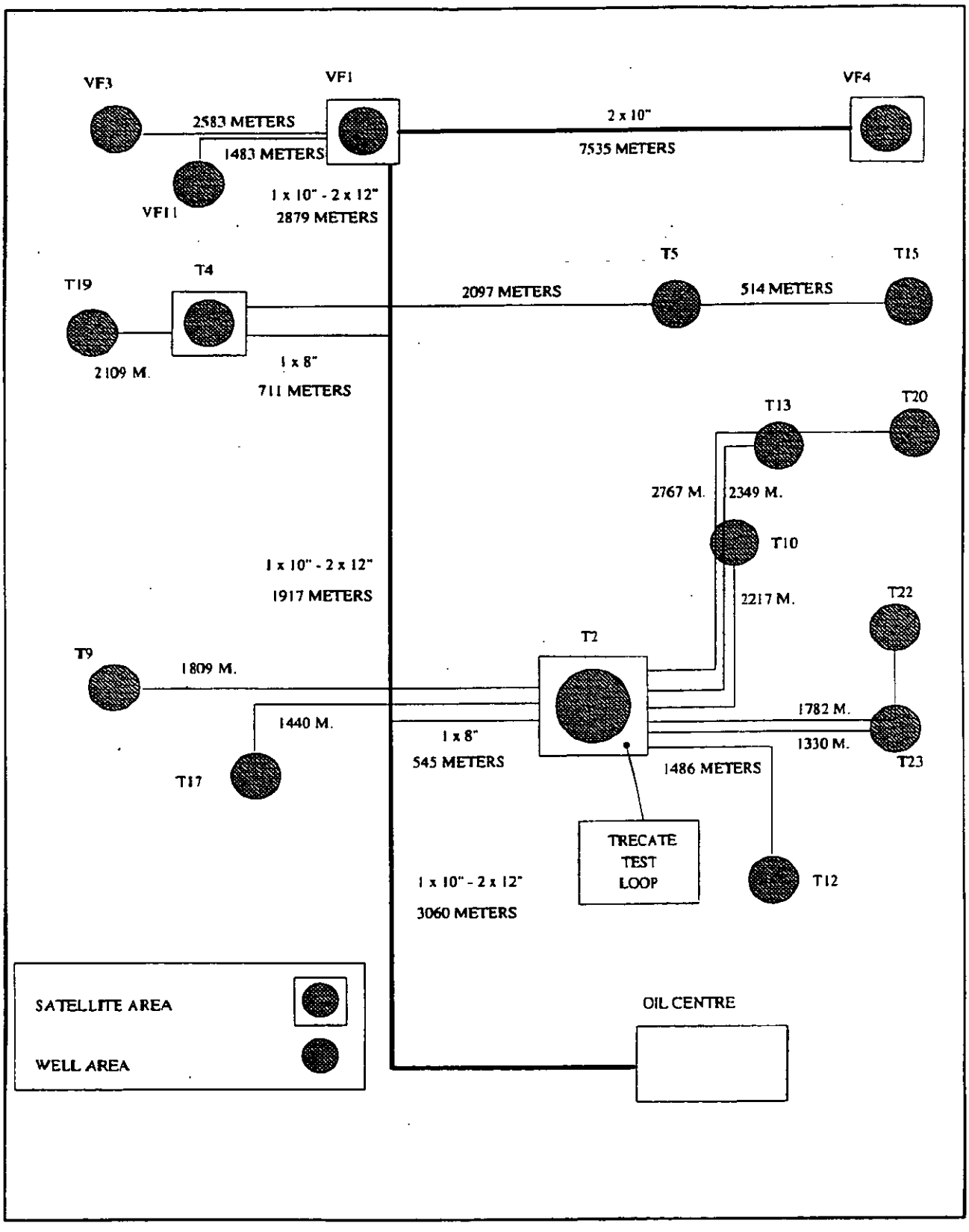


Fig. 1 - Trecate-Villafortuna overall field configuration

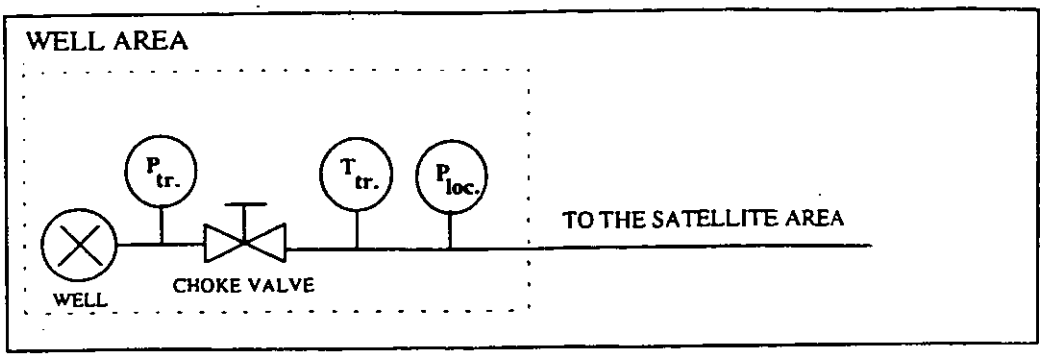


Fig. 2 - Typical configuration of a well area

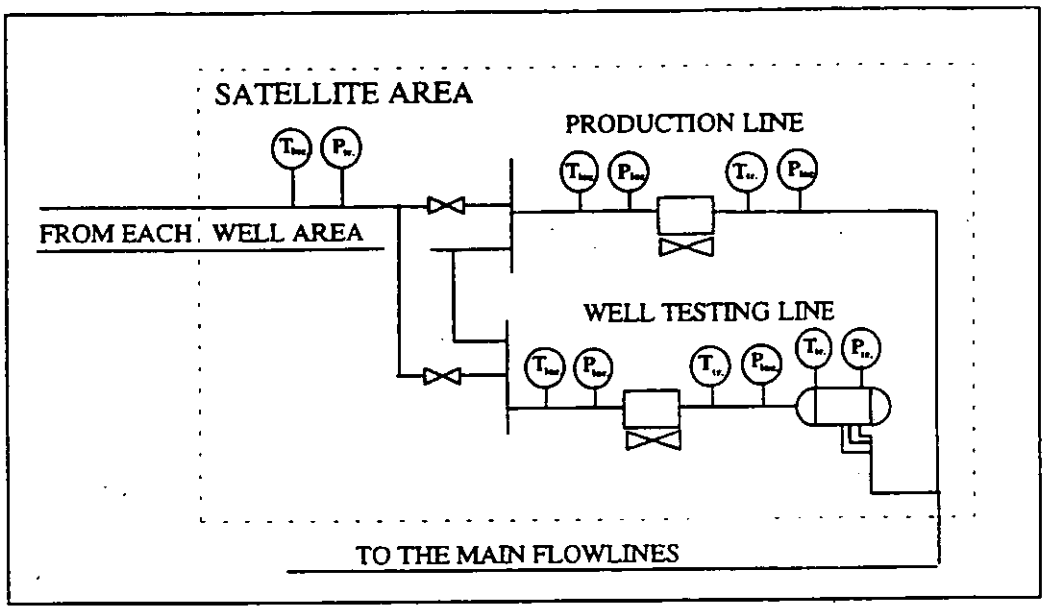


Fig. 3 - Typical configuration of a satellite area

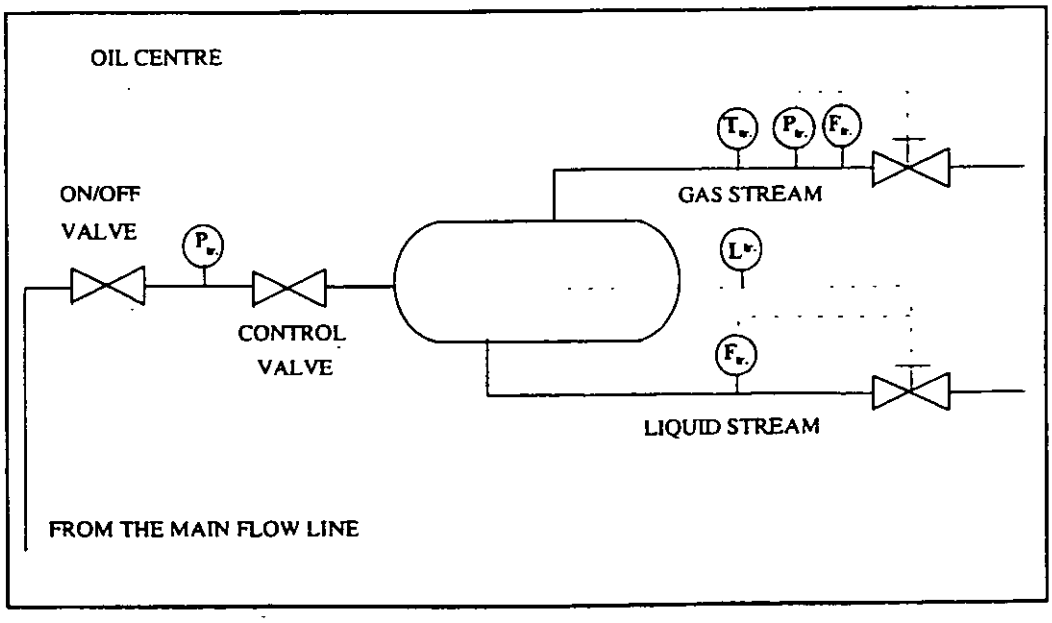


Fig. 4 - Slug catcher configuration

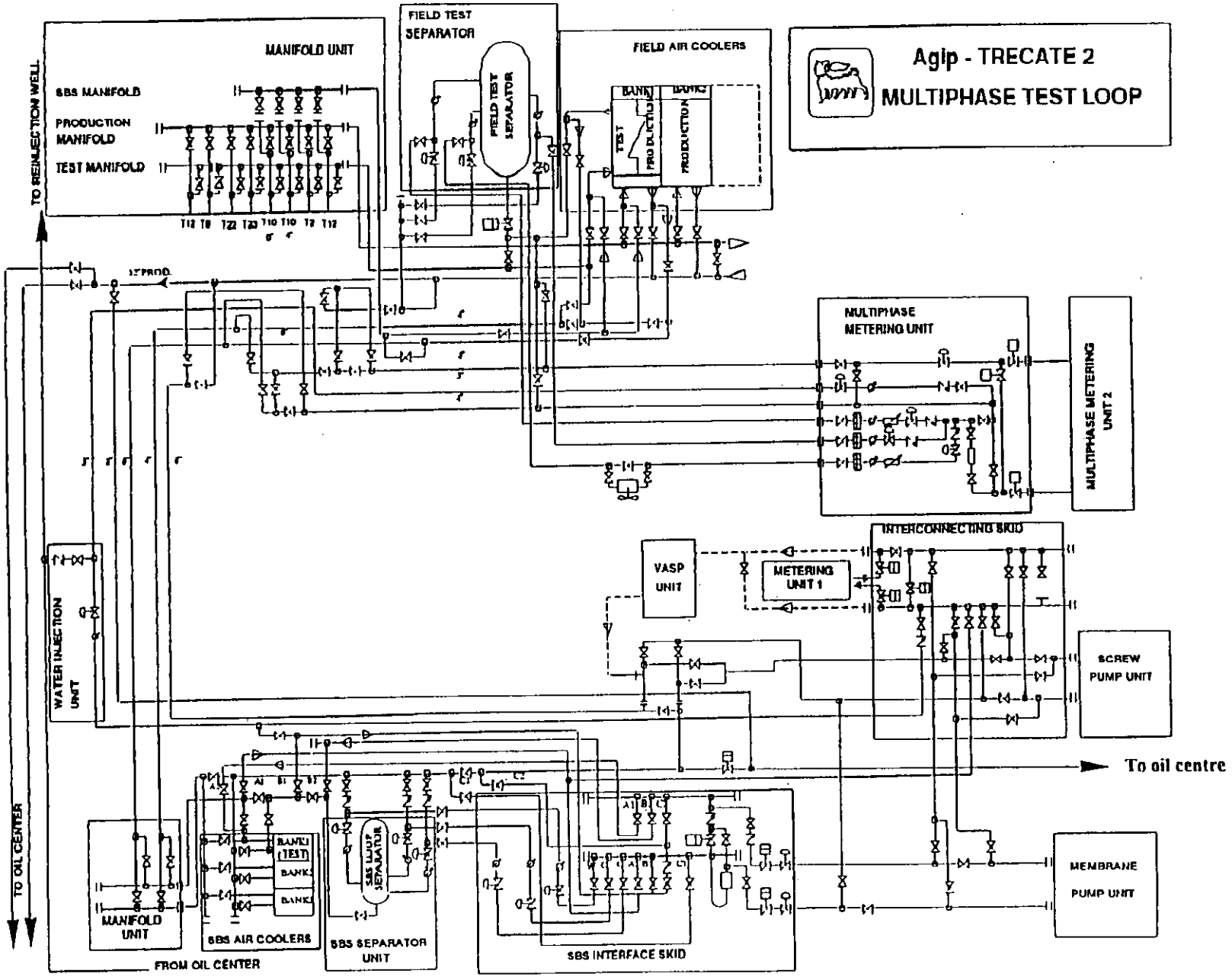


Fig. 5-Trecate multiphase test loop

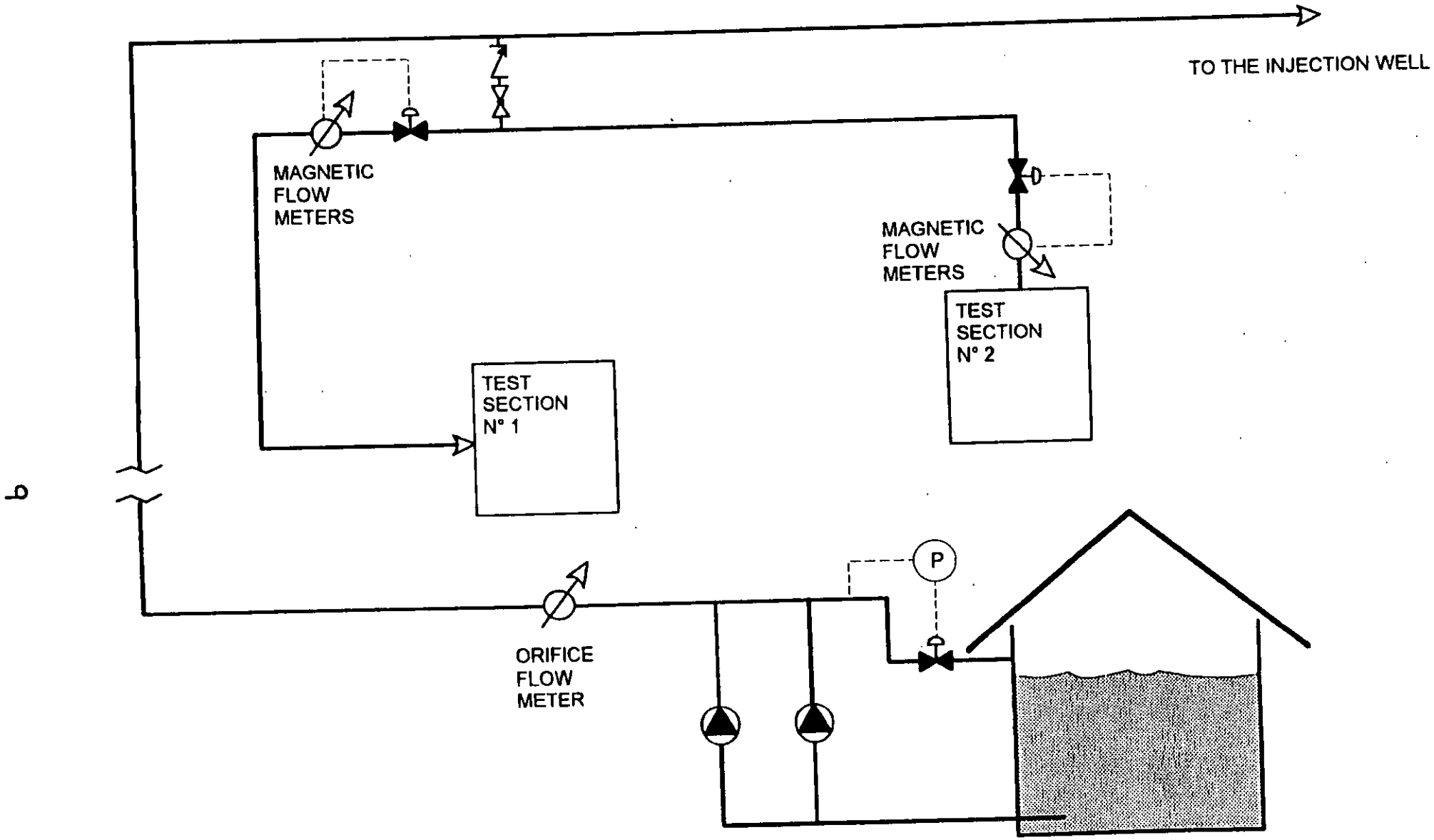


Fig. 6 - Water injection system

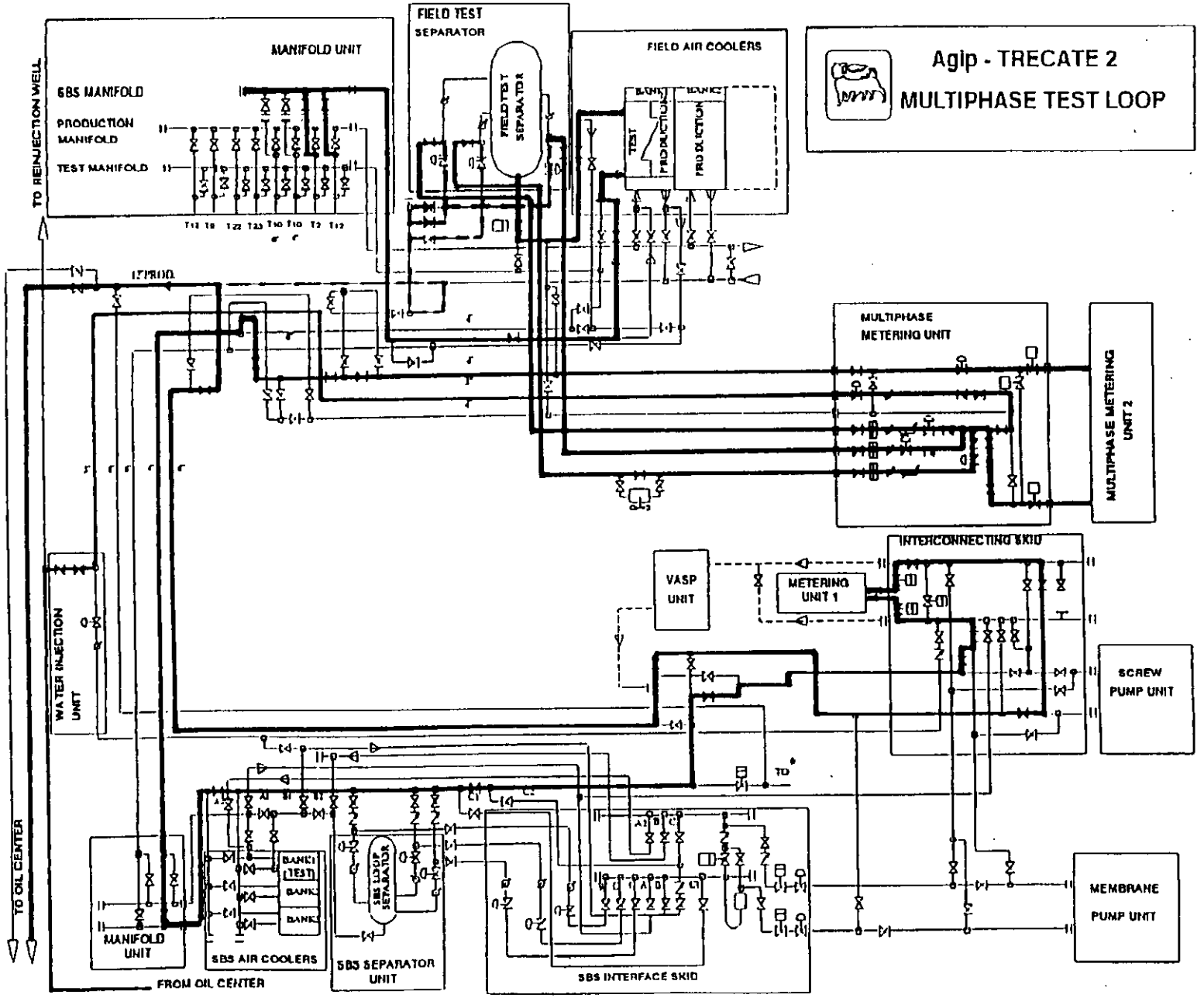


Fig. 7-Test on line

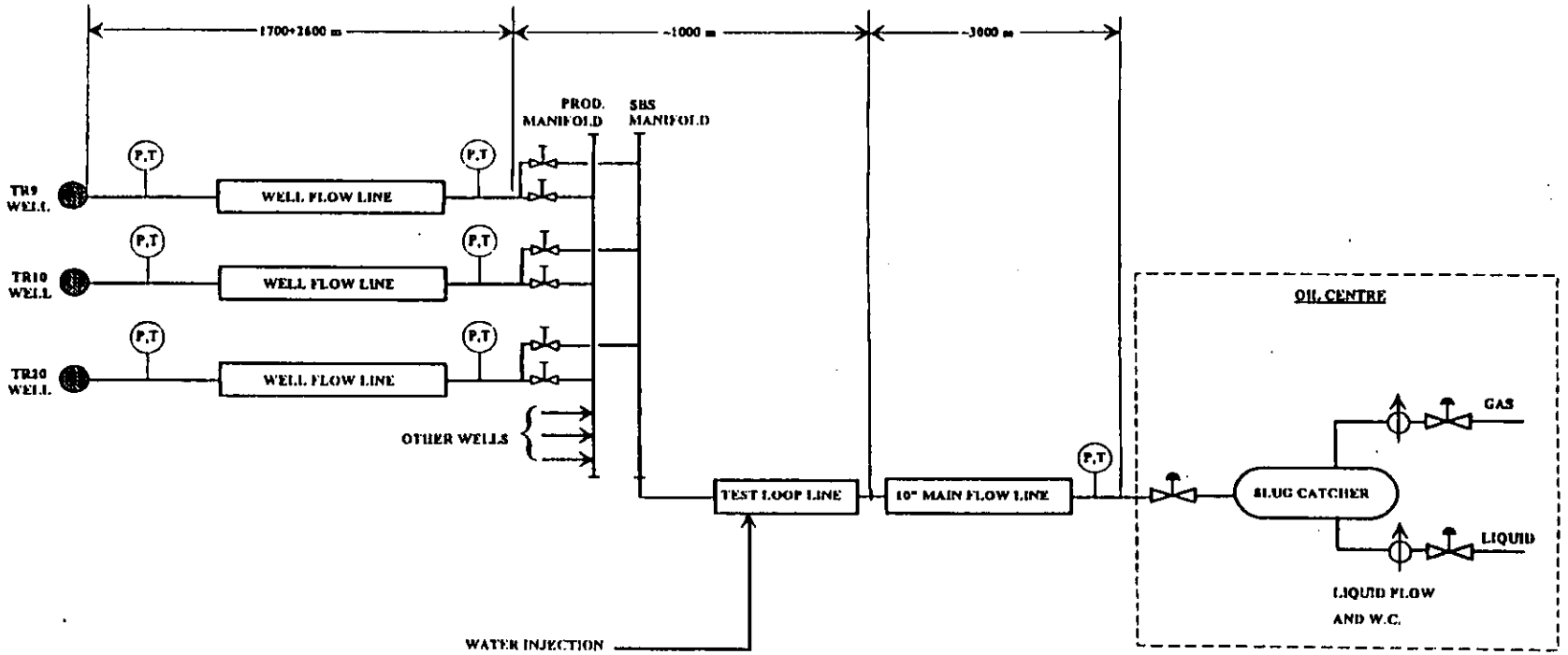


Fig. 8 - Plant configuration for fluid dynamic tests

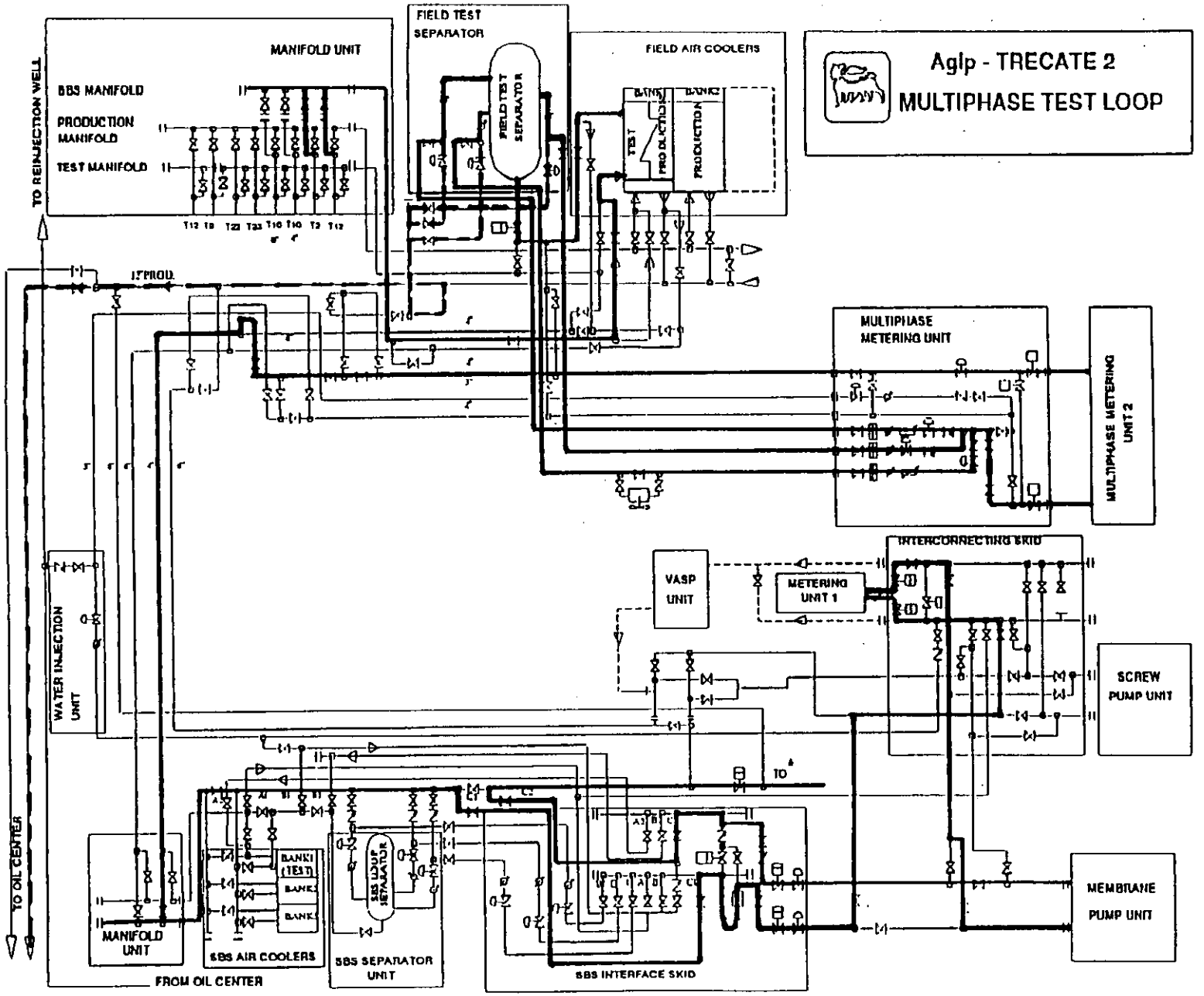


Fig. 9-Test on line with multiphase pump

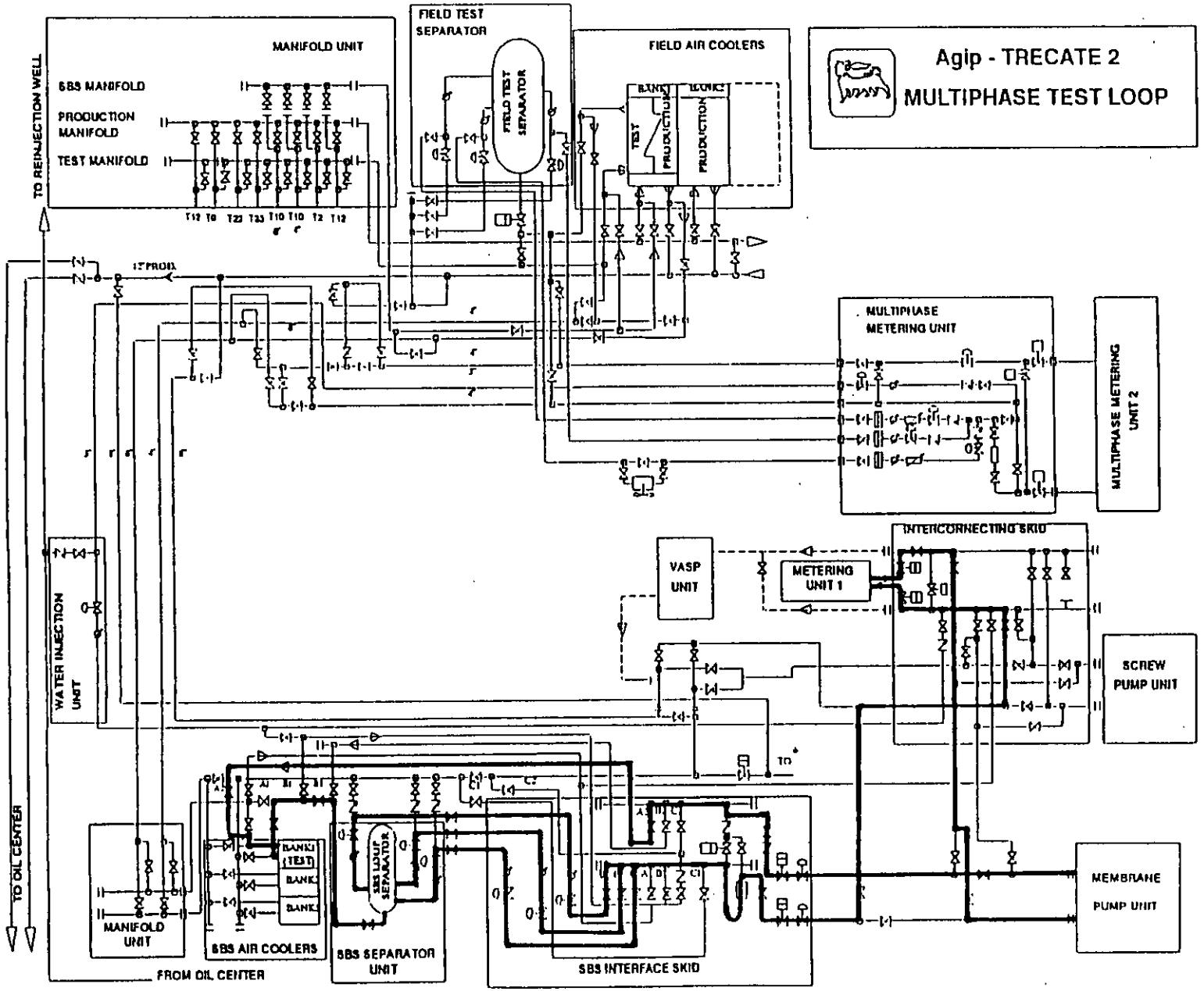


Fig. 10-Test in close loop with multiphase pump, using the test loop separator

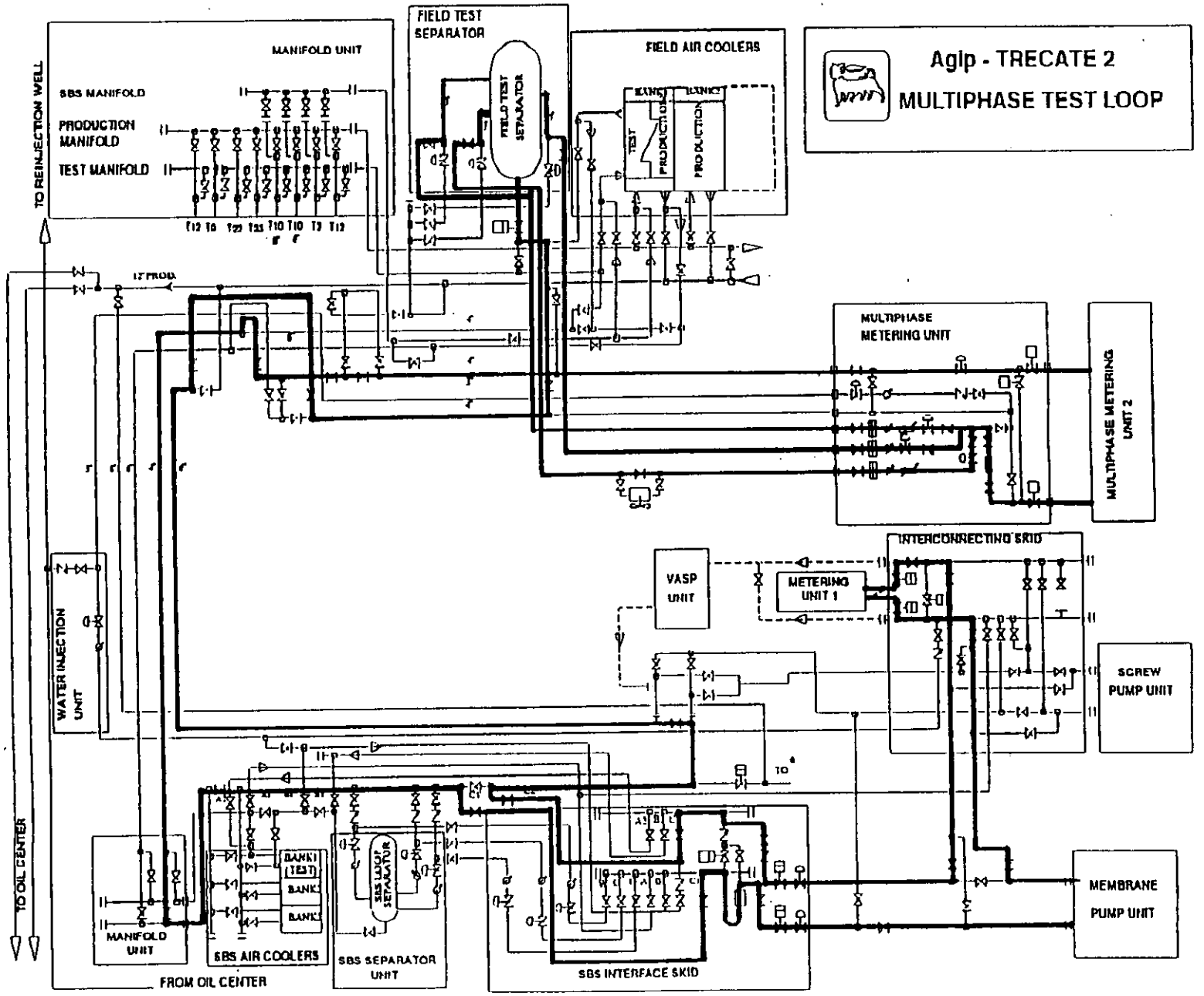
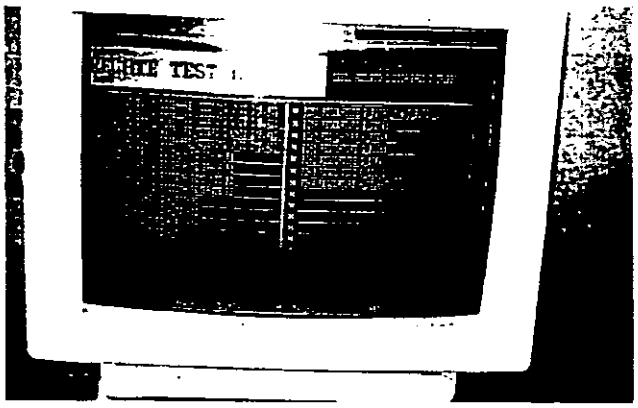
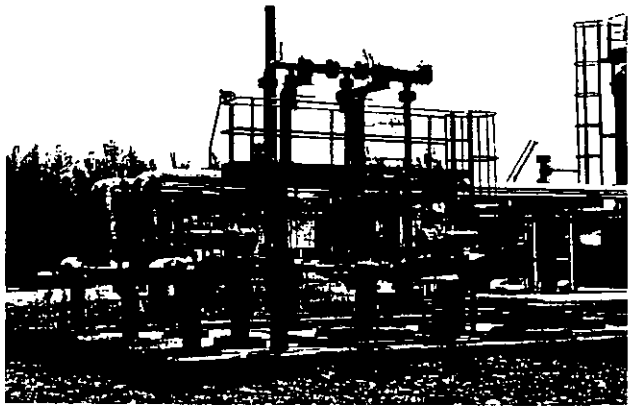


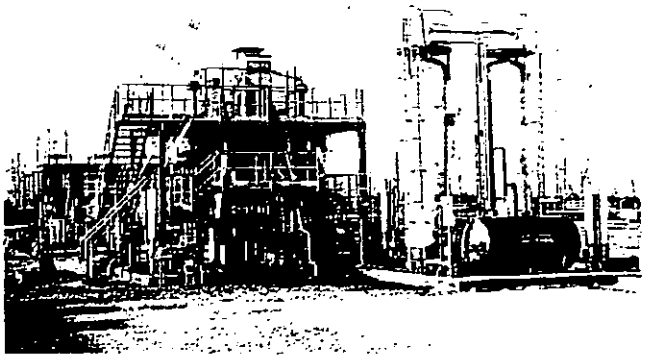
Fig. 11-Test in close loop with multiphase pump, using the field test separator



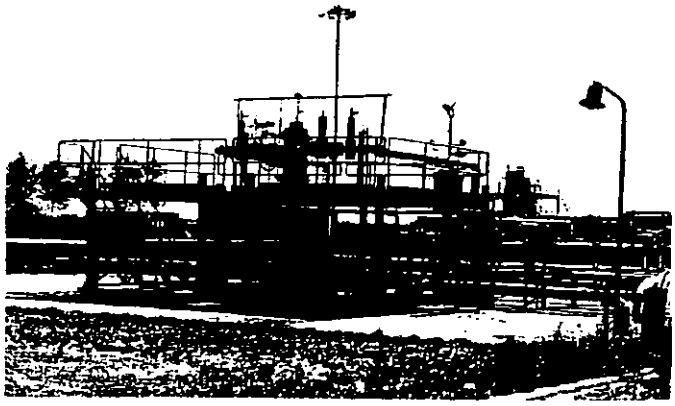
Operators console



Interface skids (test sections)



Diaphragm multiphase pump



Trecate 2 well (TR2)

Fig 12-Same Trecate test loop main components

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.