ISOIL
IMPIANTI

MASTER METER

SERVICE MANUAL

CODE	**:** ***031/IN/01***
DATED	**:** ***09/1994***

ISOIL IMPIANTI spa – Italy
Sede e Stabilimento
Head office and factory
24061 Albano S. Alessandro (BG)
74, via Madonna delle Rose
Tel. +39 035 4239011
Fax +39 035 582078
E-mail: albano@isoil.it
Web: www.isoil.com

Uffici commerciali:
Sales office
20092 Cinisello Balsamo (MI)
27, via F.lli Gracchi
Tel. +39 02 66027.1
Fax +39 02 66012457
E-mail: commerciale@isoil.it
sales@isoil.it

Sede legale:
Registered office
20124 Milano
24, viale Vittorio Veneto
Capitale soc. i.v. € 774.000
Codice fisc. e part. IVA 13066900153
C.C.I.A.A. MI – Reg. Impr. 86449/2000
R.E.A. MI 1612783

Sistema Qualità Isoil
Certificato ISO 9001
CISQ – R.I.N.A. n.83/93

I N D E X

ENCLOSED:

Introduction

1. Still now an usual way of proving positive displacement meters is by means of proving tanks, specially designed and built tanks of known capacity. These methods, when carefully conducted by skilled operators, can be accurate, but they lay themselves open to many errors. They are also slow and the equipment is cumbersome.
2. The ISOIL Master Meter has been designed to simplify the whole procedure of checking the accuracy of a meter. In many applications this can be done with the meter under test in its normal operating position, and the equipment is easily transportable. Care is necessary in the use of a Master Meter, but provided the instructions in this manual are followed strictly, the whole operation is very quick and simple.
3. It cannot be emphasized too strongly that with modern meters, repeatability is such, that it should be possible to carry out a number of runs at the same speed and obtain consistent results. On occasion these may be varied by outside influences such as temperature, but the point of this note is to recommend that, if there is a variation in the results of repeated runs at the same speed, all conditions of test and method of operation should be examined very carefully before assuming that the fault lies in the meter under test.
4. No meter, including a Master Meter, is accurate, throughout its speed range, but provided it is consistent, and the variation is known, at any given speed of reading of the Master Meter may be corrected by the application of a factor.
   By using the electronic counter Vega with the linearization of the error curve, the Master Meter error is very near to zero.
5. At the back of this manual is a Master Meter log book consisting of three sections:
   (1) **Meter Test Report.** This is a specimen form, copies of which should be provided locally for recording tests
   (2) **Master Meter Inspection Report.** On this has been entered the results of all the calibrations of the Master Meter against a proving tank.
   (3) **Master Meter History Sheet.** On this should be kept as full a record as possible of all operations of the Master Meter. It should include all movements, details of tests and products used. In fact anything which might be subsequently useful.

   In addition to the above, each depot or installation where meters are used should provide a Meter Record Book. In this should be entered records of each proving by the Master Meter and other details such as routing maintenance, throughput and service for every meter.
   For the purpose of this manual (+) plus indicates that the reading if the meter under test is greater than the reading of the master meter and (-) minus indicates that the reading of the meter under test is smaller than the reading of the master meter.

Description

6. The ISOIL Master Meter consists of a standard series p.d.meter (mounted or not on a mobile trolley). The meter is fitted with a mechanical rate of flow indicator.
   The direction of flow through the meter is indicated by arrows on the meter manifold. It must be emphasized that the Master Meter, although robust, is a precision instrument and must be properly handled and treated to ensure that it maintains its accuracy.

All rights reserved. Reproduction of this manual is forbidden.

Application

7. The master Meter is suitable for proving any type of positive displacement meter within its capacity. The obvious applications are:

Aircraft refuellers
Aircraft dispenser used with hydrant systems
Gantry, pipeline and bunkering meters
Road delivery tankers
Standby meters not installed
Preset meters

Once the principle of operation is understood, it will be seen that, provided a source of fuel under pressure is available, any meter can be tested.

Principles of Operation

8. There are five main principles to be observed:
   (1) Conditions of product, line pressure, rate of flow and temperature must be as near as possible the same as those prevailing in the normal service of the meter under test.
   (2) The same quantity of test product must pass through both meters.
   (3) Special care must be taken that neither air nor vapour passes through either meter.
   (4) The flow must be controlled downstream of both meters, except as described in paragraphs 25 and 30.
   (5) As far as possible all conditions must be the same at the end of a proving run as they were at the beginning.

9. In general, the performance of all meters varies, with changes in their operating conditions. Trials on the Isoil Master Meter have established its characteristics under various conditions of speed, product and pressure, and these are given in the form of factors with each Master Meter. Tests should be made in conditions as near as possible the same as those in which the meter under test is normally used, as the characteristics of other meters under varying condition may not be known.

10. It is immaterial whether the Master Meter is upstream of the meter under test or vice versa. The choice will depend on convenience. It is, however, most desirable that the two meters should be as close together as possible. It is essential that there should be no possibility of leaks between the two meters and that the pressure loss between them should be kept as small as possible. The Master Meter must be drained of the product which was left in it for storage, before commencing any test.

11. The most common source of error in metering and meter proving is the presence of air or vapour. This may be present in one or more of five forms:

Air trapped in the meter or connecting pipe-work.
Air drawn into the system through, for example, a leaking gland on a pump.
Entrained air in the product.
Formation of a vortex or cavitation in the product supply.
Breaking of the product due to sudden drop of pressure caused by change of diameter in the pipe, or restriction of a valve for instance.

All rights reserved. Reproduction of this manual is forbidden.

12. Care must be taken to avoid high points in the pipe-work or hoses as these may easily trap air. Sharp bends are equally undesirable. The whole system must be very thoroughly purged of air. This is best done by circulating the product. The control valve must be opened very slowly because, if air is present, there is a danger that the meters may race, with consequent damage. Circulating the product also has the advantage of stabilizing the temperature. If the return line is connected to the tank from which the pump is sucking, as would be probable in the case of a refueller, care must be taken to ensure that the dischare is drowned otherwise the product will become aerated.

13. When proving on low viscosity products, an air separator must be installed between the pump and the upstream meter, being as close to the meter as possible. When proving on high viscosity products it is essential that the storage from which the product is drawn should be allowed to stand for a sufficient time before testing, to allow air to work out. This may take up to 24 hours or more in the case of very high viscosity products.

14. It may be argued that if air passes through both meters it will affect them both equally. This is incorrect as, due to the slight difference of pressure in the two meters, air will affect them differently.

15. It is essential to use a strainer between the pump and the upstream meter, the mesh of the strainer depending on the product.

16. Because it is essential that the whole system shall remain full of product at all times, the flow must be controlled downstream of both meters. If this is not done, the velocity of the product will cause it to continue to flow through the meters after the control valve is shut. This will give false readings.

17. The Master Meter is normally used with two flexible hoses. Even the stiffest flexible hose suffers from dilatation to some extent when pressurized. For this and other reasons it is essential that pressure and other conditions at the end of a proving run should be as nearly as possible the same as they were at the beginning.

18. In order to ensure that a steady flow is available without fluctuations or pulsations a centri-fugal pump should be used.

Test Rig Layout

19. The layout of the test rig will obviously vary with the particular use of a meter under test. Various cases are examined here which are applicable in varying degrees to all meters. A feature common to all cases is that the control valve should be so situated that the counter of the meter under test is easily and accurately read when operating it. Whenever hoses are used the whole length of hose should be uncoiled and flaked on the ground. A hose, wound on a hose reel, should not be used. A pressure gauge is necessary and this should be as close to the meters as possible. The line pressure used during testing must be noted and recorded.

All rights reserved. Reproduction of this manual is forbidden.

Aircraft Refueller

20. It is probable that no test rig will be required, the vehicle's own pump, strainer, air separator and hoses being sufficient. The refueller must contain sufficient product to ensure that there is no danger of the pump drain a vortex.

21. Connect one of the vehicle's discharge hoses to the Master Meter input hose. Using another hose, connect the Master Meter discharge hose to the refueller fill point. If it is necessary to discharge over the top, take care that the end of the discharge hose is drowned. A control valve must be provided downstream of the Master Meter.

Dispenser and Hydrant Systems

22. No pump other that that feeding the hydrant system is required, and the dispenser's strainer and air separator can be used. A large container is necessary in which to discharge the product used during proving and for this a refueller or bridging vehicle will probably be most convenient.

23. Some hydrant schemes already incorporate a meter proving off-take close to the tank farm with a return line direct to the tanks.

24. Connect the dispenser's discharge hose to the Master Meter input hose. Using another hose, connect the Master Meter discharge hose via the control valve to discharge container, or to the return line referred to in paragraph 23.

Gantry, Pipeline and Bunkering Meters

25. When a Master Meter is used to test meters installed in conjunction with bulk vehicle overhead filling equipment (e.g. bulk vehicle filling gantries fitted with articulated loading arms) it should be connected via a suitable "T" piece at the base of the loading arm. It is essential that the system incorporating the meter under test and the Master Meter shall be maintained at the same operating pressure as the bulk vehicle filling line under normal operating conditions. In gantries for Bottom Loading, hose to Master Meter has to be connected to the API coupling at the end of the loading arm. Gantry meters are normally of the preset type (see also paragraph 30), and this may entail fitting the check valve assembly downstream of the Master Meter.

Road Delivery Tankers

26. Much the same applies in this case. In those tankers which normally discharge by gravity, no air separator is necessary provided that the product is allowed to settle. Again, a container at a suitable level will be required. Care must be taken to avoid drawing a vortex in the tanker.

All rights reserved. Reproduction of this manual is forbidden.

Standby Meters not installed and any meter which cannot be proved in its operating position

27. Here a simple test rig is necessary. The first requirement is a supply of fuel under pressure. For this it may be possible to arrange an off-take from the normal service of an installation, or it may be necessary to provide a special pump for meter proving. This pump, preferably centrifugal, should have a capacity sufficient to prove the meter up to its maximum rated capacity provided that this is within the maximum rated capacity of the Master Meter, which must not be exceeded.

28. If it is possible to use a pump on the existing installation it is probable that similar arrangements can be made for a strainer and an air separator, otherwise these two items should also be incorporated in the test rig. Control must be made for the discharge of the test product.

29. If an existing pump is used, it is most important that the normal working of the installation shall have no effect on the Master Meter test rig. It is essential that there shall be two valve separation throughout between the test rig circuit and the normal installation pipe-work.

Preset Meters

30. If the meter under test is fitted with a preset, it is advisable to test it in two stages:
    (1) If necessary adjust the preset mechanism to give a precise cut off so that the meter counter indicates exactly the preset quantity. The calibration of the meter under test should in no circumstances be adjusted during this operation.
    (2) Install the Master Meter with a valve downstream of it to control the flow. Preset a quantity larger than the test run and proceed as for a normal meter. Some presets incorporate a two stage shut-off valve, with a reduction of speed before the final closure. It is important that the preset quantity should be sufficient to ensure that the test run is complete before the first stage shut-off comes into operation. Now check the calibration in accordance with a normal test procedure (paragraph 31).

    It is only possible to test the calibration of these meters by comparing the totalizer reading with the reading of the Master Meter. The throughput necessary to do this will depend upon the accuracy with which the totalizer can be read and upon the accuracy of the test required e.g. if the totalizer can only be read to within 1 litre and the result is required to be within 0-1‰ it will be necessary to run 1000 litres. The total throughput divided by the number of individual deliveries will give the quantity of each delivery. From this the accuracy of each delivery can be determined.
    The Master Meter is obviously not really suitable for testing repeating preset meters where the amount of each delivery is so small as to make the operation a lengthy and tedious process.

All rights reserved. Reproduction of this manual is forbidden.

Test procedure

31. Drain the Master Meter, install it and throughly purge the whole system of air by circulating the product. It may be necessary to run several hundred liters for this purpose. Check carefully for leaks between the two meters. Now proceed as follows:
    1- Stop the flow by shutting the control valve downstream of the meters but allow pumping to continue to maintain pressure.
    2- Zeroize both meter counters. Check that there is no creep on the counters.
    3- Open the control valve until the desired rate of flow is shown on the Master Meter rate of flow indicator.
    4- Read and note pressure during each run.
    5- Run EXACTLY 1000 litres (see note "b" below) as shown on the counter of the meter under test, leaving the pump running to maintain line pressure as at (3). Check that there is no creep on the counters.
    6- Read the Master Meter counter, or if fitted, the units drum assembly to estimate to a smaller part of a unit.

    NOTES a- It is essential that the required rate of flow be reached as soon as possible and be maintained for as long as possible.
    Towards the end of the run, reduce the flow rate smoothly so as to get a precise shut-off.
    b- It is advisable to do runs in units of 100 as this makes the calculations of the results easier. The longer the run the more accurate will be resultant reading.

Calculation of Results (1)

32. Paragraphs 32 to 34 inclusive explain the necessary calculations in detail and show two examples in which two meters are tested by two different Master Meters under different conditions of product and pressure.
    Page 7 shows a graph of a typical Master Meter error curve.

These calculation are divided into five sections:
    1- Correction of Master Meter reading for its calibration factor for the speed of the run.
    2- Determination of difference between Master Meter reading and reading of meter under test.
    3- Conversion of this differences into percentage.
    4- Correction for viscosity variation.
    5- Correction for pressure variation.

Note (1) Data on correction factor due to viscosity and pressure are experimental data obtained by SGS Redwood Ltd carrying on tests on Isoil Master Meter in 1993.

All rights reserved. Reproduction of this manual is forbidden.

(a) Correct Master Meter reading by the Master Meter error for the speed of the run. This gives the correct Master Meter reading.

Speed of run	1000 l/min	Master Meter A	Master Meter B
Master Meter error	1000 l/min	+0.045%	-0.010%

	A	*B*
Master Meter reading	1001.32	999.32
Correction	- 0.45	+ 0.10
Corrected Master Meter reading	1000.87	999.42

(b) The Meter error (E) as a percentage is calculated:

$$E\% = \frac{Vi - Vo}{Vo} \times 100$$

with: Vo = Master Meter reading
Vi = Meter under test reading

The meter errors of our example are:

A

$$E(A) = \frac{1000 - 1000{,}87}{1000{,}87} \times 100 = -0{,}087\%$$

B

$$E(B) = \frac{1000 - 999{,}42}{999{,}42} \times 100 = +0{,}058\%$$

All rights reserved. Reproduction of this manual is forbidden.

33. To this result must be added or subtracted the viscosity error, if the product used during testing differs from that on which the Master Meter was itself proved. These viscosity factors are as follows:

Product	Approx. Viscosity at Temperature of Test	Viscosity Error
	Centistoke	
Gasoline	.55	-0.1%
Water	1.00	NIL
White Spirit Kerosine	1.75	+0.1%
Gas Oil Marine Diesel	5.5	+0.15%
Fuel Oil	36.5 & over	+0.27%

A

Master Meter proved on Water. Meter under test tested on gasoline.
Error of meter under test (See paragraph 32 (c) above)

	- 0.087%
Viscosity error gasoline	- 0.1 %
Meter under test when used on (a) gasoline	- 0.187%

B

Master Meter proved on Water. Meter under test tested on gas oil.

	+ 0.058%
Gas oil	+ 0.15 %
(b) gas oil	+ 0.208%

34. Due to the compressibility of petroleum products, a further correction is necessary if the line pressure during testing varies from the line pressure when the Master Meter was itself proved.
To correct for this subtract the line pressure used when the Master Meter was proved from the line pressure during tests.
For every 100 KPa (1 bar) of this remainder apply the below correction to the calibration factor of the meter under test as determined in paragraph 33 above. Add or subtract in the sense of the algebraical sign of the remainder.
Approximately, for light products, like gasoline, kerosene, gas oil the compressibility factor value it is 0,014% for every 100 kPa.

All rights reserved. Reproduction of this manual is forbidden.

EXAMPLE

	A	*B*
Line pressure during testing	350 KPa	100 KPa
Line remainder pressure when Master Meter was proved	100 KPa	200 KPa
Corrected Master Meter reading	+ 250 KPa	- 100 KPa
Error of meter under test (see paragraph 33 above)	- 0.187%	+ 0.208%
Compressibility factor	- 0.035%	+ 0.014%
	- 0.222%	+ 0.222%

If the product and line pressure during testing are the same as when the Master Meter was proved, the calculations in paragraphs 34 are not necessary.
It is suggested that the readings should be noted and calculations made on a special form, a specimen of which is attached. When properly filled up the form is a complete record of all tests and makes the calculation and checking of results easy. For each test run, the spaces outlined must be completed at the time that the readings are taken; it is from this information that the results are calculated.

35. Carry out three runs at the speed at which the meter under test is normally used. If these three runs agree with each other within the expected performance of the meter under test, the average of the three results should be taken as the meter calibration factor at that particular speed and entered in the Meter Record Book. If they do not agree, then either the test procedure was carried out incorrectly (see paragraph 3) or else the meter under test is defective.

36. If the mean result of the first three runs is outside the permitted tolerance of the meter under test its calibration must be adjusted in accordance with the Maker's instructions and local regulations. As adjustment of the calibrating mechanism may upset the blacklash in the counter gear train, before carrying out the next run it is advisable to run a small amount of product through both meters.

37. A meter generally does most of its running at or about the same speed. It is at this speed that a meter should be tested and calibrated to datum. Having calibrated it correctly at this speed it is advisable to check the calibration of the meter at other speeds. Not only does this provide information which may be useful, but it is also a good guide as to reliability and condition of any meter. Reference to the meter record book will show if the meter performance has varied significantly since the previous test. It is also possible to see if the maximum variation of accuracy over all speeds is within the expected performance of the meter.

38. As it is necessary to slow down towards the end of a delivery, a meter which inaccurate at low speeds will result in an incorrect reading over the whole delivery, even if it is accurate at datum speed.

All rights reserved. Reproduction of this manual is forbidden.

Preservation after use

39. This section deals with matter special to the Master Meter. For routine maintenance and overhaul of the meter, the Isoil p.d.meter manual should be consulted. The most important matter requiring attention is the thorough cleanliness of the meter, and the prevention of any corrosion.

40. After use the meter should be emptied. To this prepare drip trays and then disconnect the hoses from the proving rig, first having drained the entire system as much as possible. Now open the valve on the drain line hose in a suitable container and pump out all the product.

41. If the meter has been used on a black oil, it should be thoroughly washed out with Kerosine. Proceed as follows:

    With the meter inverted support both inlet and outlet hoses at as high a level as possible. Insert a funnel in the inlet hose and gradually pour in Kerosine until it appears in the outlet hose. Now pump the meter out as before. Continue until all the proving product has been removed.

42. It is advisable that the meter capsule itself should be left full of clean kerosine when the Meter is not being used. This should be circulated by an hand pump once a month.
    To avoid contamination, care must be taken to drain this before commencing a new test.

Check Proving of Master Meter

43. Experience has shown that even after many millions of litres have been passed, the accuracy and calibration factors of these meters do not vary appreciably. Nevertheless, as the Master Meter may have suffered mechanical damage or neglect it is essential that it should be check tested from time to time. Where convenient this may be carried out in the proving rig at the manufacturer's works or whenever is possible.

All rights reserved. Reproduction of this manual is forbidden.

SGS REDWOOD TECHNICAL SERVICES

ISOIL METER 4-424

This meter has been calibrated by SGS Redwood on three occasions using Redwood's own test facilities which are traceable to UK national standards. On each occasion the meter was calibrated on gas oil, kerosene and motor spirit at a number of flow rates between 200 litres per minute and 2250 litres per minute.

The results achieved with this meter have been consistent with those obtained from similar Avery Hardoll meters. On each product linearity has remained within a band of 0.1% error over a 10:1 turndown. On this basis the meter satisfies SGS Redwood's requirements for reference meter performance. The meter factor shift from product to product and the changes in meter factor from one calibration to the next have also been acceptable for reference meter operation.

It must be noted that these comments apply to one meter which has been in use for just over one year. They cannot be assumed to represent the performance of all ISOIL meters.

1 February 1994

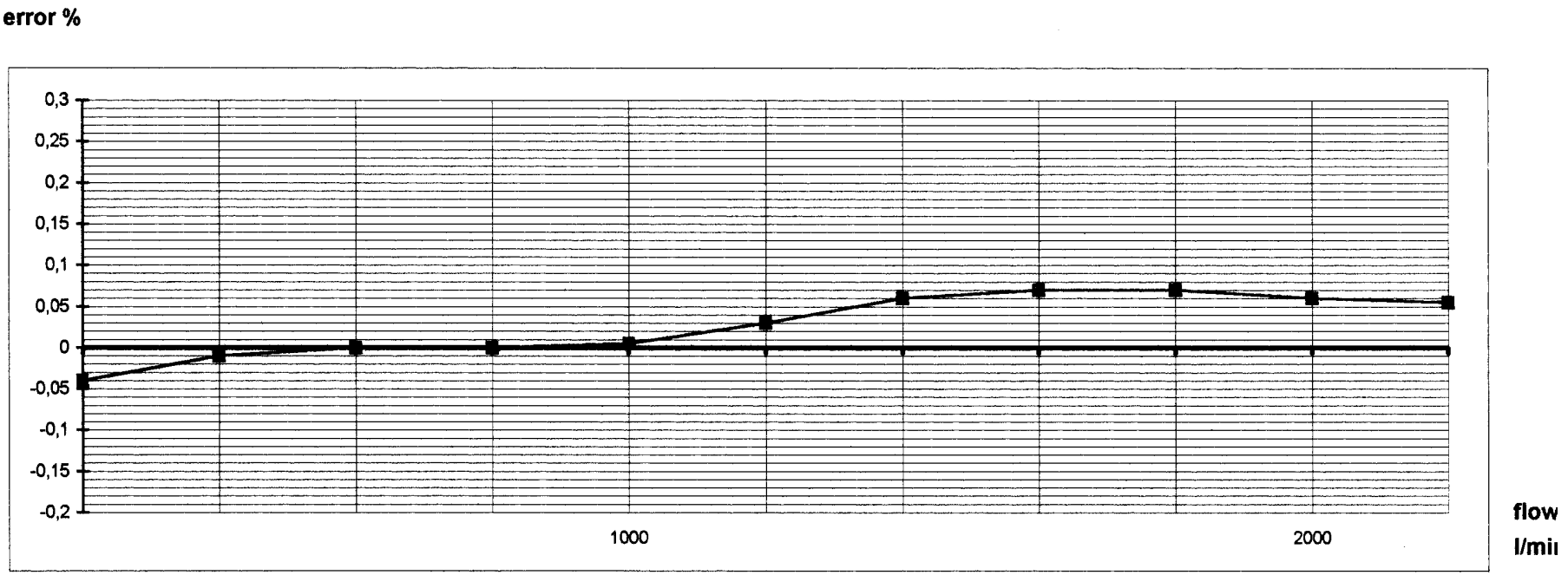
John Mills

All rights reserved. Reproduction of this manual is forbidden.

ISOIL IMPIANTI S.p.A.
All rights reserved. Reproduction of this manual is forbidden.

ISOIL

TYPICAL, AS EXAMPLE,
MASTER METER ERROR CURVE



(M-016)031.XLS

METER TEST REPORT

Place ..... Report N° ..... Date .....

Master Meter Serial N° ..... Calibrated using ..... (product)

Tested Meter Serial N° ..... Tested on ..... (product)

		1	2	3
	A Test Run N°			
	B Flow rate	.....	.....	.....
	C Master Meter error (in %)	.....	.....	.....
1	**D** Master Meter reading	.....	.....	.....
	E Correction $\frac{(C \times D)}{100}$	.....	.....	.....
	F Correct Master Meter reading (D - E)	.....	.....	.....
2	**G** Meter under test reading	.....	.....	.....
3	**H** Percentage difference $\frac{G - F}{F} \times 100$	.....	.....	.....
4	**J** Viscosity factor (%)	.....	.....	.....
5	**L** Pump Pressure during flow (KPa)	.....	.....	.....
	M Pump Pressure when Master Meter was proved (KPa)	.....	.....	.....
	N Difference (M - L)	.....	.....	.....
	P Compressibility factor $\frac{N \times \{\text{PRODUCT COMPRESSIBILITY: GASOLINE, KEROSENE, GAS-OIL}\} \; 0{,}014\%}{100}$	.....	.....	.....
	Q Test Meter error H + J + P	.....	.....	.....

When these calculation are complete the results should be entered in the Meter Record Book (see para. 5), including the totaliser reading before and after testing.

Tested by .....

All rights reserved. Reproduction of this manual is forbidden.

CERTIFICATO DI COLLAUDO MASTER METER
MASTER METER INSPECTION REPORT

ISOIL

Commessa Isoil n° _____ Data di consegna: _____
Job Isoil n° *Delivery date*

Master Meter type _____ Fornito a: _____
Master Meter type *Supplied to*

Portata l/min: max _____ min _____
Flow rate

Matricola N°: _____ Prodotto di prova: _____ Temperatura di prova: _____
Serial No *Proving product* *Test temperature*

Portata *Flow rate* l/min	Pressione *Pressure*	Lettura Master Meter *Master Meter readout V* l	Lettura misura campione *Prover tank readout Vo* l	Fattore di calibrazione *Meter factor* K = Vo/V

Collaudatore: _____
Inspector

GRUPPO ISOIL S.P.A.
Via Madonna delle Rose, 74 - 24061 ALBANO S. ALESSANDRO (BG) - ITALY

All rights reserved. Reproduction of this manual is forbidden.

MASTER METER HISTORY SHEET

All rights reserved. Reproduction of this manual is forbidden.