UK STANDARDS AND REGULATIONS RELATING TO THE DESIGN AND OPERATION OF METERING STATIONS

by

J E MILLER

HUNTER TECHNICAL SERVICES

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J. E. Miller
Hunter Technical Services

1. INTRODUCTION

The UK regulations for metering systems are firstly those which apply to crude oil and gas produced in the North Sea, and secondly those which apply to the products delivered from bonded hydrocarbon oil installations. These UK regulations, the UK standards they refer to, and the procedures by which UK standards are formulated, are discussed in this paper. Particular attention is given to the organisation and responsibilities of the Institute of Petroleum, and its working relationships with the British Standards Institution (BSI) and the International Organisation for Standardisation (ISO). The paper gives details of the latest position of the UK standards available in one form or another in the UK for dynamic measurements. Although, in order to give an overall view, gas measurement is mentioned more details of the standards are given in Paper 3 of this Session of the Workshop.

2. REGULATIONS FOR THE MEASUREMENT OF CRUDE OIL

The measurement of crude oil and gases in the North Sea is the concern of the Department of Energy (DoE), and all Petroleum production licenses granted by the Secretary of State incorporate a clause which requires a licensee to measure (or weigh) all petroleum liquids and gases won and saved, in accordance with good oil field practice. The current documents available from the Gas and Oil Measurement Branch of the DoE, which provide guidelines on the design, construction and operation of metering stations for liquids and gases, are as follows:-

2.1. Department of Energy Turbine Metering Standards for Liquid Petroleum Measurements - February 1979.
2.2. Department of Energy Operating Procedures for Approved Metering Stations - (Liquid Hydrocarbons) - October 1979.
2.3. Department of Energy Metering Standards for Gaseous Petroleum Measurements - March 1981.

It is understood that these guidelines are being revised and extended, but no details have yet been published.

The involvement of the DoE with measurement does not stop at issueing the guidelines, and a number of further steps are taken by the DoE, in conjunction with the licensee, to make sure the final installed system and its equipment is acceptable to them in terms of accuracy, reliability, fidelity etc.

Discussions are held with the licensee by the DoE on what methods of measurement for the project are being proposed since each application has its own

particular peculiarities, such as live or very viscous crude oils. Detailed examination then follows of the measurement proposals, including an analysis of the methods of calculations. When the measurement system has been built by the selected manufacturer, officers of the DoE witness the licensee's acceptance tests to ensure the system complies with the agreed design and operation criteria. Later on during the pre-commissioning phase, DoE officers again carry out on-site inspections to see that the whole system is being correctly assembled and checked out. Routine calibration procedures have to be agreed with the licensee, and field inspectors visit the site to witness these and carry out general operational checks. Finally any modifications or repairs have to be communicated to the DoE, and the inspector may wish to witness the changes that are being made.

As copies of the guidelines are available from the DoE to these who need them it is not necessary to go through them in detail. The requirements are straightforward, and represent good practice for metering and proving, and the associated measurements of temperature, pressure and density. It should be borne in mind that they are the minimum performance which is expected from the equipment. Considerable emphasis is placed on the pulse transmission system, and the design performance of the totalisers and compensators. It is also worth mentioning, particularly in view of the difficulties that are often encountered, that the other instrumentation specified as a requirement includes an automatic flow proportional sampling system, which is of course the underlying reason for Session 4 of this workshop.

If we now consider the extent to which these DoE guidelines refer to UK standards we find rather surprisingly that there are very few, since at the time they were written very little design criteria were available from UK standards. Thus the requirements and expectations for the acceptable meter factor variation over the operational flow range, the number of pulses generated in a prover run, and the resolution of totalisers are spelt out in the guidelines, rather than figures being quoted which occur in UK standards and codes of practice. It will be interesting to see if this aspect of the guidelines is still retained in any subsequent revision.

The reference standards that are listed in the DoE guidelines are these:

American Petroleum Institute

ANSI Z11-171 (API 2531) "Mechanical Displacement Meter Prover".

ANSI (API 2534) "Measurement of Liquid Hydrocarbons by Turbine Meter Systems".

Institute of Petroleum

IP252/76 "Code of Practice for the Security and Fidelity of Electronic Data Transmission Systems for the Metering of Fluids".

British Standards Institution

BS 1042 Pt 1: Sec 1.1	(ISO 5167)	"Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits running full".
BS 5844	(ISO 5168)	"Measurement of fluid flow: estimation of uncertainty of a flow rate measurement".
BS 4161		"Specification for Gas Meter Part 6. Rotary displacement and turbine meters for gas pressures up to 100 bar.

3. REGULATIONS FOR FLOWMETERS AT BONDED OIL INSTALLATIONS

The measurement for revenue accounting of products in UK land-based bonded oil installations is the concern of Her Majesty's Customs & Excise (HMCE), and the document which applies is:-

3.1 HMCE Notice 179M - Hydrocarbon Oils - Flow Meters at Bonded Oil Installations.

As this is for products rather than crude oil it is not of great concern to the subject of North Sea metering. In fact where crude oil is concerned HMCE rely on the DoE guidelines and state in Notice 179M that "For crude oil from the North Sea, meters approved for fiscal purposes by Department of Energy will be acceptable for Customs and Excise accounting purposes". There is a corresponding paragraph in the DoE Operating Procedures which states that "In addition to satisfying the relevant requirements of the Petroleum Engineering Division of the Department of Energy, the procedures where applicable meet the corresponding requirements of Her Majesty's Customs and Excise for measurement at land terminals".

In view of these cross-linked statements it is not intended to go further into the details of Notice 179M. Suffice it to say that because it presently directed towards the use of small metering systems for loading product into road and rail tankers, there is a marked difference in detail, but not in principle, from the DoE guidelines. However it is interesting that HMCE are proposing that in the long term, products should be measured in bulk as they leave the refinery. This may mean that the future requirements for product measurement will come more into line with those for crude oil measurements, and will include dedicated provers etc. Indeed this already tends to be the case for product pipelines and rail loading gantries.

The reference standards that are quoted by HMCE are:-

Institute of Petroleum

Part X Section 1. Pipe Provers

Section 2. Volumetric tank provers and reference meters.

Part XIII - as IP 252/76 (see 2.0)

4. DEVELOPMENT OF UK STANDARDS

Before examining the UK standards that are available, either completed and published, or in draft form, let us first review the structure of standards-making in the UK for petroleum measurement. The Institute of Petroleum (IP) through its Petroleum Measurement (PM) committee is the main body that produces standards and codes of practice in the first instance, for the UK oil industry. These form parts of the Petroleum Measurement Manual, which is a similar publication to that published in the USA by API. There are a number of sub-committees and panels of the PM committee (see Appendix 1), and these include in their membership, measurement experts from the oil companies, representatives from government departments and research laboratories, independent cargo surveyors and equipment manufacturers. Their first and foremost responsibility is revising and writing new sections of the Petroleum Measurement Manual. Later on in this paper those which are concerned with dynamic measurement will be discussed.

Parallel with the IP sub-committees and panels is a group of BSI committees (see Appendix 2) whose principal function is to provide the link between BSI and ISO. Membership of the BSI committees is nominated by UK organisations such as learned societies, trade associations, nationalised industries, and government departments. The IP is a major contributor to the BSI work, and its panels assist BSI in recommending UK comments on draft international standards.

The development of UK standards is usually along these lines:

- An IP code is written and published as part of the Petroleum Measurement Manual. It is likely to have considerable status in the UK and may be quoted as the reference standard in the official documents.

- If the subject forms a new field of activity in ISO then the IP code is submitted through BSI for consideration as the basis for the draft international standard. When it is accepted for this purpose then after a protracted period of comment, discussion and voting, it may emerge with many amendments as the draft international standard. (Of course similar treatment may be given to national codes from other countries).

- If the BSI committee decides to vote "yes" on the draft international standard the final version of the document is implemented as a dual-numbered BS without alteration .

The reason for going into detail in describing procedures in the UK is to make it clear that in effect UK standards are in these two forms:-

- Parts of the IP Petroleum Measurement Manual.
- ISO standards accepted by the BSI committees, and published as dual-numbered BS standards.

When there is an urgent and identified need for a new code in the IP, a group of experts with the necessary interest, time and dedication can produce it within a reasonable time span. (Appendix 3 shows those currently available for dynamic measurement) In contrast to obtain the international consensus necessary to produce an ISO standard takes a very long time and with limited resources and an involved procedure only a handful of ISO standards, and consequently BS standards, have been published over the last few years (see Appendix 4). There are several more international standards in draft form (see Appendix 5) .

5. CURRENT POSITION OF UK STANDARDS

It is now intended to look at the UK standards which relate to metering stations , and these are classified under the following headings:

5.1 Meters
5.2 Metering systems
5.3 Provers
5.4 Statistical aspects of measurement
5.5 Fidelity and security
5.6 Automatic sampling
5.7 Continuous density measurement
5.8 Calculation of oil quantities
5.9 The Petroleum Measurement Tables
5.10 Calculation terminology

5.1 Meters

Turbine meters are principally used for the measurement of crude oil in the North Sea, and these are the subject of BS 6169 Part 2 (ISO 2515). This covers design, installation, operation and maintenance, and includes Annexes on parts and characteristics of the meters and a trouble-shooting guide. A companion standard is BS 6169 Part 1 (ISO 2714) which is concerned with positive displacement meters, mostly of course used on road loading installations.

As these two documents are now available the IP has discontinued any further work and publications on meters except for Petroleum Measurement Paper No.1. This is a list of data required for a comprehensive evaluation of liquid flow meters. For the future it is worth noting that BSI is planning a comprehensive "Guide to the Selection and Application of Flow Meters" which will be in a number of parts covering the entire field of flow measurement. It will be written on a contractual basis, and is expected to be available in about 2/3 years time.

5.2 Metering systems

Within the last year the IP has set up two panels with the remit of drafting codes of practice on metering systems.

- Panel PM-D-2 is concerned with liquid measurement, and its document has

the title "A guide to the design of liquid metering systems for bulk transfer and pipeline services". The chapter headings are given in Appendix 6A.

- Panel PM-D-3 is concerned with gas measurement, and its document has the title "A guide to the design of custody transfer of gas measurement systems". The chapter headings are given in Appendix 6B.

There is no doubt that these two documents when they are complete will be extremely useful, and influential in respect of UK regulations.

As yet there is no ISO standard covering the same ground, although the API Manual of Petroleum Measurement Standards Chapter 6.6 Pipeline Metering Systems has been accepted by ISO/TC28/SC2 as the basis of a DP. It may be that the UK will have a preference for the IP code to be the UK standard but that is for the future.

5.3 Provers

There are two IP tentative codes of practice on provers. Part 10 Section 1 is intended as an instruction manual for the operators of pipe provers, and Part 10 Section 2 applies to loading road and rail tankers. Both are being updated, and revised editions are expected to be published in about a year. Part 10 Section 3 is a new comprehensive guide to provers now under development, and more details will be given in Paper 4 of this Session of the Workshop.

The ISO work on provers was initiated in 1978, and is making slow progress. Two parts on general principles and pulse interpolation techniques were issued as draft international standards in June 1984, but the part relating to pipe provers is still a draft proposal. There are some UK objections to it, which it is hoped to resolve at the next meeting of ISO/TC28/SC2 in November 1984.

The future position in the UK could be that the new IP code on provers is regarded as the accepted standard, rather than the ISO standard, but this has yet to be resolved.

5.4 Statistical aspects of measurement

In January 1979 the IP published a tentative code of practice Part XIV Section 1 on "Statistical Aspects of Measurement", which was concerned with uncertainties of measurement and statistical procedures. A very much more comprehensive and detailed treatment of the subject has now been prepared, which will be available towards the end of 1984. Strictly speaking perhaps this is not a standard but the section on estimating the uncertainties of meters and provers will be of considerable interest to those involved in metering systems.

The draft international standard DIS 4124 on meter control charts includes sections on central and on-line proving. In view of the forthcoming IP code, the UK position on this has not yet been established.

5.5 Fidelity and Security

The tentative version of Part XIII Section 1 published by the IP in 1976 on fidelity and security of data transmission systems had a very marked influence on the design of metering systems, for both crude oil and products. It established five levels of security protection to maintain the fidelity of the system and these, as has already been seen, are quoted in official regulations. Again the revision to this code, which is well underway and likely to be available in late 1984, is a much more comprehensive document. It includes chapters on system design principles, possible sources of measurement errors, power supplies, and commissioning, testing, inspection and maintenance.

The original IP document has been used as the basis for an ISO standard, and this was published in 1983 as BS 6439 - ISO 6551.

5.6 Automatic sampling

As has already been mentioned, the DoE standards for liquid petroleum measurements specify that "Crude oil metering systems should be provided with automatic flow proportional sampling systems for the determination of average water content, average density and for analysis purposes". This has not been an easy requirement to meet, and there is intense activity on various fronts to develop reliable systems giving a fully representative sample. To assist in this the IP panel produced a tentative code Part VI Section 2 in 1980.

As other countries also had an urgent need for a standard on automatic sampling further action was taken internationally. An ISO working group was set up and after several meetings it has now produced a draft international standard DIS/ISO 3171. The main contributors to this have been USA, France and the UK. It is based on the IP and API codes, together with some theoretical work by France, and is very comprehensive covering all aspects. Regretfully because of the ISO procedures it is unlikely to be published as an ISO standard until 1986. A companion standard is DIS/ISO 3170 on manual sampling, which will be available as an ISO standard rather earlier.

Now that these draft ISO standards are ready the IP sampling panels are in the process of updating their codes. It has been decided that the future IP code on automatic sampling, although based on ISO 3171, will be rewritten as a practical users guide. For manual sampling the revised IP code will correspond closely to ISO 3170 but will include the manual sampling of high pressure crude oil from pipelines.

5.7 Continuous density measurement

When the need to have a continuous measurement of density for North Sea crude oil metering became apparent in 1976, the IP set up a panel to draft a code of practice. In view of the urgency a tentative version was published as Part VII Section 2. Based on experience obtained since that time this has now been thoroughly updated and the revision was published in June 1984.

Installations suitable for fiscal measurements and custody transfer operations are described in detail.

The tentative version was originally submitted through BSI as a proposed draft international standard, but this has now been superceded by the updated version. It is now being put into ISO format before circulation for balloting in accordance with the usual ISO procedure.

5.8 Calculation of oil quantities

The original IP code, Part 1, dates back to 1964 and revision is long overdue since it does not adequately cover the modern metering systems. Within the last year a new IP panel has convened and aims to complete work on a revision of Part 1 by the end of 1984. It will provide calculation procedures in a form which can readily be used in conjunction with on-line or off-line computers. These should be particularly valuable as the basis for fiscal transactions and inter-company transfers.

The panel, in its work, is referring to ISO/DP 4267/2 which is the ISO draft proposal for dynamic measurement - calculation of oil quantities. This is making some progress towards becoming a draft international standard, but not moving very fast.

5.9 The Petroleum Measurement Tables

Attention is drawn to the new API - ASTM - IP Petroleum Measurement Tables jointly developed in the USA and the UK. They are available as Volumes I to XIV, and form implementation procedures used to produce computer - sub-routines. Because of the length and complexity of the Tables, BSI has decided not to republish them in full so that BS 6441: 1983 only provides a schedule of the Tables available in ISO 91/1 - 1982.

Within the next few months the IP intends to publish Petroleum Measurement Paper No. 2 "Guidelines for Users of the Petroleum Measurement Tables", which will contain additional information on interpolation, corrections to API standard 2540, and a computer procedure for correcting the density of crude and condensate obtained at line conditions from an on-line densitometer to density at standard reference conditions. It will also have an Appendix giving the "API Guidelines on the use of the Petroleum Measurement Tables".

5.10 Calculation Terminology

The IP and BSI committees concerned with terminology have recently agreed on the UK preferred terms for measurement calculations, and these were published in Petroleum Review June 1984. They are now going through the process of being agreed by ISO for use in international calculation standards. Those for dynamic measurement are given in Appendix 7.

Attention is also drawn to the UK standard reference conditions of pressure and temperature specified in BS 5579 for measurements on crude petroleum and its products, both liquid and gaseous. These are 101.325 kPa

(1.01325 bar) and 15°C, with the exception of liquid hydrocarbons having a vapour pressure greater than atmosphere at 15°C, in which case the standard pressure is the equilibrium pressure at 15°C. Also specified in BS 5579, but not in ISO 5024, is that the standard reference conditions for the measurement of gases includes the humidity condition 'dry' i.e. free of water. This condition does not involve a requirement that the gas should in practice be free of water vapour when measured.

6. CONCLUSIONS

It must be apparent that the main thrust in UK standards-making for petroleum measurement comes from the IP. When the need for standards and regulations for metering North Sea crude oil was appreciated the IP responded by setting up panels to deal with specific problem areas, such as continuous density measurement, automatic sampling, and fidelity/security. Tentative codes were published on a rush basis, and now that field experience has been gained, these are being revised. Other new ones on various aspects of system design for both liquid and gas are being drafted. It is anticipated that within the next year or so the UK will have a very comprehensive collection of petroleum measurement standards.

These IP codes are widely used and referred to in the UK, and for all intents and purposes they are the de facto UK standards. The BSI policy commitment to international standards has meant that only a handful of BS standards are available, as can be seen from Appendix 4. The chance that these will substantially grow in numbers over the next few years is fairly remote, because of the long delays in getting ISO standards approved and published.

It is the personal opinion of the author that it would be better for BSI to recognise IP codes as the de jure UK standards, and to drop the dual-numbering system for ISO standards.

APPENDIX 1.

SUB COMMITTEES AND PANELS OF THE INSTITUTE OF PETROLEUM PETROLEUM MEASUREMENT COMMITTEE

Sub-committee	Panel	Title
PM-A		Static Measurement
	PM-A-1	Tank Calibration
	PM-A-2	Tank Gauging
PM-B		Physical Methods
	PM-B-1	Manual Sampling
	PM-B-2	Automatic Sampling
	PM-B-3	Water and Sediment
	PM-B-4	Density-Manual
	PM-B-5	On-Line Density
PM-C		Mathematical Methods
	PM-C-1	Tables-General
	PM-C-2	Tables Implementation
	PM-C-3	Calculations
	PM-C-4	Measurement Statistics
PM-D		Dynamic Measurement
	PM-D-1	Pipe Provers
	PM-D-2	Liquid Metering Systems
	PM-D-3	Gas Metering Systems
	PM-D-4	Commercial Metering of Products
PM-E		Electronic Security
PM-F		Light Hydrocarbon Liquids
	PM-F-1	Metering Systems
PM-G		Measurement Legislation
PM-H		Measurement Editorial

(reproduced from "Review of the activities of the Petroleum Measurement Committee" by J. E. Miller and J. R. Spencer - IP Petroleum Review November 1982)

APPENDIX 2.

BRITISH STANDARDS INSTITUTION COMMITTEES CONCERNED WITH PETROLEUM MEASUREMENT

PTC/-/1	- International work on petroleum products
PTC/12	- Petroleum measurement and sampling
PTC/12/1	- Static and dynamic petroleum measurement
PTC/12/2	- Measurement of light hydrocarbon fluids
PTC/12/3	- Bulk cargo transfer
PTC/12/4	- Measurement terminology

(reproduced from "Review of the activities of the Petroleum Measurement Committee" by J. E. Miller and J. R. Spencer - IP Petroleum Review November 1982)

APPENDIX 3.

CURRENT STATUS REPORT ON PARTS OF IP PETROLEUM MEASUREMENT MANUAL FOR DYNAMIC MEASUREMENT

Part I - Calculation of Oil Quantities.

Revision in progress. Expected completion end 1984.

Part VI Section 1 - Manual Methods of Sampling.

Revision to be based on DIS/ISO 3170. Expected completion end 1984.

Part VI Section 2 - Automatic Sampling of Liquids from Pipelines.

Guide to Automatic Sampling to be drafted, partly based on DIS/ISO 3171. Expected completion mid 1985.

Part VII Section 1 - Manual Methods for Density.

Revision in progress. Expected completion end 1984.

Part VII Section 2 - Continuous Density Measurement.

Revised edition now available.

Part IX Section 1 - Positive Displacement Meters.

Discontinued - refer to BS 6169 Part 1: ISO 2714.

Part IX Section 2 - Turbine Meters.

Refer to BS 6169 Part 2: ISO 2715.

Part X Section 1 - Field Guide to Proving Meters with a Pipe Prover.

Revision in progress, expected completion end 1984.

Part X Section 2 - Recommended UK Operational Practice for Proving Gantry Meters.

Revision in progress, expected completion end 1984.

Part X Section 3 - Prover Code (N.B. Title not finalised)

New draft in progress, expected completion mid 1985.

Part XIII Section 1 - Fidelity and security for data transmission from metering systems

Still published, but also available as BS 6439 (ISO 6551).

Part XIII Section 3 – Fidelity and security for data capture systems.

New draft in progress. Expected completion end 1984.

Part XIV – Statistical Aspects of Measurement and Sampling.

Revision with wider scope in progress. Expected completion end 1984.

Part XV Section 1 – Design of liquid metering systems.

New draft in progress. Expected completion end 1984.

Part XV Section 2 – Design of gas metering systems

New draft in progress. Expected completion end 1984.

APPENDIX 4.

BRITISH STANDARDS FOR DYNAMIC MEASUREMENT

BS 6169 Part 1	(ISO 2714)	Methods for volumetric measurement of liquid hydrocatbons. Part 1 Displacement meter systems (other than dispensing pumps).
BS 6169 Part 2	(ISO 2715)	Methods for volumetric measurement of liquid hydrocarbons. Part 2 Turbine meter systems.
BS 6439	(ISO 6551)	Fidelity and security of dynamic measurement of petroleum liquids and gases in cabled transmission as electric and/or electronic data.
BS 6441	(ISO 91/1)	Petroleum measurement tables.
BS 5579	(ISO 5024)	Standard reference conditions for measurement of petroleum liquids and gases.

APPENDIX 5.

DRAFT INTERNATIONAL STANDARDS FOR DYNAMIC MEASUREMENT

DIS/ISO 91/2.2	Petroleum measurement tables – Part 2: 20°C.
DIS/ISO/3170	Manual sampling
DIS/ISO/3171	Automatic pipeline sampling
DIS/ISO/4124	Measurement control charts and statistical methods.
DP/ISO/4267/2	Calculation of oil quantities – Dynamic measurement
DIS/ISO/7278/1	Liquid hydrocarbons – Dynamic measurement – Introduction to proving systems.
DP/ISO/7278/2	Liquid hydrocarbons – Dynamic measurements – Pipe provers.
DIS/ISO/7278/3	Liquid hydrocarbons – Dynamic measurements – Pulse interpolation techniques.
DP/ISO/ (N 222)	Liquid hydrocarbons – Dynamic measurements – Densitometers.
DP/ISO/ (N 224)	Pipeline measurement assemblies.

APPENDIX 6.

A. Proposed Chapter Headings for "A Guide to the Design of Liquid Metering Systems for Bulk Transfer and Pipeline Service".

1. Introduction
2. Scope
3. Glossary and Definitions
4. System Design Considerations
5. Meter System Design
6. Equipment for Primary Measurement
7. Equipment for Secondary Measurement
8. Equipment for Qualitative Measurement
9. Flow Computation and Display
10. Aspects of Operation and Maintenance

B. Proposed Chapter Headings for "A Guide to the Design of Custody Transfer of Gas Measurement Systems".

1. Introduction
2. Scope
3. Glossary and Definitions
4. Appl ications - General Requirements
5. System Design
6. Equipment
7. Equipment (for composition and quality measurement)
8. Flow Computers
9. Records and Control Charts
10. Commissioning, Operation and Calibration
11. Routine Inspection and Maintenance
12. Uncertainty Analysis - ISO 5168

APPENDIX 7.

TERMS FOR DYNAMIC MEASUREMENT CALCULATIONS

Meter factor	the ratio of the actual volume of liquid passed through a meter to the volume indicated by the meter.
Indicated volume	the change in meter reading that occurs during transfer through a meter.
Gross volume	the indicated volume multiplied by the appropriate meter factor for the liquid flow rate concerned, without correction for temperature and pressure. Note: This includes all water and sediment transferred through the meter.
Gross standard volume	the gross volume corrected to the standard temperature and standard pressure.
Net volume	the gross volume minus the volume of water and sediment transferred through the meter.
Net standard volume	The net volume corrected to the standard temperature and standard pressure.
Standard conditions	15°C and atmospheric pressure (101.325 kPa absolute). In the case of liquids having an equilibrium pressure above 0 gauge (101.325 kPa absolute) at 15°C, the standard conditions are 15°C and the equilibrium vapour pressure of the liquid at 15°C.

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.