

PETRONAS TECHNICAL STANDARDS

ON-LINE PROCESS STREAM ANALYSIS - ANALYSERS

PTS 32.31.50.12

OCTOBER 2011



© 2011 PETROLIAM NASIONAL BERHAD (PETRONAS)

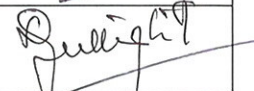
All rights reserved. No part of this document may be reproduced, stored in a retrieval system or transmitted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without the permission of the copyright owner.

PTS Circular 2011 - 1	PETRONAS 
PTS No:	32.31.50.12
Publication Title:	On-line Process Stream Analysis – Analysers
Base PTS Version:	<Release 14>

This revision of PTS **32.31.50.12- On-line Process Stream Analysis – Analysers** has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards..

The previous version of this PTS **December 2008** will be removed from PTS binder/ e-repository from herein onwards.

Document Approval

	Name	Designation	Date	Signature
Prepared/ Reviewed	Nurul Wahida bt Nor Adzman	Engineer, Measurement, Engineering, GTS	28/10	
	Chua Kien Kek	Custodian Engineer, Measurement, Engineering, GTS	29/10/11	
Approved	V R Harindran	Custodian Engineer, Instrument & Control, Engineering, GTS	29/10/11	
Verified	Dzulkifli A Razak	Senior Manager, I&C, Engineering, GTS	29/10/11	
Verified	Saifol Mualim Ahmad Yahaya	General Manager, Engineering, GTS	28/10/11	
Endorsed	Pau Kiew Huai	Senior General Manager, GTS	30.10.11	

Revision History

Date	Version	Description of Updates	Author

PREFACE

PETRONAS Technical Standards (PTS) publications reflect the views, at the time of publication, of PETRONAS OPU/Divisions.

They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPUs in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use PTS they shall be solely responsible for the quality of work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, it is expected of them to follow those design and engineering practices which will achieve the same level of integrity as reflected in the PTS. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the owner.

The right to use PTS rests with three categories of users:

- 1) PETRONAS and its affiliates.
- 2) Other parties who are authorised to use PTS subject to appropriate contractual arrangements.
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) and 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, PETRONAS disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any PTS, combination of PTS or any part thereof. The benefit of this disclaimer shall inure in all respects to PETRONAS and/or any company affiliated to PETRONAS that may issue PTS or require the use of PTS.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, PTS shall not, without the prior written consent of PETRONAS, be disclosed by users to any company or person whomsoever and the PTS shall be used exclusively for the purpose they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of PETRONAS.

The copyright of PTS vests in PETRONAS. Users shall arrange for PTS to be held in safe custody and PETRONAS may at any time require information satisfactory to PETRONAS in order to ascertain how users implement this requirement.

TABLE OF CONTENTS

1.	INTRODUCTION	1
1.1	SCOPE.....	1
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	1
1.3	DEFINITIONS	2
1.4	ABBREVIATIONS	4
1.5	CROSS-REFERENCES	5
2.	SELECTION OF ANALYSERS	6
2.1	GENERAL	6
2.2	MANUFACTURER'S DOCUMENTATION.....	6
2.3	CONSTRUCTION	7
2.4	FUNCTIONAL PERFORMANCE	7
2.5	TYPICAL CHARACTERISTICS OF SPECIFIED ANALYSERS	7
3.	SPECIFICATION OF ANALYSER	15
3.1	GENERAL	15
3.2	TYPICAL REQUIREMENTS	15
3.3	ADDITIONAL INFORMATION TO BE SUPPLIED TO THE MANUFACTURER / SUPPLIER	16
3.4	TYPICAL INFORMATION TO BE REQUESTED FROM MANUFACTURER / SUPPLIER	16
3.5	DOCUMENTATION	17
3.6	PURCHASE REQUIREMENTS	17
4.	DESIGN, ENGINEERING AND INSTALLATION OF AN ANALYSER	18
4.1	DESIGN STUDY - LOCATION OF AN ANALYSER	18
4.2	ENGINEERING OF THE ANALYSER SYSTEM	18
5.	INSPECTION AND TESTING	22
5.1	FACTORY INSPECTION AND TESTING	22
5.2	SITE INSPECTION AND TESTING.....	22
6.	CALIBRATION AND TESTING DURING START-UP AND COMMISSIONING	23
6.1	GENERAL	23
6.2	CALIBRATION AND TEST RECORDS	23
6.3	TEST MIXTURES	23
6.4	PROCEDURES FOR CALIBRATION/VERIFICATION OF ANALYSERS.....	23
7.	MAINTENANCE, CALIBRATION AND TESTING DURING NORMAL OPERATION	26
7.1	GENERAL	26
7.2	MAINTENANCE.....	26
7.3	TEST/CALIBRATION FREQUENCIES.....	26
8.	REFERENCES	27

APPENDICES

APPENDIX 1	TYPES OF ANALYSERS	29
APPENDIX 2	ON-LINE ANALYSERS IN OIL, GAS (INCL. LNG), PETROCHEMICAL PROCESSES AND UTILITIES.....	31
APPENDIX 3	TYPICAL EXAMPLE OF A REDUNDANT SERIAL LINK.....	38
APPENDIX 4	TYPICAL EXAMPLE OF A SINGLE LOOP INTEGRITY DESIGN.....	39
APPENDIX 5	TEMPLATE OF ANALYSER NARRATIVE.....	40

1. INTRODUCTION

1.1 SCOPE

This revised PTS specifies requirements and gives recommendations for the selection, specification and installation of on-line process stream analysers (also known as quality measuring instruments), including:

- selection of analysers and ancillary apparatus;
- installation of analysers and ancillary electrical apparatus, and;
- conditions in which the above should be used and operated.

It also outlines the principles for their protection against the hazards caused by internal and/or external releases of flammable substances and, if applicable, against the hazards presented by an external flammable gas atmosphere. This PTS also describes the verification and testing necessary to prove that the installation conforms to these requirements.

Instruments for the detection of fire, smoke and gas are outside the scope of this PTS; for this subject, refer to PTS 32.30.20.11.

This PTS is one of a series of on-line process stream analysis PTSs. The other publications are:

PTS 32.31.50.10	Sample take-off and transportation
PTS 32.31.50.11	Sample conditioning
PTS 32.31.50.13	Analyser Houses

This PTS is a revision of the publication of the same title and number, dated October 1995. A summary of the major changes from the previous edition is given in (1.6).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this PTS is confined to companies forming part of PETRONAS or managed by a Group company, and to Contractors nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, oil and gas production facilities, and in supply/marketing installations. When PTSs are applied, a Management of Change (MOC) process should be implemented. This is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this document as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicate a requirement.

The word **should** indicate a recommendation.

1.3.2 Specific definitions

Across-stack measurement	An in-situ measurement for flue gas analyses.
Alarm	<i>an audible and/or visible means of indication to panel operator an equipment malfunction, process deviation, or abnormal condition requiring a response</i>
Analyser	An instrument, suitable for use in Oil, Gas & Petrochemical environment, measuring either the empirical or absolute properties of a product.
Analyser house	A building with a specific closed room containing one or more analysers, which may be connected to a process installation, together with associated electrical equipment and auxiliary devices. NOTE: Laboratories are not included in this definition.
Artificial ventilation	A method of mechanical movement of air to reduce the concentration of flammable gases or vapours in the analyser house. Such ventilation may also be used to maintain the pressure inside the analyser house above or below the external ambient pressure.
Compressibility	The ratio of the real volume of a given mass of gas at a specified temperature and pressure to its volume under the same conditions as calculated from the ideal gas law.
Density	The mass of a substance divided by its volume under specified conditions.
Extractive measurement	The method whereby the sample is extracted from the process and subsequently transported to the analyser.
Extractive with pre-dilution	Extractive measurement where the sample is diluted with a controlled amount of solvent (if the sample is a liquid) or carrier gas (if the sample is a gas).
Forced ventilation	Artificial ventilation effected by blowing air into the analyser house.

Induced ventilation	Artificial ventilation effected by the withdrawal of air from the analyser house.
In-situ measurement	Intrusive measurement where the analyser or its sensor is placed in or very close to the process.
Lower Explosive Limit (LEL)/<i>Lower Flammable Limit (LFL)</i>	The volume ratio of flammable gas or vapour in air below which an explosive gas atmosphere will not be formed.
Precision	The closeness of agreement between mutually independent test results under stipulated conditions. NOTE: Precision depends only on the distribution of random errors and does not relate to the true value, conventional true value or specified value.
Purging	The operation of passing a quantity of a protective gas through an equipment or a room and its associated ducts in order to reduce to a safe level any concentration of flammable gas or vapour which may be present.
Relative density	The ratio of the density of a fluid to the density of air (if the fluid is a gas) or to the density of water (if the fluid is a liquid) under the same stated conditions of temperature and pressure.
Requisition	A vehicle for information exchange prior to order placement, using the data/requisition sheets or requisition sheets for the particular instrument to be purchased. The various sheets are listed in PTS 30.10.01.10.
Upper Explosive Limit (UEL)/<i>Upper Flammable Limit (UFL)</i>	The volume ratio of flammable gas or vapour in air above which an explosive gas atmosphere will not be formed.
Ventilation failure	A situation where the required air flow and, if applicable, the required pressure cannot be maintained.
Ventilation system	The complete installation required to produce artificial ventilation.

1.4 ABBREVIATIONS

AH	Analyser House
AMADAS	Analyser Management and Data Acquisition System
ASTM	American Society of Testing and Materials
CEMS	Continuous Emission Monitoring System
CCR	Central Control Room
COD	Chemical Oxygen Demand
DCS	Distributed Control System
DVPE	Dry Vapour Pressure Equivalent
EPA	Environmental Protection Agency
FAR	Field Auxiliary Room
FAT	Factory Acceptance Test
FID	Flame Ionisation Detector
FPD	Flame Photometric Detector
HCl	Hydrogen Chloride
IUPAC	International Union of Pure and Applied Chemistry
IEC	<i>International Electrotechnical Committee</i>
IP	<i>Ingress Protection</i>
KVP	Kinetic Vapour Pressure
LiCl	Lithium Chloride
NIR	Near Infrared
NO	Nitrogen Oxide
NO₂	Nitrogen Dioxide
NO_x	Nitrogen Oxides (NO + NO ₂)
P₂O₅	Phosphorus Pentoxide
PGC	Process Gas Chromatograph
RTU	Remote Terminal Unit
RVP	Reid Vapour Pressure
SO₂	Sulphur Dioxide
TOC	Total Organic Carbon
TÜV	Technischer ÜberwachungsVerein (German body, translates to Technical Inspection Agency)
UHP	Ultra High Purity
ZrO₂	Zirconium Oxide (or Zirconia)

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (8).

2. SELECTION OF ANALYSERS

2.1 GENERAL

Analysers shall be selected from the "List of Selected Vendors" supplied by the Principal. In the absence of a specific analyser on that list, or in the absence of the list itself, the Contractor shall consult the Principal for advice.

The Principal shall prepare the "List of Selected Vendors", based on satisfactory information regarding the following:

- The Manufacturer should have submitted to the Principal:
 - the company profile;
 - the QA/QC (Quality Assurance and Quality Control) procedures and his progress with compliance to ISO 9001;
 - sales references;
 - documentation (2.2) as required by the Principal;
 - certification of the instrument for use in flammable gas hazardous areas, if applicable;
 - test reports on mechanical, electronic and functional performance;
 - standard consumables and projected annual costs;
 - spare parts (including start up spares) list and costs.
- Construction of the instruments (2.3);
- Functional performance of the instruments (2.4);
- The Manufacturer/Supplier should have a procedure in place to brief the Principal at regular intervals on improvements or obsolescence of instruments in his supply.
- The Manufacturer/Supplier should have an organisation to provide post sales technical assistance.

2.2 MANUFACTURER'S DOCUMENTATION

The Manufacturer's analyser documentation shall consist of:

- Instruction manual with installation practices;
- Operating manual;
- Service manual.

The manuals shall include the following information:

- data sheets on the application;
- instructions for start-up;
- instructions for trouble-shooting;
- instructions for scheduled maintenance;
- instructions for validation/calibration;
- drawings for:
 - layout;
 - flow scheme;
 - wiring;
 - circuit diagrams;
 - termination;
- parts list;
- list of consumables;
- list of fragile spares;
- list of initial spares;
- list of spares for one year's operation;
- electrical safety certificates and supporting documentation.

The documents should be available in hard copies or electronic formatted copies, as specified.

2.3 CONSTRUCTION

The Principal shall specify whether enclosure protection shall be based on the IP Codes in accordance with IEC 60529 or NEMA 250. The Manufacturer shall confirm the selection of enclosure protection.

The enclosure's construction and finish, as well as other mechanical, electric, electronic and optical components, shall be suitably protected for the environmental conditions in which it will be installed, e.g., tropical and/or saliferous conditions. Generally, the Manufacturer shall specify the standard(s) applied. However, the Principal or Contractor, depending on project and location, may specify additional requirements.

All sample-wetted parts shall be suitable for the fluid and the conditions to be analysed, e.g., made from AISI 316 stainless steel, Poly-Fluoro Chlorinated plastics or glass, etc.

Instrument components shall be sufficiently accessible to allow a component to be removed for servicing with a minimum of disturbance to other components. It should be possible to make calibration or validation adjustments from the front.

Hermetically sealed relays, switches and potentiometers should be used. Other electrical contacts, such as for switches and unsealed relays, shall be gold-plated.

Use of asbestos or Poly-Chloro-Biphenyl (PCB) compounds is not allowed.

Electrical terminations shall be compatibly labelled at the wire and the terminal or, in case of system cabling, at the cable connector and the cable socket.

Fittings used shall be AISI 316 stainless steel, preferably with metric or imperial size as specified by the Principal.

2.4 FUNCTIONAL PERFORMANCE

The functional performance shall be to the satisfaction of the Principal and may be judged from the whole or part of the following:

- Manufacturer's in-house tests witnessed by the Principal;
- Petronas Group experience;
- Evaluations/tests carried out by an independent testing authority on behalf of user organisations, e.g., SIREP (GB), WIB (NL) or EXERA (FR);

NOTE: A positive evaluation or test as referred to above does not automatically mean that the instrument qualifies for acceptance for use by PETRONAS,

- Experience reported by third parties.

2.5 TYPICAL CHARACTERISTICS OF SPECIFIED ANALYSERS

2.5.1 General

Sections (2.5.2) to (2.5.22) and (Appendix 1) give recommendations to assist in making the proper selection with respect to measuring techniques, but the "List of Selected Vendors" (2.1) has priority.

The analyser shall be selected so that the relevant ASTM Test Method on or with which the measurement is based or correlated is the same one as that used in the site laboratory, measuring the same property. The Principal shall be consulted if this cannot be complied with.

Analysers that are intended for environmental/pollution control or Continuous Emission Monitoring System (CEMS) may require approval or have to conform to the requirements specified by the local environmental/pollution control authority.

NOTE: For additional information on CEMS refer to PTS 32.31.50.39.

Key characteristics that are important to the service are listed below.

2.5.2 Composition

Multiple-component analysis can be best carried out with PGC and mass spectrometer. Verification of PGC shall include zero baseline stability check and repeatability test (typically for minimum of 5 consecutive runs). Mass spectrometers have the advantage of fast response times and are sometimes advantageous for selective trace component analysis in gaseous products. A typical response time is 6 s per component.

- NOTES:
- 1) The calibration matrix of a mass spectrometer is often adversely affected by components which were not included in the initial calibration mixture or which were either under- or over-represented in the initial calibration mixture. Calibration results may therefore have limited validity.
 - 2) Certain mixtures may be difficult to analyse with a mass spectrometer.
 - 3) For PGC, the calibration mixture for background gas should be as close as possible to the material composition of the process sample. This is particularly so for the measurement of trace contaminants.
 - 4) For liquid calibration gas, the pressure of the cylinder shall be maintained above the vapour pressure of the lightest components presence in the calibration cylinder. Piston type calibration cylinder is normally selected to achieve this condition.

Infrared and ultraviolet spectroscopic techniques are typically suitable for single-component analysis of gaseous products, and have some limited application for liquid products. Infrared and ultraviolet spectroscopic techniques, more specifically Fourier Transform Infrared and Ultraviolet Diode Array techniques are also suitable for multi-component analysis in a limited number of applications. Any cross-sensitivity to components not of principal measurement interest should always be checked when infrared and ultraviolet spectroscopic techniques are used.

Modern PGCs usually offer the advantage of calculating derived physical properties such as heating value, density, distillation properties, and even octane numbers. However, their accuracies have to be checked to ensure that they meet the specified requirements.

2.5.3 Density / Relative density

Density meters should be of the vibrating type. The use of radioactive types requires the approval of the Principal.

2.5.4 Dissolved oxygen

Dissolved oxygen is normally measured with a polarographic cell. The output value is dependent on the temperature due to the change in permeability of the membrane at different temperatures. The cell should be used in accordance with the Manufacturer's specifications, e.g., for minimum flowing conditions. The sensor should be kept clean and unclogged at all time.

Metal-electrode-type dissolved oxygen meters often have option of having robust self-cleaning features. *For application in effluent/waste water, the self-cleaning feature shall be installed.* The output is dependent on oxidation-reduction potentials (REDOX) of the water. Heavy metals, free oil and sediments may impede their use.

2.5.5 Flammable gas detection (in ambient air)

Refer to PTS 32.30.20.11.

2.5.6 Flashpoint analysers

Flashpoint analysers that detect *the temperature at which the sample gas flashes on explosion should be used to measure quality of hydrocarbon (e.g.: diesel, kerosene).*

- NOTE: The response of flashpoint analysers using semi-conductors or pellistor type detectors is product (i.e. feedstock) dependent. It is also sensitive to the presence and build up of olefinic material e.g., in catalytic cracked sample. For process samples with a sulphur content > 1 %, pellistor type or flash point analysers shall not be used.

2.5.7 HCl measurement in process gas

Analysers using the change of conductivity of a reagent should be used. Alternatively, analysers using the coloration of paper tape impregnated with reagent could be considered where lower accuracy is acceptable.

2.5.8 H₂S measurement

For measurement of H₂S in ambient air, refer to PTS 32.30.20.11. For measurement of low concentration H₂S in process gas, the lead acetate paper coloration principle or PGC with flame photometric detector should be used. For higher concentrations (% range), UV spectrophotometer or PGC may be used.

Note: Newer sensor technology such as tunable sensor diode can also be used for H₂S measurement

2.5.9 KVP measurement

Where KVP is measured in order to obtain a correlation with RVP, an RVP analyser should be used directly.

2.5.10 Moisture measurements in gaseous products

- a) Dewpoint mirror techniques are absolute measurements. They are costly and are specifically suitable for higher moisture concentrations (0.05 % and higher). The technique shall not be used to measure water in natural gas, due to the difficulty in obtaining consistent results.

NOTE: High hydrocarbon concentrations may interfere. Typically, the hydrocarbon dewpoint should not be higher than 10 °C above the water dewpoint.

- b) Karl-Fischer-type titration is an absolute measurement. Output shall be expressed in mg/m³.
- c) Metal-oxide-type sensor measurements are relative measurements. The output shall be calibrated against a test gas mixture or against an absolute measurement. The output calibration is dependent on temperature and pressure. For accurate measurements the flow cell shall be kept at constant pressure and temperature. The characteristics of aluminium-oxide-type sensors are, in general, not stable and regular verification of the calibration factors is therefore required (a typical requirement is once per year, but this may vary depending on the application).
- d) P₂O₅ (phosphorus pentoxide) sensors are theoretically absolute measurements. However, they shall be treated as a relative-type measurement and calibrated with a test mixture or against an absolute measurement. This analyser type shall not be used in process streams containing double-bonded hydrocarbons or those rich in hydrogen. The analyser is flow-sensitive.
- e) LiCl (lithium chloride) type sensors are applicable for Relative Humidity measurements. Their main application is in buildings, for use as a tool for climatic conditioning.
- f) Hygroscopically coated vibrating crystal-type moisture meters have the best accuracy. This type of meter should not be used for prolonged measurements of moisture concentrations in excess of 2000 cm³/m³.

NOTE: At moisture concentrations in excess of 2000 cm³/m³, the hygroscopic layer on the crystal may be washed off.

- g) Measurement by conductivity of a hygroscopic salt-glycerol solution is fairly suitable for natural gas application as the sensor is relatively easy to rejuvenate, although this requires specialist attention.

- h) Silicon oxide type sensors are thermally stable and less hygroscopic than aluminium oxide type sensors. When equipped with a feature to momentarily heat the sensor, they burn off any hydrocarbon contaminants and 'left over' moisture from high loads, thus giving faster response and recovery. A silicon oxide type sensor is preferred to metal oxide and P_2O_5 sensors.
- i) Fibre-optic type sensors provide an in situ means of measurement and measure dew point from - 70 °C to 10 °C at pressures up to 250 bars and temperature from - 30 °C to 95 °C. It is a relative humidity measurement and converts results to ppmv, dew point.
- j) *Tunable laser diode (TLD) sensors*

2.5.11 Octane analyser

Cold flame front analysers and octane engine type analysers have been in use. Near Infrared analysers are preferred where product specifications can be satisfied.

2.5.12 Oil in/on water

For oil in/on water measurements the following applications should be considered:

Care must be taken with respect to correlation and cross-checking with laboratory measurement. The intent of the measurement shall be made clear and well documented. Wherever feasible/practicable, the analyser selected shall have the same working principle as that of the corresponding laboratory instrument.

- a) Oil on water, e.g., oil sheen in open channels - This is a qualitative detection only. Laser Diode Infra-red reflectance-type measurements are suitable.
- b) Oil emulsified/dispersed in water.

Infrared-type meters, e.g., measuring hydrocarbons dissolved in an extraction fluid such as Freon, have a reduced response for naphthenic hydrocarbons and do not respond to the aromatic hydrocarbon content of the oil.

Ultraviolet-type meters do not respond to the naphthenic and the paraffinic content of the oil. Instead they rely on the co-presence of aromatics in oil.

NOTE: Typical solubility rates for paraffinic and aromatic hydrocarbons are about 20 mg/l and 80 mg/l respectively.

- c) Total Organic Carbon - TOC (2.5.21). Any oil or hydrocarbon entering the measuring cell will be detected. The UV oxidation type is preferred to the "hot oxidation" type of TOC analyser. TOC measurement is good for measuring carbon content from carbon compounds or elemental carbon in an aqueous solution. Any oil that is insoluble in aqueous solution may not be suitable. If sample does not contain any inorganic carbon component, the acidification part of the analyser system need not be included. Higher range is possible with dilution. This type of analyser requires extensive maintenance, especially the "hot oxidation" type. The high consumption of reagent should be considered. For low range measurement, the standard sample should not be stored for long periods as it is not stable.

2.5.13 Oxygen

- a) Zirconium-oxide-type meters are suitable for measuring oxygen in combustion flue gas. These meters shall not be used for gases containing flammable gas, or unburned material, e.g., soot, *since its presence will affect the measurement, i.e.: less O₂ than actual will be detected because the O₂ is consumed for the combustion of unburned hydrocarbon*. The sensor, which is kept at a temperature of typically 800 °C, should be of an Ex-d construction in accordance with IEC 60079 by means of a flame arrestor. For very high flue gas temperature applications, a cooling extension tube shall be used. *For better air fuel ratio control, zirconium-oxide-type sensors can be combined with carbon monoxide sensors to control oxygen at the lower level.*