

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

INSTRUMENTS FOR MEASUREMENT AND CONTROL

PTS 32.31.00.32

FEBRUARY 2011



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This revision of PTS **32.31.00.32 – Instruments for Measurement and Control (February 2011)** has been updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS **32.31.00.32 (July 1999)** will be removed from PTS binder / e-repository from herein onwards.

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PREFACE

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TABLE OF CONTENTS

1	INTRODUCTION.....	1
1.1	SCOPE.....	1
1.2	DEFINITIONS	1
1.3	CROSS-REFERENCES	3
2	GENERAL REQUIREMENTS	4
2.1	SELECTION OF INSTRUMENTS.....	4
2.2	UNITS OF MEASUREMENT	6
2.3	DEFINITION OF INSTRUMENT RANGE AND SPAN.....	7
2.4	SELECTION OF RANGES	8
2.5	SIGNAL TRANSMISSION AND POWER SUPPLY	8
2.6	ELECTRICAL SAFETY IN EXPLOSIVE ATMOSPHERES	9
2.7	INSTRUMENT NAME PLATES AND WARNING PLATES	11
2.8	MEASUREMENT ACCURACY	12
2.9	REQUIREMENTS FOR MATERIAL INSPECTION, CERTIFICATION AND MARKING OF INSTRUMENTS AND RELATED COMPONENTS	13
2.10	LAMP TEST FACILITIES	14
2.11	CRIPPLED MODE OF ANALOGUE TRANSMITTERS	15
2.12	ENVIRONMENTAL PROTECTIONS	17
2.13	ELECTROMAGNETIC COMPATIBILITY (EMC)	18
3	PLANT INSTRUMENTS	19
3.1	GENERAL	19
3.2	INTEGRAL AND RECEIVING INDICATORS	20
3.3	PRESSURE AND TEMPERATURE LIMITS OF PRESSURE-CONTAINING PARTS	20
3.4	SELECTION OF MATERIALS	21
3.5	DIAPHRAGM SEALS.....	23
3.6	ACCESSIBILITY LEVELS.....	24
3.7	LOCATION AND ACCESSIBILITY	24
3.8	PROTECTIVE SHADES	25
3.9	LOCAL PANELS AND CUBICLES	26
3.10	GENERAL INSTALLATION NOTES.....	26
4	FLOW INSTRUMENTS.....	27
4.1	GENERAL	27
4.2	VORTEX FLOW METERS.....	29
4.3	ULTRASONIC FLOW METERS	32
4.4	ELECTROMAGNETIC FLOW METERS.....	34
4.5	CORIOLIS MASS FLOW METERS	36
4.6	THERMAL DISPERSION MASS FLOW METERS.....	38
4.7	DIFFERENTIAL PRESSURE TYPE FLOW METERS.....	40
4.8	<i>VARIABLE AREA FLOW METERS</i>	45
4.9	TURBINE METERS	46
4.10	POSITIVE DISPLACEMENT METERS	47
4.11	FLOW METER ACCESSORIES	48
4.12	METER PROVING FACILITIES.....	49
5	LEVEL INSTRUMENTS	50
5.1	GENERAL	50
5.2	SELECTION OF LEVEL INSTRUMENTS	52
5.3	DIFFERENTIAL-PRESSURE LEVEL INSTRUMENTS	54
5.4	DISPLACER LEVEL INSTRUMENTS	57
5.5	CAPACITANCE LEVEL PROBES	58
5.6	RADAR TYPE INSTRUMENTS	59

5.7	LEVEL SWITCHES	60
5.8	TANK GAUGING SYSTEMS FOR PRODUCT AND STORAGE TANKS	61
6.	PRESSURE INSTRUMENTS	62
6.1	PRESSURE GAUGES	62
6.2	OTHER PRESSURE INSTRUMENTS.....	62
7.	TEMPERATURE INSTRUMENTS.....	63
7.1	GENERAL	63
7.2	DIAL THERMOMETERS	64
7.3	THERMOCOUPLES	64
7.4	RESISTANCE THERMOMETERS	67
7.5	INSTRUMENTS FOR THERMOCOUPLE AND RESISTANCE THERMOMETERS.....	67
8.	ELECTRICAL PARAMETERS	68
9.	SPEED INSTRUMENTS	69
10.	MACHINE MONITORING	70
11.	FLAME DETECTION	71
12.	REFERENCES.....	72

APPENDICES

APPENDIX 1	ARRANGEMENTS OF DIFFERENTIAL-PRESSURE LEVEL INSTRUMENTS	77
APPENDIX 2	TYPICAL ARRANGEMENT OF MACHINE MONITORING SYSTEM.....	79
APPENDIX 3	MINIMUM ACCESSIBILITY REQUIREMENTS FOR PLANT INSTRUMENTS	80
APPENDIX 4	TYPICAL ARRANGEMENTS OF POSITIVE DISPLACEMENT METERS	83
APPENDIX 5	TYPICAL ARRANGEMENTS OF FLANGED THERMOWELLS	84

1 INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the selection and specification of instruments used for measurement and control of process variables.

This PTS is a revision of an earlier publication of the same number dated December 1999.

1.2 DEFINITIONS

1.2.1 General Definitions

The **Contractor** is the party which 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 which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which 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.

1.2.2 Specific Definitions

Analyser systems integrator	is a company that has the expertise to engineer, design, construct, test and commission complete analyser systems and provide other related services such as software support, on-site installation, maintenance and prefabricated analyser house installation where needed.
Instrumented protective function	is a function comprising the initiator function, logic solver function and final element function for the purpose of preventing or mitigating hazardous situations.
Instrumented protective system	is the electromechanical, electronic and/or programmable electronic Logic Solver component of the Instrumented Protective Function, complete with input and output equipment.
Modbus-RTU	is an industrial networking system that uses serial master-slave communication links. <i>Modbus RTU is an open, serial (RS-232 or RS-485) protocol derived from the client/server architecture. It is a widely accepted protocol due to its ease of use and reliability. Data transfer rate is only limited by the physical link layer</i>
Modbus TCP	<i>Is an industrial networking system that uses Ethernet communication links. The protocol is derived from the client/server architecture. This protocol runs on top of Ethernet's TCP/IP protocol</i>
Piping class	An assembly of piping components, suitable for a defined service and design limits, in a piping system. The piping classes are contained in PTS 31.38.01.12 and PTS 31.38.01.15.
The price of an item	is the amount paid to the supplier of the item in question.
The project specification	is a technical contract document forming part of the agreement between the Principal and the Contractor. It contains all basic information on the project and all instructions and specifications as are required to enable the Contractor to prepare detailed design and engineering work. It furthermore contains all procedures and requirements for the execution of the work and services to be performed by the Contractor for the realisation of the project.
Reliability	is the ability of an instrument or system to perform a specified function under stated conditions for a stated period of time.
Total cost of ownership (TCoO)	is the total cost of owning an asset over its entire life, from conception of the need through to ultimate disposal. The TCoO is made up of the following cost elements: specification, price, purchasing, introduction/ installation, execution/ operation and termination/ disposal. A method for calculating the TCoO is given in PTS 32.31.09.31.
The tolerance class	is an identification code of measuring instruments which meets certain requirements that are intended to keep errors within specified limits.
Variety control	is the process of selecting an optimum number of different types and vendors, of products, processes or services to meet prevailing needs.

1.2.3 Abbreviations

DCS	Distributed control system
EMC	Electromagnetic compatibility
HART	Highway addressable remote transducer
IPF	Instrumented protective function
IPS	Instrumented protective system
PEFS	Process engineering flow scheme
PLC	Programmable logic controller
RTU	Remote terminal unit
SCADA	Supervisory control and data acquisition
TCO	Total cost of ownership

1.3 CROSS-REFERENCES

Where cross-references are made, the number of the section or sub-section referred to is shown in brackets.

All publications referred to in this PTS are listed in section (12).

2 GENERAL REQUIREMENTS

2.1 SELECTION OF INSTRUMENTS

The selection of an instrument for a specific application is an iterative process, carried out as a joint effort of a process technologist and an instrument engineer. It is important to record the selection process for auditing purposes and future reference.

The selection process should involve the following steps:

- 1) Identify all operating cases, such as normal operation at minimum, normal and maximum flow, alternative operating modes, start-up, commissioning and emergency operation.
- 2) Determine the operating window by collecting all relevant process data for each operating case, including:
 - Fluid data such as fluid name and phase, physical properties, special fluid aspects such as corrosiveness, erosiveness, toxicity and presence of solids or contaminants, special risks such as foaming, decomposition, fouling, plugging, depositing, solidification and chemical reaction.
 - Operating data such as flow rate, pressure, temperature, density and viscosity.
 - Application aspects, such as continuous/batch operation, pulsating flow, uni-directional or bi-directional flow, backflow risk, mechanical integrity, vibration and hydraulic noise.
- 3) Collect data regarding the operating environment of the instrument. This should include the following aspects:
 - Accessibility and physical location in relation to equipment and piping.
 - Mechanical integrity.
 - Electrical safety and EMC requirements.
 - Health, safety and environmental conditions.
 - Requirements of the plant organisation regarding maintenance, data collection and retrieval, self-diagnostic and documenting features, expertise and training, stock keeping etc.
 - Authority requirements: Instruments, instrument systems and components for installation *shall comply to Malaysian Standards (MS) and/or IEC standards.*
- 4) Select the adjusted range (2.4) and accuracy (2.8) to suit the process requirements.
- 5) Select measurement options and gather additional data required for the particular measurement principle.
- 6) The types of instruments already installed at the Principal's site should be taken into consideration *to ensure brand/manufacturer variety control.*
- 7) Evaluate the pros and cons of each measurement option and select the optimum solution, considering the following aspects:
 - Coverage of and performance under the process conditions, listed above.
 - *Additional performance parameters to be considered :*
 - i. *Power consumption*
 - ii. *Failure mode alarm*
 - iii. *Vibration effect*
 - iv. *Surge protection capacity*
 - v. *Response time*

- Compliance with the aspects listed above under point 3.
- The total cost of ownership (TCoO) over a period of 10 years. (A method for calculating the TCoO is given in PTS 32.31.09.31)
- Additional hardware required for proper operation, such as calibration facilities or disposal systems.
- Specific maintenance aspects such as accessibility requirements, calibration aspects, self-diagnostic features, purging/flushing/disposal aspects.

Specific aspects for the selection of instruments per process variable are covered by the relevant sections of this document.

Specific fields of application are covered by the following PTS publications:

- | | |
|---|-----------------|
| - Instrumentation in equipment packages | PTS 32.31.09.31 |
| - On-line process stream analysis | PTS 32.31.50.10 |
| | PTS 32.31.50.11 |
| | PTS 32.31.50.12 |
| | PTS 32.31.50.13 |
| - Instrumentation of fire, gas and smoke detection systems | PTS 32.30.20.11 |
| - Control valves, actuators, solenoid valves and valve accessories, including guidance for sizing and selection | PTS 32.36.01.17 |
| - Depressuring systems | PTS 32.45.10.10 |

2.2 UNITS OF MEASUREMENT

The ranges and scales shall be in SI units unless otherwise specified, see PTS 00.00.20.10

New complexes, plants and stand alone facilities shall be designed using SI units in accordance with PTS 00.00.20.10 with the exception of new facilities within an existing field or operating area where the existing units shall be used.

For existing facilities or complexes, modification works shall use the existing units in that particular facility

Documentation presented using SI units may include the Imperial equivalent in brackets to the right of the SI units where clarity will result. Such an instance will arise when referenced standards are available in Imperial units only

It shall be a mandatory requirement for documents generated using Imperial units to include the SI equivalent units in brackets to the right of the Imperial units.

Notwithstanding the contents of the above paragraphs, it is the present policy of PETRONAS to adopt the use of SI units as the base standard of measurement whilst phasing out the use of Imperial units. Consideration should be given to this Company policy as applied to the design and specification of instrumentation

The following are preferred SI units. In some applications, more appropriate units of flow may be specified by Principal.

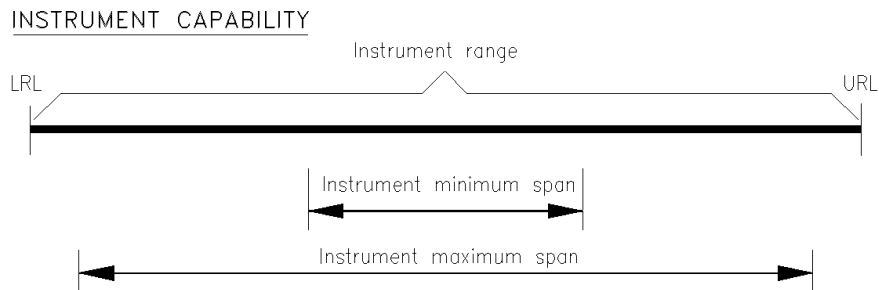
Mass flow : Kilograms per hour [kg/hr]

Volumetric flow (based on standard conditions of 15°C and 1.01325 bar):

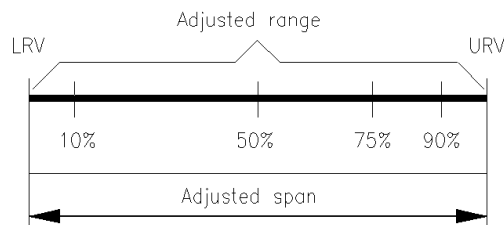
Liquids : Cubic metres per hour [m³/hr]

Gases : (Standard) cubic metres per hour [(s) m³/hr]

2.3 DEFINITION OF INSTRUMENT RANGE AND SPAN



MEASUREMENT CHARACTERISTICS



Legend:

Range	Defined in IEC 60902 as follows: The region of values between the lower and upper limits of the quantity under consideration. It is expressed by stating the lower and upper limits (e.g. minus 1 to 10 bar (ga)).
Span	Defined in IEC 60902 as follows: The algebraic difference between the upper and lower limit values of a given range. It is expressed as a figure and unit of measurement (e.g. 8 bar).
LRL	Lower Range Limit; the lowest quantity that a device is designed to measure.
URL	Upper Range Limit; the highest quantity that a device is designed to measure.
Instrument range	The region in which the instrument is designed to operate. It is a physical capability of the device. The region limits are expressed by stating the LRL and URL.
Instrument minimum span	The minimum distance between the URV and LRV for which the instrument is designed. It is a physical limitation of the device.
Instrument maximum span	The maximum distance between the URV and LRV for which the instrument is designed. It is a physical limitation of the device.
LRV	Lower Range Value; the lowest quantity that a device is adjusted to measure.
URV	Upper Range Value; the highest quantity that a device is adjusted to measure.
Adjusted range	The measurement region. It is expressed by stating the LRV and URV.
Adjusted span	The distance between the URV and LRV.

Example: A differential pressure transmitter is used to measure the level in a vessel, using a wet reference leg. 0% level corresponds with a differential pressure of -800 mbar and 100% level with -100 mbar. The catalogue of the selected transmitter lists -1800/+1800 mbar for LRL/URL respectively and span limits of 300 to 1800 mbar, so:

Instrument range	=	-1800 to +1800 mbar
Instrument minimum/maximum span	=	300 / 1800 mbar respectively;
LRV / URV	=	-800 / -100 mbar respectively;
Adjusted range	=	-800 to -100 mbar.
Adjusted span	=	700 mbar.

NOTE: 'Adjusted' range and 'adjusted' span are frequently referred to as 'calibrated' range and 'calibrated' span. This term is however only correct, if a calibration facility is used to set the LRV and URV. For 'intelligent' measuring devices, the supplier is usually calibrating the device at the LRL/URL and the user is setting the required LRV and URV by remote communication.

2.4 SELECTION OF RANGES

The accuracy (2.8) and adjusted range of an instrument should be selected to cover the operating window (2.1), which includes applicable abnormal operation and alternative operating modes. Unless otherwise stated, the normal design value should lie between 50% and 75% of the adjusted range

NOTE: For certain applications it might not be possible to combine all normal and abnormal operating conditions in one measurement at the required accuracy. In such cases, a case-by-case analysis should disclose whether additional instruments are required or the accuracy requirements and/or operating window may be relaxed. It might be acceptable to present measured values during some of the abnormal operating cases at a lower accuracy or it might be justifiable for the measurement not to produce a sensible signal under some of the abnormal process conditions during start-up, commissioning, regeneration, emergency conditions and the like.

IPF transmitters should have the same instrument range, adjusted range and accuracy as corresponding process transmitters in order to facilitate measurement comparison. For details and exceptions, see PTS 32.80.10.10. Trip settings should lie between 10% and 90% of the adjusted range.

The LRV should be selected so that the displayed result represents the zero or sub-zero value of the process variable (e.g. 0-150 tons/day, 0-100% level, 0-10 bar (ga), -1/+3 bar (ga), 0-500 °C, -50/+50 °C etc.). Elevated zero's (100-300 tons/day, 100-200 °C) should be avoided.

2.5 SIGNAL TRANSMISSION AND POWER SUPPLY

2.5.1 Electric signal transmission

Signal transmission requirements for IPF are covered by 32.80.10.10-Gen.

'Intelligent' analogue communication (at 4-20 mA) with superimposed HART *shall be standard*.

The use of Foundation Fieldbus communication shall be justified and documented taking into consideration both project and operational requirements covering TCoO.

Modbus-RTU, Modbus-TCP or OPC shall be preferred communication between DCS and other digital sub-systems including analyzer systems.

When wireless transmitters are selected, they shall be used for monitoring purposes only. Proper planning, mapping, interference study to be conducted to ascertain the viability of implementing wireless transmission.

Instrumentation such as for machine monitoring, fire and gas detection, tank gauging, sub-systems for motor operated valves, etc. may have other signal transmission requirements according to Manufacturers' standards.

2.5.2 Pneumatic signal transmission

Pneumatic signal transmission shall only be applied with the approval of the Principal, and where it is used the transmission signal shall be 0.2 to 1.0 bar (ga).

2.5.3 Power supply

The criticality of the application shall determine whether or not an instrument shall be powered from an uninterruptible power supply source at 24 VDC or 115/230 VAC. The normal operation of AC powered instruments shall not be adversely affected by power dips caused by load transfer operations of UPS systems.

2.6 ELECTRICAL SAFETY IN EXPLOSIVE ATMOSPHERES

2.6.1 General

In order to prevent electrical apparatus, including electronic process instrumentation, from becoming a source of ignition in potentially explosive atmospheres, protective measures shall be taken, based on the hazardous area classification of the particular area in which the electrical apparatus is being installed. For such electrical apparatus the appropriate safety documentation shall be available.

NOTES: 1. For protective measures of electrical apparatus used in dust hazardous areas, refer to BS 6467.
2. Area classification drawings should be available for the particular areas, prepared in line with the guidelines given in IEC 60079-10. Local guidelines on area classification may overrule IEC 60079-10.

2.6.2 Selection of type of protection

The selection of type of protection shall be in accordance with IEC 60079-14.

The following is the order of preference for the selection of type of protection:

For Zone 0 areas: Ex 'ia' only
For Zone 1 areas: Ex 'e'
Ex 'd'
Ex 'ia' ,or Ex 'ib'

For Zone 2 areas, consult IEC 60079-14, especially clauses 5.2.3/5.2.4. Apart from protection types according to IEC standards, some freedom is allowed with regard to the selection of protection types according to recognised non-IEC standards (clause 5.2.3) or national standards or codes of practice (clause 5.2.4). The order of preference is *Ex 'ic' (previously referred as Ex 'n')*, Ex 'e', Ex 'd', Ex 'ia' or Ex 'ib', 'other'. The selection of type of protection shall be subject to TCoO evaluation, taking into consideration local legislation, site practices, etc.

NOTE: For zones 1 and 2, protection type Ex 'm' (encapsulation) in accordance with EN 50028 may be used, for instance for solenoid operators.

2.6.3 Safety documentation

Safety documentation for the selected type of protection for the installed electrical apparatus shall be available as follows:

- For Zone 0 areas Certificates shall be available.
- For Zone 1 areas Certificates shall be available.
- For Zone 2 areas If the selected type of protection is according to an IEC standard, certificates shall be available.

If the selected type of protection is not based on an IEC standard, follow the guidelines of IEC 60079-14, especially clause 5.2.3/5.2.4 and the guidelines of the applied standard or code of practice.

The Principal shall arrange for the required safety documentation as defined above.

2.7 INSTRUMENT NAME PLATES AND WARNING PLATES

2.7.1 General

All instruments, junction boxes, cabinets, panels and ancillary equipment shall be provided with nameplates indicating the tag number only or the tag number and the service. For details, see standard drawing S 37.601.

In addition to the above, the text on nameplates for manual selector switches shall repeat the switch position markings and shall unambiguously describe what each switch position represents. Similarly, the text on nameplates for push buttons shall describe what action is taken when the push button is activated.

The language or languages to be used on nameplates at the Principal's site will be advised by the Principal. Licensor or local requirements may dictate special nameplate and/or language requirements, in particular for safety related instruments and instrument systems. For nameplate requirements associated with impulse lines, see PTS 32.37.10.11.

2.7.2 Field-mounted nameplates

All plant-mounted instruments, e.g. inline instruments, transmitters, local indicators, converters, control valves, limit switches, solenoid valves etc., and junction boxes shall be provided with nameplates. The nameplate shall be properly secured, for instance to the instrument support. The preferred method is by means of screws; the use of alternative methods such as adhesives subject to the approval by the Principal. No holes shall be tapped into instruments for fixing nameplates, as this will affect the integrity and guarantee of the instrument.

The material of the nameplate should be laminated plastic. The colour shall be as specified by the Principal.

IPF initiators of SIL 1 and higher shall have a red nameplate with black lettering, as per PTS 32.80.10.10.

For control valves, additional identification requirements apply, see PTS 32.36.01.17.

For valves and instruments in gaseous oxygen service, additional marking and identification requirements apply as per PTS 31.10.11.31.

NOTE: Any medium containing more than 21% oxygen by volume or a system with air at a pressure above 50 bar (ga) is to be considered oxygen service.

Thermocouples used for furnace coil balancing services require special markings as specified in [\(7.3\)](#).

2.7.3 Nameplates for indoor use

All panel-mounted instruments shall be provided with nameplates in accordance with the Manufacturer's standard.

Cabinets and distribution frames shall be provided with nameplates, carrying at least the tag number. The material of the nameplates should be laminated plastic and the colour should be as specified by the Principal.

Labels and marking methods used inside instrumentation cabinets shall be to Manufacturers' standards provided they are secure and permanent.

2.7.4 Titles on nameplates

Where abbreviations are necessary, these shall be standardised and consistent for all titles as specified in the Project Specification or the Principal's site standards.

2.8 MEASUREMENT ACCURACY

The required accuracy of a measurement depends on the duty and service and shall be defined by parties responsible for process control. The tolerance classes and accuracy figures listed below are indicative only and are only to be used after confirmation by the Principal.

Process variable	Tolerance Class A	Tolerance Class B	Tolerance Class C	Tolerance Class D
Application	– Custody transfer. – Critical reactor (ratio) feed control.	– Enhanced monitoring and control. – Internal accounting.	– Regular monitoring and control.	– Coarse monitoring and control.
Flow (see note below)	– Liquid: better than 0.25% of reading. – Gas/steam: better than 0.5% of reading.	– Liquid: better than 2% of reading. – Gas/steam: better than 3% of reading.	Better than 6% of reading.	Better than 10% of reading.
Level (see note below)	Better than 2 mm (absolute).	Better than 10 mm (absolute).	Better than 5% of adjusted span.	Better than 10% of adjusted span.
Pressure	To be assessed on a case-by-case basis to suit specific requirements.	Better than 0.25% of adjusted span.	Better than 1% of adjusted span.	-
Temperature	– TC type K/J: tolerance class 1 as per IEC 60584-2. – TC type T/B: tolerance class 2 as per IEC 60584-2. – RTD: see (7.4) – Others: To be assessed on a case-by-case basis to suit specific requirements.	-	– TC type K/J: tolerance class 2 as per IEC 60584-2. – TC type T/B: tolerance class 3 as per IEC 60584-2. – RTD: see (7.4) – Others: Better than 1% of adjusted span.	-

The accuracy figures include linearity, hysteresis, repeatability, static pressure and temperature effects.

The accuracy requirements apply under all normal design conditions, including alternative operating modes. If the accuracy figures cannot be met during abnormal process conditions, such as start-up, commissioning, regeneration and emergency operation, the Principal's approval is required; see also (2.4).

NOTE: The above accuracy requirements for flow and level measurements do NOT apply to the accuracy of the installed sensor, but to the 'presented' result of the measurement in the relevant units of measurement. If for example a liquid flow measurement of tolerance class B is to be presented in mass flow units, the 'overall' accuracy of the presented mass flow figure should be better than 2% of the reading. If in such a case a flow sensor is used that measures a volumetric flow, pressure/temperature and/or density measurements might be required to meet the 2% 'overall' accuracy requirement on the 'presented' mass flow figure.

2.9 REQUIREMENTS FOR MATERIAL INSPECTION, CERTIFICATION AND MARKING OF INSTRUMENTS AND RELATED COMPONENTS

2.9.1 In-line instruments

In-line instruments are considered to be all instruments and components direct-mounted in or on process and utility lines or equipment and which are subjected to the pressures and temperatures of the piping systems or equipment in or on which they are installed.

Typical examples:

Measurement	Types of Instrument
Flow	Turbine and PD meters with their accessories, orifice and restriction orifice plates, venturi, vortex flow meters, Coriolis mass flow meters, ultrasonic flow meters, magnetic flow meters, thermal mass flow meters.
Level	Displacer type level instruments, capacitance level instruments, tank gauges, radar gauges.
Quality	Analyser sample probes
-	Control valves, including IPF valves, depressuring valves, deluge valves.

For in-line instruments, the traceability and associated material certification for pressure retaining parts (including bolting of pressure retaining parts) shall be in accordance with the requirements of the piping class or equipment in or on which the instruments are installed.

2.9.2 On-line instruments

On-line instruments are all instruments and components connected to process and utility lines or equipment via small (maximum DN 50) block valves. They are subjected to the pressures of the piping systems or equipment on which they are installed.

Typical examples are impulse line components, transmitters, pressure gauges, analyser sampling systems, etc. Pressure or differential pressure instruments that require diaphragm seals are not considered to be on-line instruments unless the size of the diaphragm seal makes it necessary to use a line class shut-off valve. Unless otherwise specified by the Principal, no material certification is required for on-line instruments and their connections to process systems, provided that facilities are present to isolate these instruments and connections from the process. As an exception to this rule, material certification is required for the following:

- All impulse line tubing.
- Pressure retaining parts of instruments and impulse line components in 'Sour' or 'Wet H₂S' service (as defined in PTS 31.38.01.11).

2.9.3 Off-line instruments

Off-line instruments are considered to be all instruments and components which are not in direct contact with any process medium (*un-wetted instrument*) or which are not connected to any process/utility line or equipment.

Typical examples are *thermocouples*, resistance elements and bi-metallic thermometers in thermowells, signal converters, local receiving indicators, etc.

Unless otherwise specified by the Principal, no material certification is required for off-line instruments.

2.10 LAMP TEST FACILITIES

All indication lamps shall be provided with test facilities in the vicinity of the lamp, so that one man can execute the test. The test logic should be located in the DCS or IPS.

2.11 CRIPPLED MODE OF ANALOGUE TRANSMITTERS

'Crippled mode' is an abnormal situation caused by a faulty transmitter, a line break, short circuit and the like. Modern transmitters and instrument systems have features to detect such abnormal situations and to reduce (shed) the resulting adverse effects. It is recommended to make optimum use of such features as it will result in increased plant availability, well defined and controlled scenarios for (partial) shutdowns and major improvements in failure analysis.

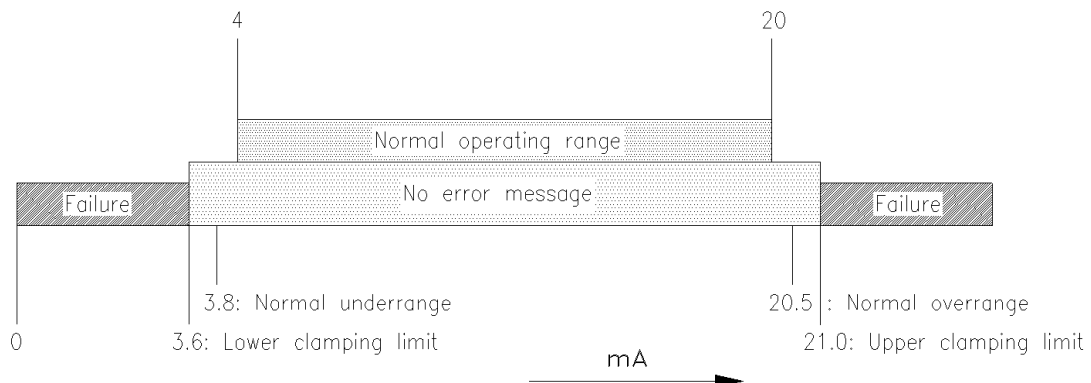
2.11.1 Crippled mode detection

If a crippled measurement is to be detected, it is important to distinguish between a real fault, i.e. a transmitter fault and/or a line break/short circuit situation, and a process under-range or over-range situation. Most modern transmitters have clamping and failure mode features intended to make such a discrimination.

An under-range or over-range situation of an analogue transmitter can occur during normal or abnormal process operating conditions. Since the *process is still* healthy, no fault alarms should be triggered.

Upon failure of the analogue transmitter, the transmitter failure mode feature drives the output signal in the upscale or downscale direction. Upon line break or a short circuit, the measured signal will also exceed the limits. Receiving systems such as DCS and IPS have functions to detect a crippled measurement on the basis of signal levels beyond the *saturation* limits. A crippled measurement shall trigger an alarm.

NAMUR recommendation NE 43 defines normal and abnormal signal levels for 4-20 mA type output signals and should be followed to the maximum possible extent. The NAMUR recommendations can be depicted as follows:



2.11.2 Crippled mode shedding

It is recommended to develop crippled mode shedding strategies in an early project phase, after the makes and models of DCS, IPS, in-line meters and transmitters have been selected. The crippled mode shedding strategy may include controller mode switching, output value selection/freezing and process alarm suppression, and sets the rules for failure mode selection of analogue transmitters (upscale or downscale).

Due to the variety of transmitters and systems, it is recommended to assess whether the crippled mode detection capabilities and limitations of each transmitter type employed in a project matches the crippled mode detection and shedding capabilities of the receiving system, such as DCS and IPS. Experience shows that the following aspects need special attention:

- Transmitters operating in digital mode are usually provided with elaborate diagnostic features for crippled mode detection. However, no uniformity exists in methodology and reporting.
- If transmitters and systems are of different makes, crippled mode detection might be limited or absent or might require parameter or software adjustments at the transmission and/or receiving side of the loop.
- Transient behaviour during the powering up or down of the transmitter circuit may affect the detection. Some transmitters and systems have (optional) features to prevent these problems.
- For each transmitter / system combination, the assessment should disclose whether the combination has the ability to detect a crippled transmitter and/or a line break and/or a short-circuit. Furthermore, the relevant parameter settings for the transmitter and the system shall be defined.
- In specific cases, compliance with Namur recommendation NE 43 might be restricted by transmitter loop powering demands or by Zener barrier current limitations.
- If the transmission distance is long, the loop resistance might be so high that a short circuit near the transmitter will not cause the loop current to exceed the 21 mA specified by Namur standard NE 43.

2.12 ENVIRONMENTAL PROTECTIONS

All instruments, systems and related components shall comply with the environmental conditions as specified in the Project specification.

Plant-mounted instruments shall be suitable for operation in industrial, humid, saliferous and corrosive atmospheres and shall be adequately protected according to the electrical area classification.

For outdoor locations, the climatic conditions of location class D2 of IEC 60654-1 apply.

The minimum degree of protection of plant instruments shall be IP 65 as defined in IEC 60529.

For cases where humid environment and high temperature gradient is expected, deluge seal cable gland should be specified.

For mechanical influences, classification in accordance with IEC 60654-3 shall apply.

For corrosive influences, classification in accordance with IEC 60654-4 shall apply. The corrosive influence class shall comply with the requirements of Class 1 (Industrial clean air) or Class 2 (moderate contamination), as specified by the Principal.

For tropical areas more stringent requirements, such as anti-corrosion coatings or tropicalisation of printed circuit boards, may be applicable and advice shall be obtained from the Principal. Special attention shall be paid to factors relating to insects, animals, etc. Special attention shall be paid to instruments and ancillary equipment which will be used in marine (e.g. jetty) services and/or installed in coastal or offshore environments. In such cases hermetical sealing of the electronic circuitry may be required.

Depending on site conditions, the contacts of switches/relays may require protection against traces of H₂S and SO₂ in the indoor and outdoor atmospheres by gold coating (at least 10 µm) or by locating them in hermetically sealed housings.

2.13 ELECTROMAGNETIC COMPATIBILITY (EMC)

Unless otherwise specified by the Principal, EMC of instruments, instrument systems and instrument installations shall be in accordance PTS 33.64.10.33.

Nickel-plated brass or stainless steel cable glands shall be fitted where instrument signal cables enter the housings of field instruments, with a low impedance earthing connection between the cable armouring/braiding and the instrument housing via the ~~metal~~ gland being ensured by a robust, circumferential (360 degrees) connection. Glands shall be constructed in accordance with PTS 32.37.20.10. The use of plastic cable glands is not allowed for instrument signal cabling.

2.14 CONTROL / AUXILIARY ROOM EQUIPMENT

Specifications for consoles shall conform to PTS 32.37.10.31 Prefabricated Instrument Consoles except for surface treatment which shall be in accordance to PTS 30.48.00.31-P. All racks and auxiliary structures shall have been subjected to a complete surface treatment in accordance with PTS 30.48.00.31-P.

Supply air shall be connected with stainless steel tubing. Signal connections shall be made with stainless steel tubing. All connections with field signals shall be made on 316L 55 bulkheads connected to 316L SS (multi-) tubings.

A system of plastic wire channel, Panduit, Klippon, or equal shall be provided for routing of wiring in panels. A clear delineation between I.S. and non I.S. wiring shall be provided. A means of visual identification such as blue-coloured panduits for I.S. wiring shall be provided.

If the spare pen of an instrument is not used, a knee connector shall nevertheless be placed in the connection.

All chart recorder specifications shall include the following requirements:

- *minimum of 3 recording channels*
- *fibre-tip disposable pens as standard*

On all chart recorders, the colour code is as follows:

- *Red = Flow*
- *Blue = Pressure*
- *Green = Temperature*
- *Black = Level*
- *Violet = Free choice or 2nd channel for above variables*

Where, for operational reasons, the preferred pen colour code cannot be followed, the recorder chassis and adjacent panel shall be labelled with the code in use.

Instrument gas supply shall NOT be taken into the control room, auxiliary room or any part of the accommodation module on offshore platforms.

Controlling and recording functions shall be segregated and shall not be combined on any single panel-mounted instrument.

3 PLANT INSTRUMENTS

3.1 GENERAL

Instruments with 4-20 mA or Fieldbus digital output signals are preferred to discrete, direct mounted, field switches (e.g. pressure switches) for their lower failure rates, better accuracy and better stability, and allow instrument signal analysis and measurement comparison. Discrete, direct mounted field switches shall not be used unless specified or approved by the Principal.

Electronic transmitters shall be of the two-wire type, shall have a 4-20mA output or digital output, shall be intrinsically-safe, and shall have an integral output indicator. All transmitters, whether pneumatic, electronic or SMART, shall have an integral or a local output indicator installed nearby the transmitter.

IPF trip initiators of SIL 1 and higher should have a red colour and the finish of plant-mounted instruments in oxygen service should be yellow *in line with the operating unit practices*. The finish of all other plant-mounted instruments may be in the Manufacturer's standard colour (but not red or yellow).

In-line instruments shall comply with the requirements of the piping class or equipment in or on which the instruments are installed.

Separate instrumentation shall be used for control and shutdown applications. Instruments in shutdown service shall have dedicated process tapplings, thermowells etc. which shall not be used for secondary applications.

Instrumentation for Alarm and Shutdown (ASD) systems - pneumatic, electronic or relay based-, also referred to as Safeguarding Systems, shall be in accordance with SES 30.31 or PTS 32.80.10.30.

Wellhead Control Panels (WHCPs) shall be in accordance with PTS 32.01.30.40

All electrical related instrumentation design and testing shall conform to PTS.33.64.10.10. Ex 'i' is the preferred method of protection for use in hazardous areas instead of Ex 'd'. Galvanic isolation (opto-isolation) barriers are preferred to shunt diode barriers.

Note:

(1) The majority of electronic field instrumentation will be certified as suitable for inclusion in I.S. circuitry. Hence, Ex 'd' protection may not be necessary for these applications.

(2) Ex 'ib' protection should be specified for most PETRONAS applications except in the unlikely instance where instrumentation are located in hazardous areas classified as Zone 0.

Instrument installation shall be in accordance with PTS 62.37.10.12.

Materials and construction shall be suitable for exposure to the climatic conditions of offshore and coastal Malaysia. The atmosphere is highly salt-laden and this should be taken into consideration with regard to high corrosive risk factor. Ambient temperature range is 21-40°C with 100% relative humidity. All equipment and instruments shall be resistant to the specified atmospheric conditions. All electronic cards and equipment shall be tropicalised. Particular care shall be taken to avoid galvanic corrosion due to contact between dissimilar metals e.g. stainless steel and galvanising.

Unless otherwise stated, all transmitters, recorders, indicators, controllers and transducers shall meet the following requirements:

- *Maximum combined error including hysteresis, dead band and linearity, shall not exceed 0.5 % of span.*

- *Output change caused by 38° C temperature change shall not exceed 1 % of span.*

Ergonomics shall be taken into account in the design and specification of instruments, instrument systems, control room layout and control stations/panels for improved efficiency of man-machine interface.

The design shall ensure fit for purpose, taking into consideration life cycle costs, proven technology, standardisation, inspection and maintenance philosophy (IMP), health, safety and environment, and operational aspects.

Selection of vendor items should, as far as possible, be from off-the-shelf (vendor standard items).

The Company makes extensive use of hydrocarbon gas as an alternative to instrument air on offshore platforms, particularly unmanned platforms. The design shall ensure that the instrument system is compatible with the expected gas composition.

Where the length of pneumatic signal-transmission tubing exceeds 60 m, signal booster relays shall be used. Where the tubing length exceeds 90 m, design consideration shall be given to the use of electronic instrumentation.

All plant instruments shall be accessible for maintenance purposes.

3.2 INTEGRAL AND RECEIVING INDICATORS

Integral or receiving indicators shall be installed in all electronic field instruments.

Where an *independent* local indicator is required to support operating personnel, the physical location of the indicator should be selected so that it can be read from the intended operator position. If this requirement cannot be met by an integral indicator, a *remote* indicator shall be applied.

Integral and *remote* indicators required for operational reasons shall be shown on PEFS/P&ID and shall present measurement information in engineering units.

3.3 PRESSURE AND TEMPERATURE LIMITS OF PRESSURE-CONTAINING PARTS

For in-line instruments, the upper and lower pressure and temperature limits of the pressure containing parts shall meet at least the requirements of the piping class. For in-line instruments associated with equipment where no piping class applies (e.g. vessels/package units), the upper and lower pressure and temperature limits of the pressure containing parts shall meet at least the upper and lower design pressure and temperature of the related equipment.

For on-line instruments, the upper and lower pressure limits of the pressure containing parts shall meet at least the requirements of the piping class. For on-line instruments associated with equipment where no piping class applies, the upper and lower pressure limits of pressure containing parts shall meet at least the upper and lower design pressure of the equipment.

In addition to the above, differential pressure type instruments shall be capable of withstanding the upper and lower pressure limit requirements of the piping class in either direction (positive and negative).

NOTES: 1. The lower pressure limit is relevant for an instrument if its value is below atmospheric pressure. In such cases it is important to realise that the instrument should be capable of functioning under (full or partial) vacuum conditions.

2. The lower temperature limit is relevant for an instrument if its value is below zero degrees Celsius.

3.4 SELECTION OF MATERIALS

This section provides an overview on the selection of materials. In all cases not clearly covered by this overview, advice from the responsible materials and corrosion engineer shall be sought. In cases where special materials are used, this shall be clearly marked on the respective items (according to a colour marking scheme).

The selection of materials shall be based on the process conditions and the selected materials shall be corrosion resistant. The material selection is in general related to the material of the equipment and piping. Precise requirements cannot be given in this PTS because of the large variety in products handled in that equipment and piping.

As a general rule, AISI 316(L) will be suitable in systems with austenitic stainless steel or carbon steel equipment and piping, but 316(L) stainless steel may be unsuitable in carbon steel systems containing water with chlorides. The stainless steel shall be resistant to intergranular corrosion as per ASTM A262 Practice E. Further guidance on materials selection is given in the following sections of this PTS *and/or* related standard drawings.

For wetted parts of in-line instruments subject to pressure, temperature, erosion and corrosion, the selection of materials shall meet the minimum requirements of the piping class.

NOTE: All materials for piping connections such as gaskets, bolts etc. for mounting of the in-line instruments are part of the scope of mechanical engineering.

For instrument impulse line material selection, refer to PTS 32.37.10.11.

For material selection of control valves, see PTS 32.36.01.17.

For further guidance on the selection of materials, see PTS 30.10.02.11. and PTS 30.10.02.13.

Specific materials selection requirements apply to the following categories:

a) 'Sour' or 'Wet H₂S' service:

'Sour' or 'Wet H₂S' services are defined in PTS 31.38.01.11. The materials selection of parts of instruments and components which under any process condition are in contact with process water or aqueous condensate shall comply with the requirements of ISO 15156 or NACE MR0103, as applicable, and the relevant piping class.

- NOTES:
1. ISO 15156 shall apply to oil and gas production facilities and natural gas sweetening plants. NACE MR0175 is equivalent to ISO 15156.
 2. NACE MR0103 shall apply to other applications (e.g. oil refineries, LNG plants and chemical plants).

b) Hydrogen fluoride (HF) alkylation service:

The material selection for wetted parts of instruments and components shall comply with the requirements of PTS 31.38.01.11. The measuring element diaphragm material shall be Hastelloy C-276.

NOTE: It should be noted that only a small section of an HF alkylation plant will be classified as HF service. For the other sections of the plant in which the concentration of HF is sufficiently low, AISI 316(L) should be selected.

c) Chemical plants:

As a general rule, AISI 316(L) will be suitable in systems with stainless steel and carbon steel equipment and piping. Where special stainless steel with increased Mo content, Incoloy 825 and/or Hastelloy C-276 are used for the equipment and/or piping, the selected material for pressure transmitters and differential pressure transmitters and manifolds, etc. should be Hastelloy C-276. In all cases not clearly covered by this rule, advice from the responsible materials and corrosion engineer shall be sought.

d) Services with strong reducing acids:

In services (e.g. demineralisation plants) where strong reducing acids such as pure hydrochloric and sulphuric acid are used, all wetted parts (excluding the diaphragms of pressure transmitters, differential pressure transmitters and diaphragm seals) shall be of Hastelloy B-2. The measuring element diaphragm material shall be tantalum (Ta). For contaminated acids and less severe reducing conditions the responsible materials and corrosion engineer shall be consulted.

e) Oxygen service:

All instrumentation in oxygen service shall meet the requirements of PTS 31.10.11.31

NOTE: Any medium containing more than 21% oxygen by volume or a system with air at a pressure above 50 bar (ga) is to be considered oxygen service.

The measuring element diaphragm material shall be selected in accordance with the above mentioned requirements. The following additional requirements apply:

- a) Stainless steel 316(L) and cobalt base alloys are the preferred diaphragm materials and should be selected, if suitable for the application.
- b) If a cobalt base alloy is selected, the Manufacturer shall guarantee that the alloy is not sensitive to weld decay by restricting the carbon content.
- c) Services containing hydrogen and 'Sour' or 'Wet H₂S' services require special attention to be paid to instrument diaphragms to prevent hydrogen penetration. These diaphragms shall be gold-coated in the following cases:
 - Dry hydrogen service, if the partial pressure of hydrogen is above 7 bar (abs) and the temperature above 30 °C.
 - All 'Sour' or 'Wet H₂S' services.

The Principal's approval is required if diaphragms of instruments operate above 100 °C in the above services.