NORSOK STANDARD I-001

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Field instrumentation

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Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are, as far as possible, intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable for most standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF), The Federation of Norwegian Industry, Norwegian Shipowners' Association and The Petroleum Safety Authority Norway.

NORSOK standards are administered and published by Standards Norway.

Annexes A and B are informative and Annex C is normative.

1 Scope

This NORSOK standard identifies the requirements to field instrumentation design.

2 Normative and informative references

The following standards include provisions which, through references in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognised standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

2.1 Normative references

ANSI B16.10,	Face-to-face and end-to-end dimensions of valves
ANSI B16.36,	Steel orifice flanges
ANSI/ASME B1.20.1,	Pipe threads general purpose (inch)
ANSI/ASME,	Performance Test Codes 19.3 - 1974, chapter 1, section 8-19 Thermowells
ANSI B16.5,	Pipe Flanges and Flanged Fittings
API RP 520,	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries, Part I and II
API RP 526,	Flanged steel safety relief valves
API RP 527,	Seat Tightness of Pressure Relief Valves
API RP 670,	Vibration, axial position and bearing temperature system
API RP 678,	Accelerometer-based Vibration Monitoring System
ASME VIII,	Boiler and pressure vessel code - Section VIII, Div. 1
DIN 3852-1,	Ports and stud ends with metric fine pitch thread, for use with compression couplings, valves and screw plugs
EN 50081-2,	Electromagnetic compatibility generic emission standard
EN 50082-2,	Electromagnetic compatibility generic immunity standard
EN 60751,	Resistance Temperature Detectors (RTD)
IEC 60079-14,	Electrical apparatus for explosive atmospheres – Part 14: Electrical installations in hazardous areas (others than mines)
IEC 60534-2-1,	Industrial-Process Control Valves – Part 2-1: Flow-Capacity Sizing Equations for Fluid Flow under Installed Conditions
IEC 61508,	Functional safety of electrical/electronic/programmable electronic safety-related Systems
IEC 61892-6,	Mobile and fixed offshore units - Electrical installations
ISA 75.01.01–2002,	Flow equations for sizing control valves
ISO 1000,	SI Units and recommendation for the use of their multiples and of certain other units
ISO 4126-2,	Safety devices for protection against excessive pressure – part 2: Bursting Disc Safety Devices
ISO 4406,	Hydraulic fluid power - Fluids - Method for coding the level of contamination by solid particles
ISO 5167 (all parts),	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full -
NORSOK E-001,	Electrical systems
NORSOK I-002,	Safety and Automation System
NORSOK L-002,	Piping Design, Layout and Stress Analysis
NORSOK L-CR-003,	Piping Details
NORSOK L-004,	Piping fabrication
NORSOK L-005,	Compact flanged connections
NORSOK M-001,	Materials selection
NORSOK M-501,	Surface Preparation and Protective Coating
NORSOK S-001,	Technical safety
OLF 070,	"Guidelines for the Application of IEC 61508 in the petroleum activities on the continental shelf"
89/336/EEC,	Electromagnetic Compatibility Directive
PED,	Pressure Equipment Directive (97/23/EC)

2.2 Informative references

ATEX 94/9/EEC, |	Explosive atmosphere
IEC 60529,	International Protection or Ingress Protection
EN 60584-1,	Thermocouples - Part 1: Reference tables
EN 60584-2,	Thermocouples - Part 2: Tolerances
BS 2915,	Specification for bursting discs and bursting disc devices

3 Terms, definitions, abbreviations and units

3.1 Terms and definitions

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

3.1.1
can
verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.2
instruments
devices used for indicating and/or control purposes

NOTE The term 'instruments' also includes actuated valves and safety valves.

3.1.3
may
verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.4
shall
verbal form used to indicate requirements strictly to be followed in order to conform to this NORSOK standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.5
should
verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.2 Abbreviations

AISI	American Iron and Steel Institute
API	American Petroleum Institute
APS	abandon platform shutdown
ASME	The American Society of Mechanical Engineers
ATEX	Equipment intended for use in potentially explosive atmospheres
BS	British Standard
BSPP	British Standard Pipe Parallel
DIN	Deutsches Institut für Normung
EN	European Standard
ESD	emergency shut down
FF®	Foundation Fieldbus
GRP	glass fibre reinforced plastic
HART®	Highway Addressable Remote Transducer
HVAC	heating, ventilation and air conditioning
IE	instrument earthing
IEC	The International Electrotechnical Commission
IS	intrinsically safe
ISA	international organization of engineers
ISO	International Organization for Standardization
IP	ingress protections
IR	infra red
MCT	multi cable transit

N/A	not applicable
NAMUR	Normenarbeitsgemeinschaft für Mess- und Regelungstechnik in der Chemischen Industrie
NPT	National Pipe Thread
OD	outer diameter
OLF	The Norwegian Oil Industry Association
OPC	open connectivity (a series of standards specifications)
PED	Pressure Equipment Directive (97/23/EC)
Profibus DP, -PA®	Profibus Nutzerorganization
PSD	process shut down
RTD	resistance temperature detector
SAS	safety and automation system
SI	System International
SIL	safety integrity level
SMART	field instrument with distributed intelligence
SPL	sound pressure level
SS	stainless steel
UPS	uninterrupted power supply
V a.c	voltage alternating current
V d.c	voltage direct current

3.3 Engineering units

Pressure:	bar, mbar, barg, bara
Level:	mm, % for indication (for guidelines, see Annex A)
Volume flow:	m^3/h (flowing condition), Sm^3/h (standard condition, see ISO 1000)
Mass flow:	kg/h
Temperature:	ºC

For other physical properties, SI units shall be utilised as per ISO 1000.

4 Functional requirements

4.1 General

This NORSOK standard shall be read in conjunction with NORSOK I-002.

4.2 Instrument supplies

Electrical supply to instrument panels in LERs: 230V a.c. 50 Hz (standard) or 24V d.c.

Electrical supply to field instruments: 24V d.c. (standard) or 230V a.c. 50 Hz.

Electrical supply to instrument field panels: 24V d.c. (standard) or 230V a.c. 50 Hz.

A minimum of two independent power supplies shall be used, one UPS and one main supply.
For critical systems/safety related systems power shall be supplied with fully redundant UPS.

24 V d.c. supply systems shall be floating and preferably adjustable within the range 24V d.c.to 28V d.c.
Earth fault and power fault monitoring shall be implemented in the 24V d.c. distribution system.

Pneumatic ring main supply: minimum 7 barg, maximum 10 barg.

Pneumatic instrument supply: 1,4 barg (standard) or as required.

Hydraulic ring main/instrument supply: minimum 180 barg, normal 200 barg, maximum 210 barg.

Hydraulic supply for wellhead/downhole depending on reservoir pressure.

An instrument air supply system with an online dew point analyzer connected to the SAS for alarm monitoring shall be installed.

4.3 Signal types

The following signal types shall be used**:**

- analogue input/output: 4 mA to 20 mA with HART® superimposed digital signal;
  NOTE HART® shall be included if supported by existing technology for this type of instrument.
- digital input: potential free contact;
- digital output: 24V d.c.;
- signals between control systems and other panels shall be powered from SAS;
- position: proximity switches with NAMUR interface;
- pneumatic signals: 0,2 barg to 1,0 barg;
- fieldbus type and wireless communications may also be used, dependant on user approval.

4.4 Instrument design principles

Instrument performance/accuracy shall be sufficient to fulfil process/unit performance requirements and should be selected to reduce calibration intervals and maintenance to a minimum. Suppliers shall provide data for long-term stability and confidence level for performance specifications. Instruments shall have advanced diagnostics to enhance safety and reduce maintenance. Only industry standard communication protocols such as HART®, HART WIRELESS®, Foundation Fieldbus® or Profibus DP/PA® shall be used. Instruments using Foundation Fieldbus® or Profibus DP/PA® shall have documented interoperability, e.g. tick-marked.

Instrumented safety system shall satisfy the OLF 070 guideline and have a minimum SIL requirement according IEC 61508. A safety analysis Report shall be part of any delivery. For off-the-shelf instruments where a failure mode effect and diagnostic analysis report or a certificate is available this can be regarded as a safety analysis report, provided it presents the data required in the OLF 070 in an easily accessible manner.

Variation of instrument types and ranges shall be kept to a minimum, e.g. thermowell lengths/transmitter ranges.

Analogue instruments shall be used instead of field switch functions, e.g. pressure transmitters versus pressure switches.

Galvanic isolation barriers shall be used for input/output signals. These barriers shall have full HART® signal transmission capability.

Field instruments and controllers of pneumatic type shall be avoided.

Where local indicators are required, local indicators and transmitters shall be combined. Separate local indicators may only be installed if necessary for local operation if process control system is not in function.

Any arrangement of instruments shall allow for the removal of a sensor/detector head while maintaining the integrity of the other sensors, e.g. in addressable systems.

Instruments shall meet requirements according to 89/336/EEC, and EN 50081-2 and EN 50082-2 regarding electromagnetic compatibility.

Flange connection for inline instruments shall follow piping class and specification, see ANSI B16.5 or compact flanges according to NORSOK L-005.

All in-line flow elements (when part of the process line) shall be flanged for removal from the process line.

Pressure vessel design (e.g. accumulators for on/off valves) shall follow NORSOK L-002 and meet the requirements of the PED.

The most frequently used measuring principles are specified in separate sections of this NORSOK standard. Other types may be used on special applications.

For field instruments not specifically dealt with in this NORSOK standard, the design shall be based on recognised international standards.

4.5 Instrument installation design principles

Instrument lines that can be clogged due to high viscosity fluids or hydrates or other factors, shall either have the instrument close-coupled to the process pipeline/equipment or protected with a chemical seal. If chemical seals are installed, a flushing ring arrangement should also be provided for flushing of diaphragm surface. Double block/bleed (3-way modular) valves to enable in-situ calibration shall be fitted.

All equipment which require maintenance or calibration etc. shall have easy access, e.g. permanent platforms or fixed ladders.

Instrumentation used for hydrocarbon services shall be constructed in such a way that any fault in the primary process barrier will not leak into the main compartment or junction box. If a leakage occurs, it shall not be possible to build up any pressure inside the instruments.

Pressure instruments shall have individual process isolation valves.
Combined solutions may be used providing they do not cause an operational disadvantage or safety reduction during servicing of instruments etc.

Each pressure instrument with process connection shall be fitted with instrument block/bleed manifold (2/5 - way valve).
Instruments for ESD/PSD shall in addition have locking devices for latching of the valves in open position.

Full functional independence between control and safety devices shall be assured, including vessel/pipeline connections, e.g. common pressure tap for control and safety devices shall not be used.

Use of combined manifolds for piping and instruments valves shall be evaluated. Combined manifolds should be used when instruments are direct mounted on or in the immediate vicinity of the pipe/vessel.

Package suppliers shall terminate hydraulic and pneumatic tubing at skid edge with bulkhead male connectors or unions.

Package suppliers shall terminate instrumentation cables in junction boxes at skid edge or at agreed termination point.

Ex-certified equipment should be selected in accordance with the following guidelines and be certified according to ATEX 94/9/EEC:

- Ex i and Ex e should be used;
- if Ex d is used, it shall be provided with an Ex e indirect entry. Compression type Ex d gland may be accepted if the equipments ATEX certificate cover gland and installed cable type, actual gas group and Ex d compartment volume (normally under 2 litre.). References to figure 1 in IEC 60079-14. Ex d compression glands shall be of the type where the braid is terminated in the gland and compression takes place on inner cable sheath;
- Ex q and Ex p should be avoided. Use of these will be upon approval from user and if used should be via an Ex e junction box;
- Ex e, Ex s, Ex m or Ex i solenoid valves shall be used. Ex d may be used upon approval from user;
- equipment, which remains energized after an APS/ESD situation, shall follow the requirements specified in NORSOK S-001, 9.4.

If safety and functional requirements are fulfilled, the following shall apply:

- field instrument process connection: 1/2 in NPT, see ANSI/ASME B1.20.1;
- field instrument pneumatic connection: 1/4 in NPT;
- field instrument hydraulic connection: 1/2 in NPT, or 1/2 in BSPP to DIN 3852-1;
- field instrument cable entry: ISO threads - size depending on cable size.

4.6 Provision for future modifications

This subclause defines the spare capacity that shall be provided at the time of plant start-up.

The installation should be prepared as follows:

- interface cabinets, junction boxes, multicore cabling etc. shall be sized to meet a 10 % increase;

- main cable ladders and transits shall be sized to meet a 10 % increase;
- a minimum of 20 % spare branches, each fitted with a valve and plug, shall be provided for each air and hydraulic distribution manifold.

4.7 Degrees of protection by enclosures

Minimum degree of protection provided by enclosures shall be as follows:

- for outdoor, in naturally ventilated areas and wash down areas: IP 56
- dry indoor areas: IP 20
- other areas: IP 44

NOTE Above represents minimum requirements. It should be noted that regulations may contain more stringent requirements and shall be consulted, see IEC 60529.

4.8 Instrument materials

4.8.1 General

Instrument materials defined in this subclause shall apply. However, instruments may be specified with superior materials due to service requirements (particularly for internals).

4.8.2 In-line instruments

The following apply:

- control valves, safety valves and other in-line instruments;
  - body, bonnet, and bolts/nuts according to piping standard
  - internals according to vendor recommendation and company/purchaser requirements
- magnetic flow meter: SS Type 316 body (non magnetic) with lining may be used;
  - for operating temperature > 60 ºC, body shall be painted according to NORSOK M-501
- orifice plates, temperature wells etc.
  - according to piping standard, but minimum SS Type 316 stainless steel.

4.8.3 Off-line instruments

Instrument process wetted parts, tubing, tube fittings and bulk material are given in Table 1.

Table 1 – Material requirements for off-line instruments

Atmosphere/ field environment	Service [a]	Material for instrument tubing [c]	Material for other components, i.e. Instrument wetted parts/ fittings/ small valves [c]	Maximum temperature to minimise risk of external crevice stress corrosion cracking	Maximum temperature to minimise risk of internal crevice corrosion [d]
Indoor and dry atmosphere or external non-saliferous atmosphere	Hydrocarbon and hydraulic	SS Type 316	SS Type 316	Maximum 60 °C [b]	N/A
	Instrument air	SS Type 316	SS Type 316	Maximum 60 °C [b]	N/A
	Sea water	Titanium grade 2	Titanium grade 2 and 5 Hastelloy C-276	N/A N/A	85 °C 30 °C
	Fresh water	SS Type 316	SS Type 316	Maximum 60 °C [b]	N/A
External and saliferous marine atmosphere	Hydrocarbon and hydraulic	SS Type 316 SS Type 6 Mo 25 Cr Duplex	SS Type 316 SS Type 6Mo Hastelloy C-276	Maximum 60 °C for SS type 316 Maximum 110 °C for type 25Cr Duplex Maximum 120 °C for SS type 6Mo	N/A N/A N/A
	Instrument air	SS Type 316 SS Type 6 Mo 25 Cr Duplex	SS Type 316 SS Type 6Mo Hastelloy C-276	Maximum 60 °C for SS type 316 Maximum 110 °C for type 25Cr duplex Maximum 120 °C for SS type 6Mo	N/A N/A N/A
	Sea water	Titanium grade 2	Titanium grade 2 and 5 Hastelloy C-276	N/A N/A	85 °C 30 °C

Atmosphere/ field environment	Service [a]	Material for instrument tubing [c]	Material for other components, i.e. Instrument wetted parts/ fittings/ small valves [c]	Maximum temperature to minimise risk of external crevice stress corrosion cracking	Maximum temperature to minimise risk of internal crevice corrosion [d]
	Fresh water	SS Type 316 SS Type 6 Mo 25 Cr Duplex	SS Type 316 SS Type 6Mo Hastelloy C-276	Maximum 60 °C for SS type 316 Maximum 110 °C for type 25Cr Duplex Maximum 120 °C for SS type 6Mo	N/A N/A N/A

[a] See NORSOK M-001 for sour (H_2S/SSC) service restrictions.
[b] Maximum operating temperature of 70 °C indoor or in sheltered areas for SS Type 316 stainless steel. Non-insulated systems.
[c] Piping class material shall be taken into consideration.
[d] A maximum temperature for risk of initiation of crevice corrosion will apply. Maximum 30 °C in chlorinated seawater is recommended.

NOTE As a general rule the same material on tubing and fittings. For 6MO tubing SS Type 316 fittings may be used. In the event that the materials are different, it must be ensured that the compression tube fitting material is hardest and in accordance with supplier recommendations.

Material selection temperature, Tm

a) Instrument tubing, fittings etc. without heat tracing and/or insulation:

Instrument side of isolation valve:
If stagnant conditions: Tm = operating temperature of the line to which the instrument is connected reduced by 25 ºC. Applicable for operating temperature above 25 ºC.
If circulating conditions: Tm = operating temperature of the line to which the instrument is connected

Piping side of isolation valve:
Tm = operating temperature of the line to which the instrument is connected

b) Instrument tubing, fitting etc., with heat tracing and/or insulation:

Tm = operating temperature of the line to which the instrument is connected, or maximum heat tracing operation range, whichever is the highest

4.8.4 Instrument housing

Instrument housings shall be resistant to saline atmospheres. SS Type 316 or other non-corrosive material shall be used. Aluminium housings should be avoided.

4.9 Air supply design

Each consumer shall be supplied with separate filter regulator.

Air manifolds shall be marked with consumers tag no and be provided with a drain isolation valve at lowest point.

4.10 Instrument installation bulk materials

All compression tube fittings shall be of the same make. The compression fittings shall have 2 seal rings (twin ferrules).

Pressure ratings for compression tubes, tube - and pipe fittings, instrument valves and manifolds shall comply with the corresponding process requirements.

Tubing shall be seamless and shall be in metric sizes.

Standard tubing sizes:

- Signal air, impulse tubing, instrument air supply to instruments and hydraulic supply
  (below 413 barg): 10 mm x 1,5 mm
  (maximum 520 barg): 10 mm x 2,0 mm
- Instrument air supply: 25 mm x 1,5 mm or 25 mm x 2,0 mm
- Instrument hydraulic supply 25 mm x 2,5 mm or 25 mm x 3,0 mm

The Supplier shall use standard tubing sizes, wherever possible, but shall evaluate and advise if other outside diameters are required to satisfy process requirements.

4.11 Temperature measurements

4.11.1 General

Temperature measurements shall normally be performed by platinium resistance thermometers 100 RTDs in accordance with EN 60751.
On installations, where heavy vibration is a problem, thermocouples (type K) should be considered.
For temperature measurements above 600 ºC, thermocouple material Chromel Alumel, type K, in accordance with EN 60584-1 and EN 60584-2 should be used.

Temperature transmitters should be mounted directly on the thermowell except for motor winding temperature measurement and similar. Temperature transmitters that accept dual elements and have the possibility to swap elements upon failure (hot back-up) should be considered.

Temperature elements not accessible during operation shall, for selected critical equipment, be installed with dual elements (backup element) and terminated in the field for easy access.

Clamp-on and surface mounted (e.g. boss welded to pipe) temperature elements, may be used if accuracy and response time requirements are met.
These types of elements should always be considered for high vibration or high velocity.

4.11.2 Thermowell*s*

Thermowells shall be of the flanged type, size 1,5 in, normally.

For tanks and vessels and for pressure class 2 500 lb and above, the size shall be 2 in.

Flange facing according to ANSI B 16.5 or NORSOK L-005.

For non-critical utility service, thermowells of threaded type, NPT, can be accepted.

Thermowells shall not be longer than strictly necessary to obtain required accuracy and to avoid vibration "cracking".

Thermowell strength calculations (e.g. wake frequency calculations) shall be performed for process hydrocarbon systems according to ANSI/ASME Performance Test Codes 19.3.-1974, chapter 1, section 8-19 Thermowells.

Temperature elements shall be mounted in such a manner that the element can be installed and removed from the thermowell for maintenance, without disconnecting the cable.
The thermowells inner diameter shall be suitable for temperature indicators and temperature elements with stem diameters of 6 mm OD should be used and thermowell lengths shall be standardised.

4.11.3 Temperature gauges

Bi-metallic or gas filled temperature gauges with 100 mm nominal head diameter should be used for local indication with 360 degree orientation. Stem diameters should be 6 mm OD.

Temperature gauges with capillary tubing shall not be used.

Manufacturer’s standard ranges shall be used and dials shall have large, easy to read digits with black on white background.

4.12 Flow measurements

4.12.1 General

Measuring principles and technology shall be selected according to generally accepted best practices and to application. Typical evaluation criteria are as follows:

- performance requirements;
- high range ability requirements;
- pressure-drop requirements;
- fluid properties;
- pipe sizes;
- low flows (practical span);
- straight pipe requirements;
- installation to be in accordance with manufacturers recommendations;
- installed costs;
- operational costs.

All flow elements shall be marked with flow direction, pressure rating and Ex classification. Irrespective of design, the flow meter should not cause flashing or cavitation at any position in the line and pressure drop should generally be kept at a minimum and should not cause an unacceptable restriction to flow (unless it is a dedicated flow restriction).

4.12.2 Flow orifice plates, nozzles, pitot- and venturi tubes

Flow orifice plates, nozzles, pitot- and venturi tubes shall be calculated, manufactured and installed according to ISO 5167 (all parts) or manufacturers recommendation.

Straight length requirements shall as a minimum satisfy the "0,5 additional uncertainty" requirements in ISO 5167 (all parts) or meet the recommendations of the manufacturer.

Welded neck orifice flange to ANSI B16.36 with flange tapping is standard for raised face flanges and corner tapping is standard for ring type joint facing, according to NORSOK L-CR-003, Piping Details PD040 & PD041. Where compact flanges are used, the manufacturer recommendations shall be adhered to.

Temporarily installed spacers shall be clearly marked as such.

Flow element shall be in accordance with ISO 5167 (all parts). Other primary elements that reduce requirements for straight pipes can also be used.

4.12.3 Ultrasonic-, magnetic-, vortex- and turbine meters

These instruments should generally be considered on large pipe sizes or where only a small pressure drop is acceptable and higher performance is required.

4.12.4 Mass flow meters

Coriolis effect mass flow meters should be considered on liquids, slurries and gases when it is deemed beneficial to read direct mass or where no straight pipe run is available and/or when high accuracy is needed.

4.13 Pressure measurement

4.13.1 General

If pulsating pressure is likely to occur, a pulsation dampener shall be used.

All pressure instruments shall withstand an overpressure of minimum 130 % of upper range value without the need for recalibration.

Differential pressure instruments shall be able to withstand full static (line) pressure on either of the inputs with the other input at zero (atmospheric pressure) without need for recalibration or damage to the sensor.

The following apply:

- accuracy, including hysteresis, linearity and repeatability should be better than 0,1 % of span;
- temperature- and static pressure effect should be actively compensated;
- turndown should as a minimum be 20:1;
- longterm stability shall be stated.

Differential pressure instruments for low ranges equipped with capillaries and chemical seals should be insulated and diaphragm size should be 3 in. Ranges below 50 mbar should be avoided.

Dynamic response time shall be suitable for critical loops like anti-surge and PSD functions.
Pressure transmitters should be able to withstand 0,95 barg vacuum.

4.13.2 Pressure gauges

Pressure gauges shall be of the heavy duty, safety type with blow-out back as defined in recognised standard.

Gauges with ranges from 0,6 barg, shall have bourdon type element and shall have liquid filled house/case.

The nominal house/case diameter should as a minimum be 100 mm for pressure gauges.
Differential pressure gauges should be avoided due to sensitivity of static pressure.

The manufacturer's standard ranges should be used.

The following apply:

- accuracy shall be 1 % of full scale range;
- gauges shall have stainless steel movements.

4.14 Level measurement

4.14.1 General

Direct vessel mounted instruments with non-moving parts should be used.

Measuring principles shall be selected according to application. Typical evaluation criteria are as follows:

- non moving parts;
- density;
- pressure;
- accuracy;
- temperature;
- vessel geometry;
- nozzle locations;
- clogging;
- scale build-up.

4.14.2 Local level indicators (gauges)

Level indicators shall cover maximum and minimum operational levels including high/low trip points.

Gauges with magnetic indicators should only be used in clean liquid applications. If used on interface (oil/water) applications, extra care should be taken and these applications will be subject to approval from user.

Reflex type gauges should only be used on clear mediums. For interfaces (oil/water), the transparent type gauge should be used.
If reflex and transparent type gauges are used, they shall have forged steel columns and toughened glass. Shrouded covers should be used to protect glass edges from sandblasting.

Level gauge glasses shall have flanged connections and shall be fitted with gauge valves with offset pattern and safety ball check valves.

If several level glasses are used to cover level on same vessel, visible sections shall overlap by not less than 50 mm.

The installation shall be fitted with process isolation, drain and vent valves complying with NORSOK L-003.

Simpler solutions may be used on small and non critical vessels.

4.14.3 Radar gauges

Radar gauges of either the free propagation type (cone radars) or guided wave type can be used on open and pressurized tanks. Guided wave radars should be mounted in a dedicated bridle with shut-off valves at the top and bottom. A cone radar gauge can be installed directly on a tank provided a full-bore ball valve is installed to isolate the gauge from the process.

The following should be considered:

- foaming;
- vessel environment;
- emulsion/interface.

4.15 Control valves

4.15.1 Valve requirements

Sizing of control valves shall be made in accordance with the IEC 60534-2-1, and ISA 75.01.01-2002 standards and/or the control valve Supplier's sizing computer program.

The valve body, and the inline (wetted part) material specification shall be selected according to the given pipe spec, galvanic series, process data sheet, and valve sizing calculation.

Noise calculations shall be performed for all control valves. The SPL shall not exceed 85dBA. In operation the SPL is to be measured one meter downstream the valve, and one meter away from the pipe. See IEC 60534 for aerodynamic and hydrodynamic noise calculation.

Globe valves should be used, but subject to service conditions and application, other types such as angle valves, ball valves, or disc/butterfly valves may be used.

The size of control valves should be 1 in, 1,5 in, 2 in, 3 in, 4 in, 6 in, 8 in, 10 in, 12 in, 14 in, 16 in and higher.

All valves shall be equipped with integral position indicators.

Leakage class for control valves should be specified with leakage class III, IV and V according to ANSI/FCI 70-2. For applications with high differential pressure, shut off leakage class V shall be used.

Face to face dimensions shall be according to ANSI B16.10.

An arrow indicating direction of the flow shall be permanently marked on each side of the valve body.

Self-acting control valves shall be used only when a sufficient differential pressure exists.

4.15.2 Actuator requirements for control valves

Spring return pneumatic diaphragm/piston type actuators should be used.

In special applications that may change over time (e.g. applications with scaling problems), the actuator shall be dimensioned with sufficient force (torque/thrust) at minimum supply pressure, with safety factor of minimum 1,25.

If service conditions or valve design exclude the use of above mentioned principle, then double acting pneumatic piston actuators should be used.

Hydraulic or electric actuators may be used for special applications.

On loss of signal or power supply, the valve shall go to a predefined position: 'Fail Open', 'Fail Close' or 'Fail in position'. This shall be according to process system design and risk assessment.
Control valves shall be equipped with SMART type positioners.

Valves with a defined failure action should be labelled or colour coded to indicate the valve position on loss of signals/ supply.

Suggested colour code is:
Green: Fail open
Red: Fail closed

Actuators for valves with a defined failure action should be labelled or colour coded to indicate the valve position on loss of signals/supply.

4.16 Solenoid valves

Solenoid valves shall not be used for direct operation in pipes with process media.

Solenoid valves should be used in signal/impulse lines for air and hydraulic.

4.17 Pressure relief valves and bursting discs

All the pressure relief valves shall be sized in accordance with the information on the data sheet and the method outlined in API RP 520, part I and II, for sizing of pressure relief valves for hydrocarbon systems.

Pressure relief valves shall be sized using homogenous equilibrium method which assumes that all phases are always in equilibrium and are a homogenous, i.e. no slip between the gas and the liquid.

Flanged steel safety relief valves for hydrocarbon systems shall conform to API RP 526.

Relief valves for the process piping, excluding steam and air pressure piping shall be of the enclosed spring type.

All relief valves for hydrocarbon systems shall have approval according to ASME VIII.

Seat tightness of pressure relief valves shall conform to API RP 527.

The total effective flow area of the orifice(s) selected shall exceed the calculated area only by an amount as limited by standard orifice sizes available.

Before orifice sizes Q, R and T are implemented, the relief valve manufacturer shall critically evaluate these large sizes against process medium/conditions.

The number of relief valves shall be kept to a minimum in a multiple safety valve installation.

In a multiple safety valve installations, all orifices shall be equal.

Design, sizing and approval of relief valves for utility systems shall be performed to a recognised international standard/institution.

Bursting discs shall be designed according to ISO 4126-2. BS 2915 or equivalent may also be used.

4.18 Pilot operated relief valves

Pilot operated relief valves should be avoided in hydrocarbons applications due to risk of freezing. If pilot operated relief valves are used, the non-flowing type is preferred.

4.19 On/off valve actuators

4.19.1 General

At minimum supply pressure the actuator's torque/thrust shall be 25 % above maximum torque/thrust required at the maximum differential pressure across the valve.

The actuator shall be provided with a local indicator showing the valve position.

On loss of signal or supply, the valve shall be driven to the normally open or normally closed position as required.

Devices for control of the speed in both directions shall be installed on the control unit. It shall not be possible to fully close the restrictors.

Electrical actuators may be used for non safety applications. Electrical actuators should be avoided in classified areas due to maintenance requirements for flamepaths.

Valves with a defined failure action should be labelled or colour coded- to indicate the valve position on loss of signals/ supply.

Suggested colour code is:
Green: Fail open
Red: Fail close

Actuators for valves with a defined failure action should be labelled or colour coded to indicate the valve position on loss of signals/supply.

4.19.2 Shut-down and blow-down applications

Hydraulic or pneumatic single-acting spring return operated actuators should be used for shut-down valves.

Double-acting actuators may be used when this proves beneficial based on an evaluation including weight, space etc.

Hydraulic accumulators shall be of the piston type, nitrogen charged, with magnetic positions indicator

The valve control accumulator units and valve control panels shall be installed close to the valve.

Valve control panels for shut-down valves shall be equipped with local reset function.

4.20 Choke valves

Remote operated production choke valves should be provided with a pneumatic stepping or electrical actuator.

For pneumatic stepping actuator each step for both directions shall be equal in length.

Manual operation in both directions shall be possible.

4.21 HVAC actuators

Actuators for HVAC shut-off and fire dampers shall be of spring return type.

Pneumatic HVAC actuators shall be designed to operate properly between maximum and minimum air supply pressure as specified in 4.2.

The spring force shall be selected to keep the blade(s) in proper alignment, ensure air tightness in closed position and prevent chattering.

Actuators for HVAC pressure control dampers shall be provided with positioners.

4.22 Vibration field instruments

Vibration/proximity probes for vibration detection shall conform to API RP 670 and API RP 678, as relevant.

4.23 Fire and gas detectors

4.23.1 General

Detectors shall have high reliability, be well proven, and they shall have an acceptable response time. Optimal detector location in each fire area is important. Establishing the correct detection principle, together

with the right sensitivity setting will increase safety, and maintain operational process regularity. A single action detection philosophy may be used. If a voting philosophy is used, it is important to ensure sufficient coverage, When the voting principle for gas detection is used, other alarm settings than the traditionally 20 % and 60 % lower explosion limit should be used, see NORSOK S-001.

The application shall determine the detection principle to be used.

Due to standardisation and maintenance requirements, the variation of detector types (i.e. open path gas detectors) should be kept to a minimum.

Detectors should comply with IEC 61508 and OLF-070 related to SIL.

Fire and gas detectors may be of the SMART addressable (i.e. field bus) type.

Detectors shall have a self test system. This system shall be initiated automatically.

4.23.2 Smoke detectors

Optical, and/or Ionisation smoke detectors with normal (medium) sensitivity, should be used, see Table 2.

Table 2 – Smoke detector types

Smoke detector type	Light obscurance (%/m)
Optical	1 to 37
Ionisation	1 to 37
Early warning	0,01 to 1
Aspiration	0,01 to 1

Detectors shall not be sensitive to water vapour.

Detectors shall have local alarm indicators to visually indicate when detectors are in alarm mode.

Early warning of smoke detection by means of single point detector and/or aspiration system may be used for cabinets in LERs.

4.23.3 Heat detector

Heat detectors shall only be installed if no other detection principle is suitable. Heat detectors may be a combination of rate of rise, and fixed temperature.

4.23.4 Flame detector

Flame detectors shall be of the IR or combination ultra violet/IR type and ambient temperature shall be taken into considerations.

The sensitivity setting should be determined according to distance from detector to fire object.
A low sensitivity setting shall not be used.
The optical lens may have a built-in adjustable heater.

Use of current sink or current source signal type shall be according to system design.

Sensors shall not be susceptible to spectral response variation when subjected to continuous operation.

Special means to avoid false triggering from steady state radiation sources should be applied.

4.23.5 Gas detector

IR detectors should be used.

In areas with a risk of harmful H_2S concentrations, H_2S detectors shall be used, i.e. drilling mud/shale shaker area.

Open path detectors shall be evaluated in combination with point detection. The number of sensors and their location for each fire area should be determined by gas spread modelling analysis.

“Catalytic detectors shall not be used unless proper detection performance by other types is not achieved. Ultrasonic gas leak detectors may be used. This type of detector may be beneficial in areas where the background noise level is constant. This application may be considered on normally unmanned installations.

Use of current sink or current source signal type shall be according to system design.

See NORSOK S-001, 12.4, for additional requirements.

4.24 Diagnostics

The use of the advanced diagnostics in field instruments shall be used to reduce maintenance and unscheduled stops in production. The implementation of an asset management database that supports routines for a calibration management system, alarm logging, software to support predictive maintenance, logging of configuration changes in an audit trail should be implemented. Historical tracking of the instruments should be based on instrument identifications as well as tag number.

The asset management database shall be used in both online and offline mode and shall be able to interface with locally, hand-held configuration tools as well as data exchange with industry standard software packages. Interfaces to support remote access from shore via protocols like OPC shall be implemented.

Proprietary systems shall not be used.

Critical on-off valves should have a system for leak detection.

5 Installation

See NORSOK E-001 and IEC 61892-6.

5.1 General requirements

Equipment should be located in accordance with the following requirements:

- protected against damage;
- protected against vibration;
- protected against weather and water jets;
- operability and serviceability;
- display instruments to be legible and visible from main access areas or walkways;
- accessibility for maintenance without scaffolding, stepladder etc.

Instruments installed in exposed areas should be sheltered by use of weather protection or GRP/AISI 316SS enclosures. If transmitters have a local indicator, the enclosure shall have window for easy reading. Test connections for calibration and maintenance shall be fitted outside enclosure. Pre insulated tubing (or heat trace tubing) may be used.

Instrument locations shall be selected to avoid interference with escape routings, walkways, other equipment, pipes etc. and obstruction against activities related to transport and lifting operations.

Equipment shall not be supported on pipe work, handrails or access ladders. Equipment sensitive to vibration such as open path gas detectors shall be mounted on fixed structures.

Equipment shall not be mounted on blast walls/explosion relieves. Equipment can however be installed on support frames for the blast walls if the integrity of the blast wall is not interfered.

Equipment located in areas which do not allow for maintenance accessibility as specified, should be installed such that the equipment can be rotated, raised or lowered into areas where maintenance can take place without the need for scaffolding.

Care shall be taken that the forces developed by the expansion of piping or vessels shall not damage instruments or impulse tubing.

5.2 Equipment earthing and bonding (see NORSOK E-001, 9.1)

5.2.1 General (see IEC 61892-6, 4.1, and NORSOK E-001, 9.1.1)

Additional requirement:
Instruments mounted in GRP pipe or lined pipe shall have equipotential bonding.

5.2.2 Earthing of exposed conductive parts (see IEC 61892-6, 4.2, and NORSOK E-001, 9.1.2)

No additional requirements.

5.2.3 Equipotential bonding (see IEC 61892-6, 4.3, and NORSOK E-001, 9.1.3)

No additional requirements.

5.2.4 Instrumentation earth (see NORSOK E-001, 9.1.4)

Additional requirement:
Screen to be left floating in field end and insulated in a shrink lug for access.
Braided armour to be connected to junction box earth stud.

5.2.5 Earth bar and earth boss (see NORSOK E-001, 9.1.5)

No additional requirements.

5.3 Cables and wiring (see IEC 61892-6, Clause 5, and NORSOK E-001, 9.2)

5.3.1 General (see NORSOK E-001, 9.2.1)

Additional requirement:
Fire-resistant cables shall be used for the following systems:

- deluge circuits;
- fire-damper circuits;
- fire and gas circuits;
- gas release circuits;
- ESD circuits;
- fire pump start circuits;
- public address communication equipment;
- equipment for evacuation;
- HVAC system where this is used to provide safe area classification;
- parts of PSD to be in operation during an emergency (to be evaluated on a case by case basis).

All offshore cables shall be halogen free.

5.3.2 Cable segregation (see NORSOK E-001, 9.2.2)

Additional requirement:
Due to possible problems of electromagnetic interference and/or electromagnetic compatibility, necessary precautions shall be taken to avoid mixing low-voltage signals with Level 2 and Level 3 type signals.

5.3.3 Cable routing (see NORSOK E-001, 9.2.3)

No additional requirements.

5.3.4 Cable installation (see NORSOK E-001, 9.2.4)

Additional requirement:
Sufficient spare cable length shall be provided for equipment that may need future adjustment (e.g. floodlights, loudspeakers, etc.) or where equipment has to be dismounted for maintenance and calibration without disconnecting the cable.

Typical instruments that require additional cable length are

- loudspeakers,
- temperature transmitters with element,
- solenoids,

- smoke detector inside rooms (2,5 m to allow final location after smoke test),
- flame detectors.

5.3.5 Cable cleating and strapping (see NORSOK E-001, 9.2.5)

Additional requirement:
Flying leads on proximity switches shall be protected by seamless instrument tubing. Spring conduit shall not be used on flying leads.

If a flying lead is used in conjunction with moving equipment, the flying lead to be protected with armoured hoses, e.g. hydraulic hoses.

5.3.6 Temporary cables (see NORSOK E-001, 9.2.6)

No additional requirements.

5.3.7 Cable gland selection (see NORSOK E-001, 9.2.7)

No additional requirements.

5.3.8 Cable termination (see NORSOK E-001, 9.2.8)

See also Annex A, Drawing number I-001-102.

5.3.9 Spare conductors (see NORSOK E-001, 9.2.9)

No additional requirements.

5.3.10 Support system (cable ladders and trays) (see NORSOK E-001, 9.2.10)

5.4 Marking and labelling (see NORSOK E-001, 9.12)

5.4.1 General (see NORSOK E-001, 9.12.1)

No additional requirements.

5.4.2 Cable ladders (see NORSOK E-001, 9.12.2)

No additional requirements.

5.4.3 Equipment (see NORSOK E-001, 9.12.3)

No additional requirements.

5.4.4 Cables (see NORSOK E-001, 9.12.4)

No additional requirements.

5.4.5 Identification of wires (see NORSOK E-001, 9.12.5)

Additional requirement:
The core of cable pair shall have the following colors:

1	Positive pole	(+)	Black
2	Negative pole	(-)	Blue (White)

The core of triple cable shall have the following colors:

1	Black
2	Blue (White)
3	Brown

5.4.6 Colour coding of earth conductors, earth bars and cable screen (see NORSOK E-001, 9.12.6)

Additional requirement:
- earth connectors and IE bars shall be marked with yellow/green and covered with sleeves;
- IE bars shall be marked yellow/green and with a red mark for bars containing non-IS cables only;
- a blue mark for bars containing IS cables only;

- both red and blue mark containing non-IS and IS cables.

5.4.7 Tubing- and manifold labelling

Distribution manifolds to be tagged.

Tubing for pneumatic supply and hydraulic supply and return shall be marked with consumer tag no at the distribution manifold or at hook-up to main line.

When tubing passes through bulkheads/MCT, tubing shall be marked with tag number on both sides.

NOTE This is not valid for local control panels.

5.5 Bulk materials

5.5.1 Junction boxes (see NORSOK E-001, 9.13.1)

Additional requirements:
Junction boxes should be made of glass fibre reinforced plastic with polyester resin. In outdoor areas exposed to changing environmental conditions stainless steel SS Type 316 may be used.

When junction boxes are installed in outdoor areas, drain plugs (breather plug) shall be installed. Anti condensation heating element should be provided in boxes containing active components.

Junction boxes shall be designed with sufficient space for the expected number of cables and cable make-offs.

5.5.2 Cable support systems (see NORSOK E-001, 9.13.4)

No additional requirements.

5.5.3 Equipment brackets and supports (see NORSOK E-001, 9.13.5)

No additional requirements.

5.5.4 Multi cable transits (MCTs) (see NORSOK E-001, 9.13.6)

No additional requirements.

5.5.5 Earth bosses (see NORSOK E-001, 9.13.7)

No additional requirements.

5.5.6 Fixing materials (see NORSOK E-001, 9.13.8)

No additional requirements.

5.5.7 Precautions against galvanic corrosion (see NORSOK E-001, 9.13.9)

No additional requirements.

5.6 Instruments

5.6.1 In-line instruments

All in-line instruments shall be installed in accordance with supplier recommendations.

Special consideration should be given to flow instruments, i.e. mounted in horizontal pipes, vertical pipes, liquid filled, avoid gas in liquid etc.

Prior to final installation of control valves and other in-line instruments, the process lines shall be properly flushed.

5.6.2 Off-line instruments

Each instrument shall be available for maintenance and disconnection without interfering with the process.

The installation shall be arranged so that it can be heat traced and thermal insulation applied.

All indicating instruments, which include transmitters with indicators, to be located between 1 m to 1,8 m above deck level.
Direct mounted instruments shall be used, whenever applicable.

Impulse tubing shall be as short as possible and be installed so that gas/liquid pockets are avoided. Instruments shall be installed below tapping point for liquid service and above tapping point for gas service.

For pressure measurements in liquid applications with minimum operating pressure above 5 barg, instruments may be installed above tapping point as for gas service.

Impulse tubing shall have minimum 1:12 slope.

5.7 Tubing installation

5.7.1 Support

Instrument tubing shall be supported on field trays or cable ladders for tubing sizes less than 16 mm OD.

Cable tray, ladder or equivalent shall be used for larger sizes when mechanical protection is required.

Trays are not required for internal tubing on components if tubing is sufficiently protected.

Tubing sizes above 25 mm outside diameter shall as a minimum have support every 1,5 m.

5.7.2 Clamping

Tubing clamps shall be made of non-corrosive material, stainless steel SS Type 316 and/or flame retardant plastic.

Tubing clamps shall not cause mechanical damage to the tubing in case of vibration.

Tubing to be fastened to self drained tubing clamps with span maximum every 60 x tubing diameter.

Galvanic corrosion between tubing and tubing support system shall be avoided. The tubing clamp shall, when installed, not allow for water/sea water to be accumulated between tubing and tubing clamp on wall, this is to avoid crevice corrosion.

Parallel runs of tubing on the same support shall be arranged such that it is possible to have access to every connection point.

5.7.3 Installation

Installation into or through panels shall be by use of bulkhead unions or MCTs.

Instrument tubing and cables may be installed on the same field tray for shorter distances (approximately 5 m). Instrument tubing and cables may be routed through the same cable/tubing penetration.

All tubing and/or tube fittings which are not connected shall be sealed with end-plugs/caps of same material as the tubing and/or tube fittings.

Vent, drain and manifold valves shall be available outside insulation for test connections. Tubing shall be installed to reach outside insulation for test connections.

Capillaries of filled systems shall be continuously supported. Spare capillaries shall be coiled inside a cable tray or have similar mechanical protection. Minimum bending radius shall be 80 mm. Special attention should be paid when clamping capillaries in order to avoid mechanical damage.

All tubing shall be cut by proper tubing cutting tools and de-burred. Tubing shall be blown through with clean, dry air before final installation.

All compression tube fittings shall be of the same make on whole installation.

5.7.4 Qualification

The installation shall be carried out by skilled personnel certified according to OLF requirements.

5.7.5 Testing and flushing

All tubing and components (e.g. control panels, actuators, accumulators etc) in hydraulic systems shall be hot oil flushed and cleaned in accordance to NORSOK L-004, cleanliness level, ISO 4406 17/15/12.

5.7.6 Sealing compound

Sealing compounds for process services, instrument air services and hydraulic oil services shall be used in accordance with supplier recommendations. Use of tread tape shall be approved by customer.

5.7.7 Heat traced tubing

Where tubing has to be heated the pre insulated tubing should be evaluated.

The heat trace tubing shall have heat-shrinkable connection in both ends.

Heat trace tubing shall be installed on cable field tray and ladder according to bending radius.

Clamping shall be with ties, same as cable installation.

Loose ends during installations shall be sealed off with self-vulcanising tape in accordance to supplier instructions.

5.7.8 Tubing and fitting materials

The compression tube fittings shall in general be of the same material as the tubing. In the event that the materials are different, it shall be ensured that the compression tube fitting material is hardest and in accordance with supplier recommendations.

5.8 Fire and gas

5.8.1 Gas point detector

All detectors with restricted access shall be equipped with test tubing in the same area to a single point or to a connection box 1,5 m above deck. Weather protection to be installed according to manufacturers specifications.

5.8.2 Open path gas detector

Detector shall be installed on steel framework to prevent vibrations.

5.8.3 Acoustic gas leak detector

To be mounted according to manufacturers instructions.

5.8.4 Flame detector

Detector shall be installed on steel framework to prevent vibrations.

5.8.5 Smoke detector

If a smoke test is required, the final location shall be decided after test.

ANNEX A
(informative)
Typical installation drawings

DRAWING NO.	TITLE
I-001-101	INSTRUMENT EARTH PHILOSOPHY
I-001-102	INSTRUMENT EQUIPMENT TERMINATION
I-001-103	INSTRUMENT TERMINATION IN FIELD JUNCTION BOXES
I-001-104	INSTRUMENT TERMINATION IN PANELS
I-001-105	SPLICING OF FIBRE OPTICAL CABLE
I-001-106-001	INSTRUMENT HOOK-UP DIAGRAM, DIFF. PRESS. TRANS. W/ CAPILLARY AND DIAPH. SEAL
I-001-106-002	INSTRUMENT HOOK-UP DIAGRAM, DIFF. PRESS. TRANS. W/ CAPILLARY AND DIAPH. SEAL
I-001-107-001	INSTRUMENT HOOK-UP DIAGRAM, PRESS. TRANS. W/ CAPILLARY AND DIAPH. SEAL
I-001-107-002	INSTRUMENT HOOK-UP DIAGRAM, PRESS. TRANS. W/ CAPILLARY AND DIAPH. SEAL
I-001-108	INSTRUMENT HOOK-UP DIAGRAM, PRESS. TRANSMITTER GAS SERVICE
I-001-109	INSTRUMENT HOOK-UP DIAGRAM, PRESS. TRANSMITTER LIQUID SERVICE
I-001-110	INSTRUMENT HOOK-UP DIAGRAM, DIFF. PRESS. TRANSMITTER LIQUID SERVICE
I-001-111	INSTRUMENT HOOK-UP DIAGRAM, DIFF. PRESS. TRANSMITTER GAS SERVICE
I-001-112	INSTRUMENT HOOK-UP DIAGRAM, PRESSURE GAUGE
I-001-113	INSTRUMENT HOOK-UP DIAGRAM, AIR DISTRIBUTION MANIFOLD W/ CONSUMER
I-001-114	INSTRUMENT HOOK-UP DIAGRAM, HYDRAULIC DISTRIBUTION MANIFOLD W/ CONSUMER

ANNEX B
(informative)
Level measurement guidelines

Vessel/tank type	Level definition	Remarks
Horizontal vessels	0 % = inside bottom or lowest measurable level 100 % = inside top or highest measurable level or 300 mm to 700 mm above highest alarm (separator)	Due to sand/sediment, the lower instrument nozzle will be located at an angle of 18° to 30° to the vessel vertical centre. This means that instrument will begin to measure from approximately 5 % height. This does not apply to radiation units.
Horizontal vessels with boot	0 % = lowest measurable level 100 % = highest measurable level	Normal operations for these types of vessels are restricted to within the boot. The control system shall define 0 % as inside vessel bottom.
Vertical vessels - scrubbers	0 % = lowest measurable level 100 % = highest measurable level ~ 10 % above high-high level	Operational ranges on scrubbers are by nature small. Thus there is no point in covering the whole vessel height.
Tanks with flat bottom	0 % = lowest measurable level 100 % tank overflow	Generally storage tanks. This does not apply to tanks where the transmitter has high-high shutdown function.
Tanks with sloping bottom	0 % = lowest measurable level 100 % = tank overflow	Generally storage tanks. This does not apply to tanks where the transmitter has high-high shutdown function.

ANNEX C
(normative)
Instrument data sheets

Instrument data sheet		Corresponding process data sheet
A01 (Not published)	ANALYSER	PR4
E01 (Not published)	RUPTURE DISK	PR3
F01	TURBINE AND POSITIVE DISPLACEMENT FLOW METER	PR4
F02	ULTRASONIC AND VORTEX FLOW METER	PR4
F03	MAGNETIC FLOW METER	PR4
F04	VARIABLE AREA FLOW METER	PR4
F05	MASS FLOW METER	PR4
F06	PITOT TUBE AND ANNUBAR	PR4
F07	ORIFICE FLANGES AND PLATES	PR4
F08	VENTURI FLOW ELEMENT	PR4
F09	VORTEX FLOWMETER	PR4
K01	INDICATING LAMP	NA
K0	INDICATING METER	NA
K03	POTENTIOMETER	NA
K04	PUSH-BUTTON/HAND SWITCH	NA
I01	I/P AND P/I CONVERTERS	PR4
I02	PNEUMATIC CONTROLLER	PR4
L01	LEVEL INSTRUMENT ELECTRIC	PR6
L02	LEVEL INDICATOR	PR6
L03	LEVEL GLASS	PR6
L04	LEVEL INSTRUMENT CAPACITIVE/CONDUCTIVE	PR6
L05	LEVEL GLASS/GAUGE	PR6
L06	LEVEL SWITCH VIBRATING FORK	PR6
L07	LEVEL INSTRUMENT NUCLEONIC	PR6
P01	PRESSURE INSTRUMENT ELECTRIC	PR5
P02	PRESSURE INDICATOR	PR5
S01	FIRE AND GAS DETECTOR	NA
T01	THERMOWELL	PR4
T02	TEMPERATURE INSTRUMENT ELECTRIC	PR5
T03	TEMPERATURE INDICATOR	PR5
V01	BLOCK VALVE HYDRAULIC/PNEUMATIC ACTUATOR	PR1
V02	CONTROL VALVE HYDRAULIC/PNEUMATIC ACTUATOR	PR2
V03	SOLENOID VALVE	PR2
V04	SAFETY/RELIEF VALVE	PR3
V05	BLOCK VALVE - ELECTRIC ACTUATOR	PR1
X01	MISCELLANEOUS INSTRUMENT	NA

Process data sheet

PR1	BLOCK (ON - OFF) VALVE
PR2	CONTROL VALVE
PR3	SAFETY/RELIEF VALVE
PR4	INLINE/FLOW INSTRUMENT
PR5	PRESSURE & TEMPERATURE TRANSMITTER / INDICATOR / SWITCH
PR6	LEVEL INSTRUMENT
PR7	RESTICTION ORIFICE PLATE