



NATIONAL PETROCHEMICAL COMPANY
STANDARDS

ENGINEERING STANDARD
FOR
INSTRUMENTATION

NPCS-ES-IN-01

REVISION : 0

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1 GENERAL

1.1 SCOPE

1.1.1 The purpose of this standard is to define qualitatively the general requirements for instruments, protective devices and control system.

1.1.2 This standard determines the minimum requirement for the instrumentation design according to the best engineering practices.

1.1.3 For units of measurement refer to NPCS-ES-GN-03.

1.2 STANDARDS AND CODES

1.2.1 All instruments design, equipment and installation shall conform to the latest edition of the followings standards:

ISA Standards and Practices for Instrumentation of Instrumentation Society of America.

API Relevant Instrumentation and Standards of American Petroleum Institute.

IEC International Electric Code for Area Classification.

NEMA National Electrical Manufacturers Association Code of Enclosure.

ASME American Society of Mechanical Engineers Codes.

ANSI American National Standards Institution, Codes for Leakage through Control Valves and Instrument Connections.

BS British Standards.

DIN German Standards.

NFPA National Fire Protection Association.

AGA American Gas Association.

1.2.2 The following design documents are applicable for instrumentation :

General ISA is applied unless otherwise specified.

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Design, materials and workmanship shall be in accordance with the applicable codes and standards as listed below (latest edition) :

Process piping

ANSI B31.3	Petroleum Refinery Piping.
ANSI B16.5	Steel Pipe Flanges, Flanged Valves and Fittings.
ANSI B2.1	Pipe Threads.
ASME	Boiler and Pressure Vessel Codes, sections and VIII.
ANSI B1.1	Bolt Thread.

Relief valves

ASME	Unfired Pressure Vessel Code, section VIII division I.
API	Standard 2000, Guide for Tank Venting.
API RP520	Parts I and II for Design and Installation of pressure Relieving System.
API RP526	Flanged Steel Safety Relief Valves.
API RP527	Commercial Seat Tightness of Safety Relief Valves with Metal to metal Seats.

Thermocouples and thermocouple extension wire

ANSI	MC96.1.
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Resistance bulbs

DIN	43760
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Electrical

ISA	RP12.1 through RP12.6 and IEC among others.
ISO R228/1	Pipe Thread(Electric Connection).
IEC 79	Electrical Apparatus for Explosive Gas Atmosphere.

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IEC 144 Degree of Protection by Enclosure.

IEC 529 Classification of Degrees of Protection
Provided by Enclosures.

Material

ASTM specification, section II.

Welding

ASME Boiler and Pressure Vessel Code, section
IX, latest edition.

ANSI B31.3 For Process piping.

AWS Standard AWS D1.0 for Structural Steel.

Orifice plate

ISA RP3.2

AGA (American Gas Association) Gas Measurement
Committee Report No.3, Orifice Metering of
Natural Gas.

BS 1042 Conical Entrance and Quarter Circle
Orifice Plates.

ISO 5167 Measurement of Fluid Flow by Means of
Orifice Plates and Nozzles.

Control valves

ISA S-75.1 Control Valve Sizing Equation.

ISA S-75-03/04 Uniform Face to Face Dimensions for
Flanged Globe-Style Control Valve Bodies
and Flangeless Valves.

Instrument piping material

ANSI B31.3

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1.3 INSTRUMENTS SYMBOLES

The method for representing instrument equipment on piping and instrument flow diagrams and utility flow sheets shall, in general, be in accordance with ISA S-5.1, "Instrumentation Symboles and identification", ISA S-5.2 for "Binary Logic Signal" and ISA S-5.3 for "Graphic Symbols for Distributed Control/Shared Display Instrument, logic and Computer System".

1.4 GENERAL DESIGN

1.4.1 In general, all remote instruments and control functions shall be 4 MA to 20 MA DC and of the 2-wire.

1.4.2 Local control loops shall be pneumatic 0.2-1.0 barg.

1.4.3 Instrumentation for the machinery packages, utility and off-site units shall be of the same types and manufacturers as for the process control instruments, except for the area classification requirements.

1.4.4 All equipment shall be furnished with all necessary weather and antifreeze protection to prevent damage due to climate or from the plant atmosphere. As a minimum, all outdoor enclosures shall be weatherproof IP 55 according to IEC 144.
IP 54 should be approved by NPC.

1.4.5 All electronic transmitters to be provided with an integrally mounted 50 mm dial output gauge.

- 0-10 square root for flow.
- 0-100 linear for all others.

For flow control applications the gauge shall be located to be visible from the control valve by-pass.

1.4.6 Instrumentation for the plant shall be sufficient in every respect to provide adequate control and safety during all phases of operation.

1.4.7 Furnaces and boilers, whether used for start-up services or otherwise, shall be provided with approved flame management systems.

1.4.8 All control systems shall be designed for fail-safe operation of the plant, as determined by NPC and/or liscensor.

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- 1.4.9 All safety and relief valves, control valves and orifice meters shall be adequately sized in order to enable the instruments to cope with both normal operation conditions and the conditions existing during start-up, shut-down or permissible overcapacity operation.
- 1.4.10 All control valves shall be provided with block and by-pass valves.
- 1.4.11 Varying Conditions
provision should be made for the measurement of static pressure and temperature in the system downstream of the flow elements on installation for the metering of gases, where the pressure and temperature are not constant.
- 1.4.12 Contacts of the switches shall generally be, normally closed.
- 1.4.13 Solenoid valves in instrument air service shall be such that their deenergization make safe position.
- 1.4.14 A noninterruptible electrical power system shall be furnished to provide a minimum of 1/2 hr of operation of critical instrumentation in the event of loss of plant power.
- 1.4.15 All recorder chart drives shall be electric. For local recorders with no electric power accessibility, a weekly hand wind chart drive shall be used. Chart drive speed shall be approximately 25 mm per hr, with three to four hours recording visible.
- 1.5 UNITS OF MEASUREMENT
- 1.5.1 Temperature instruments shall have linear scales, calibrated in direct reading degrees centigrade ($^{\circ}\text{C}$) and charts calibrated correspondingly.
- 1.5.2 Pressure instruments shall have linear scales, calibrated in "bar" and charts calibrated correspondingly. Differential pressure instrument ranges to be in millibar.
- 1.5.3 Vacuum instruments shall have scales calibrated in millibar (mbar) absolute and charts calibrated 0-100 linear.
- 1.5.4 Standard conditions for oil and gas measurement (pressure and temperature) are established as 15°C and 1.01325 bar.
- 1.5.5 Flow instruments shall have charts and scales calibrated 0-10 square root.



- 1.5.6 Other process variable units are as listed in the table 1.1.

TABLE 1.1

PROCESS VARIABLE	UNITS OF MEASUREMENT
FLOW :	
Steam	kg/h
Vapor	sm ³ /h at 15" C
Liquid	m ³ /h
process level	0-100 percent
Tank level	Meters and decimal meters (i.e. maximum 99.999 m)
Length	mm
Viscosity	
Density	kg/m ³ at 15" C
Conductivity (electrical)	S/m
Weight	Kg, Ton
Concentration	%, PPM, PPB
Power	kW

1.6 SCALES

- 1.6.1 Scales of measurements shall be as follows:

<u>Receiver local</u>	<u>Scale/Chart scale</u>
Flow-liquid	0-100 lin./ 0-10 sq.rt.
Flow-gas	0-100 lin./ 0-10 sq.rt.
Flow-steam	0-100 lin./ 0-10 sq.rt.
Pressure	0-100 lin./ Direct
Low press. or vac.	0-100 lin./ Direct
Temperature	0-100 lin./ Direct
Level-Percentage	0-100 lin./ Direct

NOTE : oteCombinations 0-100 linear and 0-10 square
root charts may also be used where applicable.



1.6.2 Scales of field mounted receiver gauges shall be 0-10 square root or 0-100 linear and the scale factor shall be written on the scale plate.

1.7 MEASURING RANGES OF INSTRUMENTS

1.7.1 Differential Pressure Flow Meters

- a) Normal flow rate shall normally fall between 40% and 80% of full scale, provided that anticipated minimum and maximum flow rates will be between 15% and 95% of full scale.
- b) Measuring ranges satisfying the preceding subsection shall be selected from the following standard ranges :

0 - 10	X 10"	
0 - 12	X 10 ^M	*
0 - 15	X 10"	
0 - 18	X 10"	*
0 - 20	X 10 ^M	
0 - 25	X 10"	
0 - 30	X 10 ^M	
0 - 35	X 10"	*
0 - 40	X 10"	
0 - 45	X 10"	*
0 - 50	X 10 ^M	
0 - 55	X 10 ^M	*
0 - 60	X 10 ^M	
0 - 70	X 10 ^M	
0 - 80	X 10 ^M	
0 - 90	X 10 ^M	*

Notes :

- M means exponents and it will be integer.
- Measuring ranges marked with asterisk (*) shall preferably not be used.
- The measuring ranges which are not shown will be adopted where required.



Area flow meters

- a) Normal flow rate shall be between 50% and 70% of capacity, provided that anticipated minimum and maximum flow rates will be between 15% and 95% of full scale.
- b) Measuring ranges satisfying the preceding subsection shall be selected from the following standard ranges :

1.0	-	10	x	10"
1.2	-	12	x	10 ^M
1.5	-	15	x	10 ^M
1.8	-	18	x	10"
2.0	-	20	x	10 ^M
2.5	-	25	x	10"
3.0	-	30	x	10"
3.5	-	35	x	10"
4.0	-	40	x	10 ^M
4.5	-	45	x	10"
5.0	-	50	x	10 ^M
5.5	-	55	x	10 ^M
6.0	-	60	x	10 ^M
7.0	-	70	x	10 ^M
8.0	-	80	x	10"
9.0	-	90	x	10 ^M

Note : Refer -to Notes of paragraph 1.7.1.

Rotameters for Purge

For the liquid service, scales shall be 20 cc/min to 200 cc/min, and for gas service, 100 cc/min to 1000 cc/min.

.7.4 Displacement type level instruments

Measuring ranges shall be 300, 500, 600, 700, 800, 1000, 1200, 1500 or (2000) mm.

Note : The measuring ranges marked with parentheses shall not be used as much as possible.

.7.5 Differential pressure level meters

Normal level shall be between 40% and 70% of full scale and maximum and minimum level shall be between 95% and 10% of full scale.

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1.7.6 Pressure instruments

- 1) Operating pressure shall generally be put between 50% and 85% (65% for pressure gauges) of full scale.
- 2) Measuring ranges and units shall be as follows :

0 - 10	mbar
0 - 20	mbar
0 - 25	mbar
0 - 5 0	mbar
0 - 100	mbar
0 - 150	mbar
0 - 200	mbarG
0 - 200	mbar
0 - 250	mbar
0 - 300	mbar
0 - 500	mbar
0 - 0.1	barA
0 - 0.2	barA
0 - 0.3	barA
0 - 0.4	barA
0 - 0.6	barA
0 - 1.0	barA
0 - 1.5	barA
0 - 2.0	barA
0 - 2.5	barA
0 - 3.0	barA
0 - 3.5	bar.4
0 - 5.0	barA
0 - 7.0	barA
0 - 10.0	barA
0 - 15.0	barA
0 - 20.0	barA
0 - 30.0	barA
0 - 70.0	barA
0 - 500.0	barA

Note : The measuring ranges which are not shown will be adopted where required.

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1.7.7 Local Temperature Instruments

- a) Local temperature instruments such as liquid-in-steel type thermometers with capillary tube, gas filled-in-steel type thermometers and bimetallic type thermometers, shall have one of the following measuring ranges :

Measuring range (°C)

-50	-	0
-50	-	+50
-50	-	+100
0	-	+100
0	-	+150
0	-	200
0	-	250
0	-	300
0	-	400
0	-	500

- b) Operating temperature shall be between 30% and 75% of full scale.

1.7.8 Miscellaneous

The scale of instruments except above mentioned, shall be followed by Licencer's recommendation with NPC approval,

1.8 ACCURACY

Instruments shall conform to the following accuracy.

Instrument direct ind. pneumatic electric

- PANEL MOUNTED RECEIVER:

- | | |
|--------------|----------------|
| a) Indicator | $\pm 0.5\%$ FS |
| b) Recorder | $\pm 0.5\%$ FS |

- LOCAL INSTRUMENT:

- | | |
|--------------------------------------|----------------|
| a) Differential pressure transmitter | $\pm 0.5\%$ FS |
| b) Pressure transmitter | $\pm 0.5\%$ FS |
| c) Area flow | $\pm 2\%$ FS |
| d) Mass flow meter | $\pm 0.5\%$ |



e)	Mass flow meter (High accuracy)	$\pm 0.2\%$
f)	Positive displacement flow meter (general)	$\pm 0.5\%$
g)	Positive displacement flow meter (high accuracy)	$\pm 0.2\%$
h)	Vortex flow	$\pm 1\% *$
i)	Displacement type level	$\pm 1.5\%$ FS
j)	Float type tank gauge	
k)	Controller	$\pm 1.5\%$ FS
l)	Pressure switch	$\pm 1.5\%$ FS
m)	Thermocouple type K(CA)	Class 0.75
n)	Thermocouple type T(CC)	Class 0.75
o)	Resistance bulb	Class A
p)	Purge meter	$\pm 5\%$ FS
q)	Pressure gauge	$\pm 1.5\%$ FS
r)	Bimetallic thermometer	± 1 Graduation

Note : * means $\pm 0.5\%$ around normal flow rate

1.9 CONTROLLERS AND CONTROL MODES

- 1.9.1 Field-mounted controllers shall be of the force balance type, having subpanel with transfer switch and be at least weather proof.
- For DCS requirements for controllers, see NPCS-MS-IN-40. Manifolds shall be provided, if necessary, so the controller can be removed for servicing without additional equipment or shut-off cocks, while on manual control from the board. All controllers shall be provided with a 0-2 barg (0-30 psig) output air gauge. In addition, field-mounted controllers shall be supplied with a standard air filter regulator set on 0-2 barg (0-30 psig) supply air gauge. Field controllers and their manifolds shall be rigidly-mounted at minimum distance from control valves. One or more of the following control functions will be specified for each controller; values are approximate.



- a) Narrow proportional Adjustable 1-50%.
- b) Normal proportional Adjustable 1-150%.
- c) Wide proportional Adjustable 10-1000X.
- d) Fast reset Adjustable 0.1-100 repeats per minute.
- e) Slow reset Adjustable 0.05-10 repeats per minute.
- f) Derivative Adjustable 0.01-10 minutes.
- g) One knob proportional/reset Adjustable 50-200% with 1-120 repeats per minute or a fixed 150% with adjustable 1-100 repeats per minute. Device shall be specifically designed for flow control.

- 1.9.2 All controllers shall be easily reversible and have manufacturer's standard range of control function nearest to those specified.
- 1.9.3 Panel-mounted temperature controllers shall be furnished with adjustable proportional, reset and rate action.
- 1.9.4 Field-mounted temperature controllers shall be furnished with adjustable proportional action.
- 1.9.5 All flow controllers will be furnished with adjustable proportional and fast reset action.
- 1.9.6 Panel-mounted level controllers will be furnished with adjustable proportional and reset action.
- 1.9.7 In general, field-mounted level controllers will be furnished with adjustable proportional action only.
- 1.9.8 Panel-mounted pressure controllers shall be furnished with adjustable proportional and reset control action.
- 1.9.9 Field-mounted pressure controllers shall be furnished with adjustable proportional control action and reset action.
- 1.9.10 Controllers, used for intermittent services, such as antisurge or minimum flow by-passes, shall have adjustable proportional control action only.



1.9.11 Auto/Manual switches shall normally be provided for all controllers not in sight of the associated control valve, Controllers adjacent to their valves will normally have auto/manual switches only, if no by-pass valve is provided. All such switches shall be of the type designed to ensure "bumpless" transfer.

1.9.12 **Location of Controllers**

On pneumatic installations where the length of the line from transmitter or control valves to the control room exceeds 200 m, larger diameter transmission tubing shall be used. Electronic transmission shall be considered, if rapid response is necessary.

1.10 INSTRUMENT MATERIAL

1.10.1 Wetted parts including sensing elements shall be of **AISI 316** Stainless Steel, except where the process condition requires other materials. The materials employed in special services shall be selected according to the application from :

S.S.-316 L, Tantalum, Monel, Hastelloy C, etc., according to NACE MR-0175.

1.10.2 Movement(linkages,etc.)for instruments shall be stainless steel.

1.10.3 Instruments shall have metal housing with manufacturer's standard finish. Large case (conventional style) instruments shall have minimum weatherproof gasketed doors. Miniature instruments shall have weatherproof and dustproof gasketed housing, when ordered for field installation. Doors shall be provided with a suitable sized viewing area of transparent plastic material for observation of process variable, set point, etc.

1.10.4 All instrument material shall be equal or better than the required material in the piping or vessel specification.

1.10.5 Instruments shall have no copper, brass, bronze or aluminium parts in Ammonia services .

1.10.6 For corrosion considerations,, material shall be **selected** according to NACE MR-01.

1.10.7 Electronic printed circuit boards shall be coated with suitable material against corrosive or conductive dust where required.

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1.11 INSTRUMENT CONNECTIONS

Connections of instruments shall be as follows:

Instrument Type	Service	Connection
- Differential pressure or pressure instruments (General purpose)	Inst.-Impulse piping Impulse-Process piping	NPT 1/2 Screwed 1/2" Flanged
- Ditto (Diaphragm seal type)	Inst.-Process	2", 3", 4" or 6" Flanged
- Displacement type level instruments (External chamber)	Inst.-Process Drain	2" Flanged 3/4" Flanged
- Ditto (Internal chamber)	Inst.-Process	4" Flanged
- Float type level switch	Inst.-Process	2" Flanged
- Float type tank	Measuring tape	3" Flanged
- Gauge glass	Inst.-Process	2" Flanged
- Pressure gauge (General purpose)	Inst.-Piping	NPT 1/2" Screwed
- Pressure gauge (Diaphragm seal type)	Inst.-Process	1", 1-1/2", 2" or 3" Flanged
- Differential pressure gauge	Inst.-Impulse piping Inst.-Process piping	NPT 1/2" Screwed 3/4" Flanged
- Temperature Instrument	Well-Process	1 1/2" Flanged other size (If any) 1/2" Screwed
- Pneumatic type Instrument	Inst.-Signal Inst.-Air Supply	NPT 1/4" NPT 1/4"

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Instrument Type	Service	Connection
- Electric type Instrument	Inst.-Signal Inst.-Power Supply	M 20 mm x 1.5mm M 20 mm X 1.5mm
- Capacitance type level switch	Inst.-Equipment	2" Flanged
- Powder level switch	Inst.-Equipment	2" or 4" Flanged
- Manometer	Inst.-Impulse -piping	1/2" Flanged

Note : Connections, except above mentioned, shall be in accordance with Licensor's recommendation with NPC approval.

1.12

COLOR AND PAINTING

1.12.1

The colour of instruments, panels and valves shall be as follows :

Item	place	Colour (Munsel Code)
- DCS	All Parts	Manufacturer's Standard
- Console Panel	Outside	Same color as DCS
- Panels	Outside Inside Channel base	2.5 G 8/3 5 Y 9/3 2.5 G 3/5
- Panel-mounted Instruments	Mask Bezel	Manufacturer's standard Ditto
- Local mounted Instruments	All Parts	Ditto
- Control Valve	Body and Yoke Actuator	Silver General: Silver Emergency: 2.5YR 6/13 Fire fighting: 5R 4/13
- Name Plate	Panel front	General: Base White Letter Black Emergency: Base 7.5R 4/14 letter white
- Miscellaneous	All Parts	Manufacturer's standard



- 1.12.2 Manufacturer's Standard Painting for field instruments shall be used; Stainless Steel shall not be painted.
- 1.13 DEGREE OF PROTECTION REQUIREMENTS
- 1.13.1 In general for Zone 0 Continuous Hazard Area, intrinsically safe design shall be considered for hazard protection and explosionproof design shall not be used.
- 1.13.2 For Zone 1 and Zone 2 intrinsically safe and explosionproof design; both are acceptable. One of these two methods shall be selected in the first stage of project engineering execution upon NPC approval.
- 1.13.3 In case intrinsically safe system is used, all instruments systems shall meet the requirements of ISA RP-12.6 "Installation of Intrinsically Safe Instrument Systems in Class 1 Hazard Locations". The electronic instruments shall also be approved as meeting the requirements for intrinsically safety by a recognized inspection and regulating agency.

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- 1.13.4 In case Explosion Proof System is used, all instrument installations shall be in accordance with the table 1.2.

TABLE 1.2

MINIMUM DEGREE OF PROTECTION OF ELECTRICAL MATERIAL

MATERIAL:	ZONE 0	ZONE 1	ZONE 2	NONCLASS
Motors	Not allowed	Flameproof Exd	Increased Safety Exe	Industrial IP 54
Outdoor panels	Not allowed	Flameproof Or pressurized Exd , Exp		Industrial IP.55
Lighting; fixtures;	Not allowed	Increased safety Exe	Increased Safety Exe IP 55	Industrial IP 55
Outlets	Not allowed	Flameproof Exd	Flameproof Exd	Industrial IP 55
Switches	Not allowed	Flameproof Exd IP 55	Flameproof Exe IP 55	Industrial IP 55
Instru-ments	Intrinsic safe Exia II T3 IP 55	Flameproof Exd IP 55	Nonsparking Exe IP 55	Industrial IP 55

Notes:

- Gas groups and temperature class shall not differ for each process unit and shall be of highest degree determined from the area classification drawings.
- Equipment for classified areas shall be selected in accordance with above table and comply with the relevant IEC standards (IEC 79).
- On flameproof equipment, increased safety terminal compartments are allowed.
- Outlets in zone 1 areas are allowed, but should be avoided.



- All the relevant instruments would have to be individually certified by an internationally recognized testing authority, such as BASEEFA, PTB, etc., for the following purposes :
 - a) Use in the hazardous area classification specified in the project.
 - b) For the chosen method of protection.
- For EX'e' type, approval from local codes is acceptable.
- Copper or copper bearing alloys shall not be used in any-part of the installation or instrument likely to be exposed to the caustic atmosphere. This shall also apply to the internals of the instrument unless they are self-purging, e.g. pneumatic controllers; except the internals of electronic instruments with in wheatherproof housings.
- The central control room shall be located or designated in non-hazardous area.
- Electronic instruments with intrinsically safety shall be engineered and mounted on vendor's pre-arranged and engineered console type , split architecture display and nests.

1.14 MARKING AND TAGGING

1.14.1 As a minimum, the following marking of general items shall be placed on the nameplate of all instruments.

Manufacturer's name.

Model number.

Serial number.

1.14.2 The relevant items of the following general specification shall be marked on the nameplate of all instruments.

Tag number.

Material of body and trim.

Connection size and rating.

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- 1 14.3 Nameplates ,showing tag number and service ,shall be provided for those console mounted instruments ,where facilities exist to carry these.
- 1 14.4 Field-mounted instruments shall ,in general ,be identified by tag number only on a Stainless Steel or Aluminium label in addition to manufacturer's standard nameplate.
The tag number shall also be mentioned on manufacturer's standard nameplate. If the instrument is mounted in an enclosure ,the nameplate shall be located on the fixed part of the enclosure. The nameplate shall not be drilled into instruments.
- 1 14.5 Local panels ,auxiliary racks ,cabinets and junction boxes shall be provided with a nameplate ,showing the identification number.



2 FLOW INSTRUMENTS

2.1 GENERAL

2.1.1 SCOW

2.1.1.1 This section covers the minimum requirements for primary flow elements and transmitters.

2.1.1.2 The minimum rating for all in-line mounted instrument devices shall be 300 lbs.

2.1.2 References (Latest Edition)

API RP550 Installation Refinery Instruments and Control Systems.

AGA Gas Measurement Committee Report No. 3, Orifice Metering of Natural Gas.

ASME Fluid Meters-Their Theory and Applications.

Principles and practice of Flow Meter Engineering, by L.K. Spink.

2.2 PRIMARY ELEMENTS

2.2.1 Orifice Plates

2.2.1.1 Orifice bores shall be calculated by using the formula based on AGA Report No.3 or Principles and Practice of Flow Meter Engineering by L.K.Spink, latest edition . Maximum flow rate shall be chosen so that a rounded factor is available.

2.2.1.2 Local flow measurements for use with orifice plates or other d.p. devices shall be of the filled bellows type. The standard range for differential pressure meters shall be as follow 500 mm, 1250 mm, 2500 mm and 5000 mm water gauge. Differential pressure range shall normally be 0.25 bar (100" water column). However , for gas and vapor service, the differential pressure range in bar(inches of water) shall normally not exceed the absolute pressure in bara(psia).

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- 2.2.1.3 Meter range shall be selected in accordance with the following guide lines.
For orifice meters, normal flow rate shall be between 40% to 80% of capacity, provided anticipated minimum, maximum flow rate will be between 15% to 95% of capacity.
- 2.2.1.4 Orifice plates shall generally be used for flow measurement; except in the following circumstances:
- Where accuracy required is higher than normally obtained from an orifice plate.
 - Where wide vibrations in flow rate occur.
 - Where system allowable pressure drop is very small.
 - Where measuring highly viscous liquids and slurries.
 - Where piping layouts prevent the use of adequate straight lengths.
- 2.2.1.5 Slip-plates with orifice flange taps shall be used for line sizes 1" NB and larger.
- 2.2.1.6 The minimum pipe size for an orifice meter run shall be 1 1/2". For pipe size less than 1 1/2", special calibrated meter run shall be considered, or the line be increased to 2" and a standard concentric orifice plate be used.
- 2.2.1.7 Meter run tolerance with respect to smoothness, out of round, etc., shall be 0.5% of D, based on a ratio of 0.70. The tolerance varies with the d/D ratio and may be considered a straight line function when plotted versus the d/D ratio with a tolerance of 0.5% at d/D = 0.70 and a tolerance of 4.5% at d/D = 0.10.
- 2.2.1.8 The location for the meter run and meter installation shall be selected to provide accessibility from a platform of portable stairs for servicing.
- 2.2.1.9 Integral orifice meters (combination primary elements-measuring device) may be used for small flows.
In conjunction with this type, a suitable strainer shall be installed preceding the meter.
- 2.2.1.10 The pipe size shall be expanded in diameter to avoid d/D ratios exceeding 0.70.

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- 2.2.1.11 Orifice bores of less than 3.2 mm to be avoided. Orifice meter differential range and pipe size shall be selected so that the ratio of orifice diameter to actual internal pipe diameter (d/D) does not exceed 0.7. In any case actual orifice diameter shall not be less than 6.25 mm.
- 2.2.1.12 Flow meters using concentric orifice plate shall normally be used except for the following cases
- a) Where required accuracy is not obtained.
 - b) Where flow rate varies in wide range.
 - c) Where allowable pressure drop is limited.
 - d) High viscosity liquid and slurry service.
 - e) Where other type flow meters are not advantageous.
- 2.2.1.13 Eccentric type orifice plates shall be used for fluids containing two phases. The eccentric type orifice plates shall have the bottom of the orifice bore flush with the bottom ID of the pipe. Eccentric orifice plates shall be used in horizontal only.
- 2.2.1.14 Quadrant edge orifice plates may be used for flow measurement where Reynolds numbers below 10000.
- 2.2.1.15 Bevelled or rounded edge orifice plates shall be used for viscous fluids.
- 2.2.1.16 Drain holes or weep holes for concentric orifices shall be provided at the top of the plate on all liquid services and at the bottom of the plate for steam and gas applications with orifice bores of 25 mm or larger. The drain hole or weep hole may be excluded from the orifice bore calculation.
- 2.2.1.17 The correction factor for viscosity and Reynolds numbers shall be taken as 1.0 for orifice bore calculations, unless an estimated viscosity is available.
- 2.2.1.18 For gas service, a C_p/C_v ratio of 1.3 may be used in the calculation of the orifice bore, when none is available.



- 2.2.1.19 The minimum orifice flange rating shall be 300 lbs ANSI. The use of higher rated flanges, or of facing other than raised face, shall be as called for in the piping specification.
- 2.2.1.20 For location of orifice taps, see NPCS-SD-PI-24. When space problems occur, 45 taps on the orifice flanges are acceptable.
- 2.2.1.21 Orifice bore tolerance shall be as follow:

Orifice Size		Tolerance Plus or Minus	
mm	(inch)	mm	(inch)
6.350	10.2500)	0.007	(0,0003)
9.525	(0.3750)	0.013	(0.0005)
12.700	(0.5000)	0.015	(0.0006)
15.875	(0.6250)	0.020	(0.0008)
19.050	(0.7500)	0.023	(0.0009)
22.225	(0.8750)	0.025	(0.0010)
25.400	(1.0000)	0.031	(0.0012)
31.750	(1.2500)	0.036	(0.0014)
38.100	(1.5000)	0.043	(0.0017)
44.450	(1.7500)	0.051	(0.0020)
50.800-127.0	2.00-5.00	0.064	(0.00251
Over 27.000	(Over 5.000)	0.13*	(0.0005)**

* Per 25 mm of diameter.

** Per inch of diameter.

- 2.2.1.22 Plate material shall be ASTM A240 type 316 or equivalent stainless steel or such superior material as demanded by process conditions, and in accordance with ISA RP3.2.
- 2.2.1.23 Where orifice plates are required for insertion between ring type joints, the orifice shall be mounted in a carrier ring with integral pressure tapings.
- 1.2.1.24 Orifice plates shall be installed in tapped orifice flanges.
For piping around the flanges, see NPCS-CS-IN-01.
A straightening vane is not at acceptable alternate for required upstream length of pipe.
- .2.1.25 Orifice plates shall be 1/8" thick in type 316 S.S. in 6" sizes and smaller, shall be 1/4" thick in 8" to 16" sizes and shall be 3/8" thick in 18" sizes and larger.



2.2.1.26

45' taps on the orifice flanges are not acceptable. The orientation of the pressure taps shall be as follows :

- a) Liquid and steam : horizontal with the valves installed on the same side.
- b) Gas and air : vertical with the valves installed upwards.

If the orientation is impracticable ,the recommendations of API RP550 shall be followed,.

2.2.1.27

Special and Monel Orifice Plate

If holding ring is required, it shall be cadmium -plated carbon steel. Orifice plate and holding screws or snap ring, if required, shall be Monel. Stainless Steel and asbestos gaskets shall not be used.

2.2.1.28

Ring type plate holders shall be manufacturer's standard plate mounting.

2.2.1.29

Each plate shall be provided with a tab with projects beyond the flange. The symbol number, plate material, the actual measuredbore and the ID of the pipe shall be stamped on this tab. The tab shall be in line with the drain or weep hole and shall indicate the direction of flow.

2.2.1.30

Transmitters in a shut-down loop and transmitters in a control loop shall use opposite tapping on a common orifice. Extra transmitters for increasing the flow metering range shall be mounted on the same tapping.

2.2.1.31

Other types of flow elements should be considered where their use is desirable and the above mentioned elements are not applicable.

2.2.1.32

For compressible fluid (gas and steam) flow measurement instruments containing a static pressure recording or indicating element, the flow coefficient shall incorporate a multiplier for pressure. The pressure multiplier shall be calculated for use on a 0-10 square root chart and shall be the square root of the full absolute static pressure. For the pressure element range, see "Pressure Instruments", section 4 of this standard.

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2.2.2 Other Primary Elements for Differential Meters

2.2.2.1 Annubar elements may be used for steam ,gas or clean liquid services of 10" or larger piping diameter.

2.2.2.2 Flow nozzles may be used for the high viscosity service such as high pressure steam.

2.2.2.3 Venturi tubes may be used where the high capacity or good pressure recovery is required , e.g. gas compressor suction.

2.2.2.4 Pitot and pitot venturi elements may be used where high accuracy is not required or the pipe diameter is too large for acceptable orifice plate design. Venturi meters shall be in accordance with DIN standards.

2.2.3 Orifice ,Flow nozzle and Venturi Tubes Installation

- a) The orifice shall be installed in the horizontal section of piping as a rule. In the following cases ,it may be installed in the vertical section of piping:
- Dry gases.
 - When it is ensured that the fluid is liquid and that the pipe is essentially filled with liquid.
- b) The installation position of orifice shall be determined so that a straight section of a pipe will be provided as needed in the upstream and downstream across the orifice. The distance of the straight section of pipe shall be determined by considering the condition of pipe fittings and the opening ratio of the orifice according to ASME. General use pipe shall be used as a orifice meter run where orifice flow measurement shall be adopted as general operation monitoring and controlling. Machined metering pipe shall be used where orifice flow measurement shall be used as custody transfer monitoring.
- c) Differential pressure transmitters may only be mounted directly on the pipelines where the transmitter has to be installed ,for process requirements ,in the same level as the orifice (It is called pipe mounting).



d) The orifice taps shall be preferably located on the horizontal and vertical taps; these are considered permissible for dry vapour or liquids.

2.2.4

Positive Displacement Meters

2.2.4.1

Positive displacement flow meters shall be used for the following liquid services where high accuracy (within $\pm 0.5\%$) measurement is required.

- a) High viscosity service.
- b) Indication limited to local application.
- c) Where inadequate meter run is provided for turbine meter.
- d) Where integrated flow quantity and high accuracy is required.
- e) Where such method is desirable or required by customs regulations, weight and measures acts or other statutory regulations.

2.2.4.2

Installation of positive displacement meters for liquid services shall be arranged to ensure continuous flooding of the meter and shall include a strainer with indication of differential pressure and drain up-stream of the meter. Except where meeting for customs and excise purposes, a by-pass and isolating valve shall be provided, bridging both strainer and meter. Careful consideration shall be given to bearing type, lubrication and protection against abrasive materials. Each product transfer meter shall be equipped with a transmitter wired to ticket printing counter. Six digit read-out indicators will be used. In addition, air eliminators and flow control valve shall be provided, if required.

2.2.4.3

Body material shall be Carbon Steel of the 130% operating pressure rating.

2.2.4.4

The meter body configuration shall be so constructed to minimize pressure drop through the meter.

2.2.5

Variable Area Flow Meters

2.2.5.1

Variable area flow meters may be used for small flow rates where local indications recording and/or controlling is required. They may also be used where rangeability, nonlinearity, viscosity or the hazardous nature of fluid makes the differential pressure type instrument unsuitable.



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- 2.2.5.2 Area flow meters shall be of metal tube type in principle.
- 2.2.5.3 Glass tube type meters may be used for the following services:
- a) Air, water and nitrogen gas at pressure below 5 barg and ambient temperature.
 - b) Analyzer sampling line and the like, at pressure below 500 mbarg and ambient temperature.
- 2.2.5.4 Gland assemblies shall be of "O" ring construction, unless process conditions require otherwise.
- 2.2.5.5 Tube construction shall be beaded, ribbed or flat except for the plain tapered tubes used for armored type. Plain tapered tubes shall have internal guiding.
- 2.2.5.6 Floats shall be self-cleaning and shall be designed for maximum immunity to viscosity variations and dimensional stability.
- 2.2.5.7 Rotameters shall be completely assembled with all accessories before shipping with the orientation of connections, which shall be noted as if viewed from the front of the rotameter.
- 2.2.5.8 Accuracy shall be within $\pm 2\%$ of full scale.
- 2.2.5.9 Construction
- a) Area flow meters of 3/4" or larger shall have flanged connections.
 - b) Metal tube type meters shall have magnet coupling mechanism for float position detection.
 - c) Process connections of meters shall be bottom-side or bottom-top, except when damper is required.

For the fluid service to be avoided stagnancy such as slurry process, the connection shall be bottom-top.
 - d) Bodies shall have the same pressure rating as that of process line.
 - e) Metering tubes and floats of metal tube type meters shall be of 316 stainless steel.



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- f) The material of metering tubes for glass tube type meters shall be hard glass and that of floats shall be 316 Stainless Steel.
- g) Meter bodies shall be equipped with inlet and outlet float stops and where feasible, clean-out plugs which may be utilized as connection taps.
- h) Indicating scales shall have length safety glass shielding which is gasketed both sides and shall be approximately 125 mm in length of extension meters used for transmitting service or for armored meters and 250 mm on length for local indicators not of the armored type.

2.2.5.10 Variable area meters shall be installed so that repair, maintenance and replacement will not disturb the operation of the plant. If isolation valves are required, they shall be gate type of the same size as the meter connections. The by-pass valves, if required, should be a gate type and sized the same as the main line.

2.2.5.11 The meter body configuration shall be so constructed to minimize pressure drop through the meter.

2.2.5.12 Nonreset type counters with calibration adjustments shall be provided. Counters shall be weatherproof.

2.2.5.13 Straight through strainers with mesh size, material and rating as will be noted on the data sheets, shall be installed preceding each meter.

2.2.5.14 The accuracy of measuring device shall be 0.2% of full flow.

2.2.5.15 Any of the following requirements shall be provided, if specified on the data sheets :

- a) Automatic temperature compensation.
- b) Additional reset type counters.
- c) Electrical transmission to remotely located accessories complete with auxiliary contact for set stop valves and other accessories as what will be specified on the data sheets.