MODULE 1:

INSTRUMENTATION

DRAWINGS & SYMBOLS

INSTRUMENTATION DRAWINGS & SYMBOLS

Objectives

At completion of this module, the trainee will have understanding of:

1. Instrumentation symbols and abbreviations,
2. Structure of instrument codes (Tag Numbers),
3. Process Block Diagram
4. Process Flow Diagram (PFD)
5. Piping and Instrumentation Drawing (P&ID)
6. Electrical Loop Drawing
7. DCS (I/O) Input & Output Loop Drawing
8. Pneumatic Loop drawing
9. Cause and Effect Diagram
10. Functional Logic Diagram
11. Instrument Installation Hook-Up Diagram (Pneumatic or Process)

Introduction

This manual has been written to provide the reader with an understanding of the various codes and symbols used to illustrate instrumentation in facilities designed for the production of oil, gas and associated hydrocarbon products.

Instrument codes and symbols are graphically represented in technical diagrams such as Process Flow Schemes (PFD) and in Pipeline and Instrumentation Drawings (P&ID).

Such drawings are of particular importance to operation and maintenance technicians who are required to understand the process control systems associated with an installation.

However, difficulties are often experienced primarily due to the existence of several systems of instrument codes and symbols which have been developed over the years by owners and contractors who carry out the engineering design, construction and operation of processing installations.

Purpose of Codes and Symbols

The primary purpose of using codes and symbols is to enable the various instrument functions required in a process to be clearly and concisely represented on Process Flow Diagrams (PFD) and on Pipeline and Instrumentation Drawings (P&ID).

The measuring instrument and control device function codes and symbols indicate which process parameter is being measured, the relative locations of the measurement and control devices and the permissible limits applicable to certain variable process conditions.

In cases where supervisory computer systems are installed in a system, special symbols are used to indicate the computer and the instruments, which are connected to it.

For instance, letter codes and symbols permit the following instrument; functions to be graphically represented.

Process Monitoring Instrument Codes

- Flow rate (F)
- Level (L)
- Pressure (P)
- Quality (Q)
- Speed (S)
- Temperature (T)

These codes are integrated with various symbols to distinguish between indicators, recorders and in certain cases, their geographical locations.

At the end of this section, there are several sheets contain wide range of the applicable instrument symbols and abbreviations.

Emergency or Safety Instrument Codes

A list is given below, for the abnormal conditions, which must be measured by function qualification instruments. State display or alarm signals from such instruments are for the purpose of alerting the process operator, thus enabling corrective action to be taken. In cases of emergency or to safeguard vital equipment, the instruments automatically initiate trip or shutdown actions.

- High level (H) initiates an alarm.

- Extreme high level (HH) trips the inlet valve shut.

- Low level (L) initiates an alarm.

- Extreme low level (LL) trips the outlet valve shut.

Low flow (L) initiates an alarm and may also open a minimum flow spill-back or recycle valve to prevent the pump from overheating. Extreme low flow (LL) trips the pump motor to prevent damage.

High-pressure (H) increases the overhead condenser coolant flow. Extreme high pressure (HH) initiates an alarm and opens a vent valve to flare.

High temperature (H) initiates an alarm. Extreme high temperature (HH) trips the fuel inlet valves to protect the furnace coil from overheating.

Structure of the Instrument Codes

In general, every conventional measuring or controlling instrument Installed in a process unit is identified by three separate codes as follows.

- A location number code indicates the specific process unit in which the instrument is installed.
- A function letter code indicates the property or process variable being measured or controlled.
- A serial number code identifies the specific instrument and therefore prevents confusion when there are several Instruments In a single process unit, each having the same function letter code.

The combination of the three codes is known as the Instrument tag number, which has the basic format -

xx a - yyy

TAG NUMBERS

"**xx**" is a two-digit number used to identify the process unit.

'a' is a letter code containing two or more capital letters and is used to identify the instrument function.

'yyy' is a three-digit number used to identify the particular instrument.

When the instrument code or tag number is written on a drawing or document, a dash is inserted between the '**a**' and the '**yyy**' sections of the format. For example, a pressure indicating controller installed in a process unit coded **10** and identified by serial number **101**, is described in written form as **10 - PIC - 101**.

In the case of the same tag numbers, the process pressure correcting element, usually a control valve, often has the same tag number as the control instrument.

However, when the controller operates two valves in a split range mode, the valves are tagged and numbered consecutively, for example,

10 - PIC - 101 ----------→ **10 – PCV – 101-1**

10 – PCV – 101-2

NOTE:

Refer to the Following reference documents in the next pages:

1- List of General Abbreviations
2- List of Instrument Identification Code
3- Instrument Symbols (ISA S501)
4- Legend of Symbols

GOW	Gas/Oil/Water
gpm	gallons per minute
GT	Gas Turbine
H_2S	Hydrogen Sulphide
HHP	High-High Pressure
HP	High Pressure
hr	hour
HSE	Health, Safety and Environment
HVAC	Heating/Ventilation/Air-conditioning
in	inch
IR	Infra Red
KO	Knock-out
lb	pound (weight)
LC	Locked Closed
LCR	Local Control Room
LCV	Level Control Valve
LED	Light Emitting Diode
LEL	Lower Explosive Limit
LER	Local Equipment Room
LI	Level Indicator
LIC	Level Indicator Controller
LNG	Liquefied Natural Gas
LO	Locked Open
LP	Low Pressure
LPG	Liquefied Petroleum Gas
LT	Level Transmitter

M	Thousand
m^2	square metres
m^3	cubic metres
MAC	Manual Alarm Callpoint
MAWP	Maximum Allowable Working Pressure
MGL	Main Gas Line
MM	Million
mmscfd	million standard cubic feet per day
MOL	Main Oil Line
MOOCS	Modernization of Offshore Control Systems
MOV	Motor Operated Valve
MSF	Main Structure Frame
MTU	Master Telemetry Unit
N_2	Nitrogen
NGL	Natural Gas Liquids
NO	Normally Open
NRV	Non-return Valve
NTP	Normal Temperature and Pressure
OCCP	Original Central Collection Platform
O/I	Output/Input
OIS	Operator Interface Station
P&ID	Piping and Instrument Diagram
PAH	Pressure Alarm High
PAHH	Pressure Alarm High-High
PAL	Pressure Alarm Low
PALL	Pressure Alarm Low-Low
PC	Personal Computer

PCS	Process Control System
PCV	Pressure Control Valve
PDIC	Pressure Differential Indicator Controller
PDRC	Pressure Differential Recorder Controller
PFD	Process Flow Diagram
PGP	Power Generation Platform
PIC	Pressure Indicator Controller
PLC	Programmable Logic Controller
ppm	parts per million
psia	pounds per square inch (absolute)
psig	pounds per square inch (gauge)
PSLL	Pressure Switch Low-Low
PSU	Power Supply Unit
PSV	Pressure Safety Valve
PTB	Pounds per Thousand Barrels
RFIS	Remote Flare Ignition System
RO	Restriction Orifice
RTU	Remote Telemetry Unit
RV	Relief Valve
SCADA	Supervisory Control and Data Acquisition
SDV	Shutdown Valve
sec	second(s)
SG	Specific Gravity
SOV	Solenoid Operated Valve
SSV	Surface Safety Valve
TAH	Temperature Alarm High
TAHH	Temperature Alarm High-High

TAL	Temperature Alarm Low
TALL	Temperature Alarm Low-Low
Temp	Temperature
TIC	Temperature Indicator Controller
TSLL	Temperature Switch Low-Low
UPS	Uninterruptible Power Supply
US	Umm Shaif
US gal	United States Gallons
USSC	Umm Shaif Super Complex
UTC	Unique Tracking Commodity (used in PASSPORT)
UV	Ultra Violet
VDU	Visual Display Unit
wg	water gauge (inches pressure)
WI	Water Injection
WIP	Water Injection Platform
WO	Work Order
WV	Wing Valve
XV	Emergency Shutdown Valve
ZCC	ZADCO Central Complex
°C	degrees Centigrade
°F	degrees Fahrenheit

FUNCTION IDENTIFICATION CODE

Term	Code
AMMETER	II
ANALYSER ALARM HIGH	AAH
ANALYSER ALARM HIGH-HIGH	AAHH
ANALYSER ALARM LOW	AAL
ANALYSER ALARM LOW-LOW	AALL
ANALYSER ALARM MULTIFUNCTION	AAU
ANALYSER MULTIFUNCTION	AU
ANALYSER ELEMENT	AE
ANALYSER INTEGRATE ELEMENT (AUTO-SAMPLER)	AQE
ANALYSER INTEGRATE ALARM HIGH	AQAH
ANALYSER INTEGRATE ALARM LOW	AQAL
ANALYSER INDICATOR CONTROLLER	AIC
ANALYSER INDICATING TRANSMITTER	AIT
ANALYSER RECORDER	AR
ANALYSER RECORDER CONTROLLER	ARC
ANALYSER RECORDING SWITCH	ARS
ANALYSER SWITCH	AS
ANALYSER SWITCH LOW	ASL
ANALYSER SWITCH HIGH	ASH
ANALYSER TRANSMITTER	AT
BURNER ALARM LOW	BAL
BURNER CONTROLLER	BC
BURNER ELEMENT	BE
BURNER GLASS	BG
BURNER INDICATOR	BI
BURNER RECORDER	BR
BURNER SCAN CONTROLLER	BJC
BURNER SCAN INDICATOR	BJI
BURNER SCAN RECORDER	BJR
BURNER SWITCH	BS
BURNER TRANSMITTER	BT
COMBINATION ELEMENT	UE
COMBINATION SWITCH	US
COMBINATION SCAN CONTROLLER	UJC
COMBINATION SCAN INDICATOR	UJI
COMBINATION SCAN RECORDER	UJR
CONDUCTIVITY ALARM	CA

Term	Code
CONDUCTIVITY ALARM HIGH	CAH
CONDUCTIVITY ALARM LOW	CAL
CONDUCTIVITY ELEMENT	CE
CONDUCTIVITY INDICATOR	CI
CONDUCTIVITY INDICATING CONTROLLER	CIC
CONDUCTIVITY RECORDER	CR
CONDUCTIVITY RECORDING CONROLLER	CRC
CONDUCTIVITY SCAN CONTROLLER	CJC
CONDUCTIVITY SCAN INDICATOR	CJI
CONDUCTIVITY SCAN RECORDER	CJR
CONDUCTIVITY SWITCH	CS
CONDUCTIVITY TRANSMITTER	CT
CURRENT ALARM	IA
CURRENT ALARM HIGH	IAH
CURRENT ALARM LOW	IAL
CURRENT CONTROLLER	IC
CURRENT ELEMENT	IE
CURRENT INDICATOR	II
CURRENT INDICATOR CONTROLLER	IIC
CURRENT INDICATING INTEGRATOR	IQI
CURRENT RECORDER	IR
CURRENT RECORDING CONTROLLER	IRC
CURRENT SCAN CONTROLLER	IJC
CURRENT SCAN INDICATOR	IJI
CURRENT SCAN RECORDER	IJR
CURRENT TRANSMITTER	IT
CURRENT TRANSFORMER	IE
DENSITY ELEMENT	DE
DENSITY SWITCH	DS
FLOW ALARM HIGH	FAH
FLOW ALARM LOW	FAL
FLOW DIFFERENTIAL ALARM HIGH	FDAH
FLOW DIFFERENTIAL ALARM HIGH-HIGH	FDAHH
FLOW DIFFERENTIAL ALARM LOW	FDAL
FLOW DIFFERENTIAL SWITCH LOW	FDSL
FLOW ELEMENT	FE
FLOW INDICATOR	FI
FLOW INDICATOR CONTROLLER	FIC
FLOW INTEGRATE CONTROLLER	FQC
FLOW INTEGRATE INDICATOR	FQI
FLOW INTEGRATE RECORDER	FQR
FLOW INDICATING TRANSMITTER	FIT

FUNCTION IDENTIFICATION CODE (Contd.)

Term	Code
FLOW MIXER	FX
FLOW QUANTITY INDICATING CONTROLLER	FQIC
FLOW RELAY	FY
FLOW RECORDER	FR
FLOW SCAN CONTROLLER	FJC
FLOW SCAN INDICATOR	FJI
FLOW SCAN RECORDER	FJR
FLOW SWITCH	FS
FLOW SWITCH LOW	FSL
FLOW SWITCH HIGH	FSH
FLOW TRANSMITTER	FT
FLOW TEMPERATURE ALARM	FTA
FLOW VALVE	FV
HAND CONTROL STATION	HK
HAND LIGHT SWITCH	HLS
HAND RELAY	HY
HAND SAFETY SWITCH	HSS
HAND SCAN SWITCH	HJS
HAND SWITCH	HS
LEVEL ALARM HIGH	LAH
LEVEL ALARM HIGH-HIGH	LAHH
LEVEL ALARM LOW	LAL
LEVEL ALARM LOW-LOW	LALL
LEVEL CONTROL	LC
LEVEL CONTROL SWITCH	LCS
LEVEL GAUGE	LI
LEVEL INDICATOR	LI
LEVEL INDICATING TRANSMITTER	LIT
LEVEL SCAN CONTROLLER	LJC
LEVEL SCAN INDICATOR	LJI
LEVEL SCAN RECORDER	LJR
LEVEL SWITCH HIGH	LSH
LEVEL SWITCH HIGH-HIGH	LSHH
LEVEL SWITCH LOW	LSL
LEVEL SWITCH LOW-LOW	LSLL
MOISTURE ALARM	MA
MOISTURE ALARM HIGH	MAH
MOISTURE ALARM LOW	MAL
MOISTURE ELEMENT	ME
MOISTURE SCAN CONTROLLER	MJC
MOISTURE SCAN INDICATOR	MJI
MOISTURE SCAN RECORDER	MJR
MOISTURE SWITCH	MS
MOISTURE TRANSMITTER	MT
MULTIFUNCTION SCAN ALARM	UJA
MULTIFUNCTION SCAN INDICATOR	UJI
MULTIFUNCTION SCAN RECORDER	UJR
MULTIVARIABLE MULTIFUNCTION	UU
MULTIVARIABLE SCAN TRANSMITTER	UJT
POSITION ALARM	ZA
POSITION CONTROLLER	ZC
POSITION ELEMENT	ZE
POSITION INDICATOR	ZI
POSITION RECORDER	ZR
POSITION INDICATING CONTROLLER	ZIC
POSITION RECORDING CONTROLLER	ZRC
POSITION SCAN CONTROLLER	ZJC
POSITION SCAN INDICATOR	ZJI
POSITION SCAN RECORDER	ZJR
POSITION SWITCH	ZS
POSITION TRANSMITTER	ZT
POWER ALARM	JA
POWER ALARM HIGH	JAH
POWER ALARM LOW	JAL
POWER ELEMENT	JE
POWER CONTROLLER	JC
POWER INDICATOR	JI
POWER RECORDER	JR
POWER INDICATING CONTROLLER	JIC
POWER RECORDING CONTROLLER	JRC
POWER SCAN CONTROLLER	JJC
POWER SCAN INDICATOR	JJI
POWER SCAN RECORDER	JJR
POWER SWITCH	JS
POWER TRANSMITTER	JT
PRESSURE ALARM HIGH	PAH
PRESSURE ALARM LOW	PAL
PRESSURE DIFFERENTIAL ALARM HIGH	PDAH
PRESSURE DIFFERENTIAL SWITCH HIGH	PDSH
PRESSURE DIFFERENTIAL INDICATOR	PDI
PRESSURE DIFFERENTIAL INDICATING CONTROLLER	PDIC
PRESSURE INDICATOR	PI
PRESSURE INDICATING TRANSMITTER	PIT
PRESSURE POINT	PP
PRESSURE RECORDER CONTROLLER	PRC
PRESSURE SCAN INDICATOR	PJI
PRESSURE SCAN RECORDER	PJR
PRESSURE SWITCH	PS
PRESSURE SWITCH HIGH	PSH
PRESSURE SWITCH LOW	PSL
PRESSURE VALVE	PV
QUANTITY ALARM	QA
QUANTITY ALARM HIGH	QAH
QUANTITY ALARM LOW	QAL
QUANTITY CONTROLLER	QC

FUNCTION IDENTIFICATION CODE (Contd.)

Term	Code
QUANTITY INDICATOR	QI
QUANTITY RECORDER	QR
QUANTITY INDICATING CONTROLLER	QIC
QUANTITY INDICATING INTEGRATOR	QQI
QUANTITY RECORDING CONTROLLER	QRC
QUANTITY SCAN CONTROLLER	QJC
QUANITTY SCAN INDICATOR	QJI
QUANTITY SCAN RECORDER	QJR
QUANITY SWITCH	QS
QUANTITY TRANSMITTER	QT
SPEED ALARM SWITCH LOW	SASL
SPEED SWITCH	SS
SPEED TRANSMITTER	ST
TEMPERATURE ALARM HIGH	TAH
TEMPERATURE ELEMENT	TE
TEMPERATURE INDICATOR	TI
TEMPERATURE SCAN INDICATOR	TJI
TEMPERATURE SCAN RECORDER	TJR
TEMPERATURE SWITCH HIGH	TSH
TEMPERATURE TRANSMITTER	TT
THERMOWELL	TW
TIME ALARM	KA
TIME ALARM HIGH	KAH
TIME ALARM LOW	KAL
TIME CONTROLLER	KC
TIME INDICATOR	KI
TIME RECORDER	KR
TIME INDICATING CONTROLLER	KIC
TIME INDICATING INTEGRATOR	KQI
TIME RECORDING CONTROLLER	KRC
TIME RELAY	KY
TIME SCAN CONTROLLER	KJC
TIME SCAN INDICATOR	KJI
TIME SCAN RECORDER	KJR
TIME SWITCH	KS
TIME TRANSMITTER	KT
VISCOSITY ALARM	VA
VISCOSITY ALARM HIGH	VAH
VISCOSITY ALARM LOW	VAL
VISCOSITY ELEMENT	VE
VISCOSITY CONTROLLER	VC
VISCOSITY INDICATOR	VI
VISCOSITY RECORDER	VR
VISCOSITY INDICATING CONTROLLER	VIC
VISCOSITY RECORDING CONTROLLER	VRC
VISCOSITY SCAN CONTROLLER	VJC
VISCOSITY SCAN INDICATOR	VJI
VISCOSITY SCAN RECORDER	VJR
VISCOSITY SWITCH	VS
VISCOSITY TRANSMITTER	VT

INSTRUMENTATION SYMBOLS

INSTRUMENT LINE SYMBOLS

ALL LINES TO BE FINE IN RELATION TO PROCESS PIPING LINES.

(1) INSTRUMENT SUPPLY * OR CONNECTION TO PROCESS

(2) UNDEFINED SIGNAL

(3) PNEUMATIC SIGNAL **

(4) ELECTRIC SIGNAL ---------- OR

(5) HYDRAULIC SIGNAL

(6) CAPILLARY TUBE

(7) ELECTROMAGNETIC OR SONIC SIGNAL *** (GUIDED)

(8) ELECTROMAGNETIC OR SONIC SIGNAL *** (NOT GUIDED)

(9) INTERNAL SYSTEM LINK (SOFTWARE OR DATA LINK)

(10) MECHANICAL LINK

OPTIONAL BINARY (ON-OFF) SYMBOLS

(11) PNEUMATIC BINARY SIGNAL

(12) ELECTRIC BINARY SIGNAL ---\-----\--- OR

NOTE: 'Or' means user's choice. Consistency is recommended.

* The following abbreviations are suggested to denote the types of power supply. These designations may also be applied to purge fluid supplies.

AS - Air Supply
IA - Instrument Air } Options
PA - Plant Air
ES - Electric Supply
GS - Gas Supply
HS - Hydraulic Supply
NS - Nitrogen Supply
SS - Steam Supply
WS - Water Supply

The supply level may be added to the instrument supply line, e.g., AS-100, a 100-psig air supply; ES-24DC, a 24-volt direct current power supply.

** The pneumatic signal symbol applies to a signal using any gas as the signal medium. If a gas other than air is used, the gas may be identified by a note on the signal symbol or otherwise.

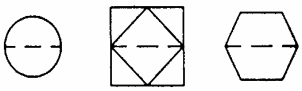
*** Electromagnetic phenomena include heat, radio waves, nuclear radiation, and light.

GENERAL INSTRUMENT OR FUNCTION SYMBOLS

	PRIMARY LOCATION *** NORMALLY ACCESSIBLE TO OPERATOR	FIELD MOUNTED	AUXILIARY LOCATION *** NORMALLY ACCESSIBLE TO OPERATOR
DISCRETE INSTRUMENTS	1 	2 	3 
SHARED DISPLAY, SHARED CONTROL	4 	5 	6 
COMPUTER FUNCTION	7 	8 	9 
PROGRAMMABLE LOGIC CONTROL	10 	11 	12 

* Symbol size may vary according to the user's needs and the type of document. A suggested square and circle size for large diagrams is shown above. Consistency is recommended.

** Abbreviations of the user's choice such as IPI (Instrument Panel #1), IC2 (Instrument Console #2), CC3 (Computer Console #3), etc., may be used when it is necessary to specify instrument or function location.

*** Normally inaccessible or behind-the-panel devices or functions may be depicted by using the same symbols but with dashed horizontal bars, i.e. 

GENERAL INSTRUMENT OR FUNCTION SYMBOLS (Contd.)

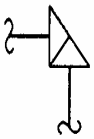
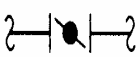
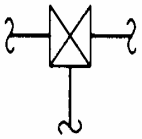
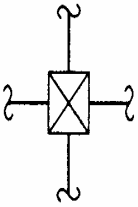
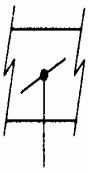
13	14 6TE 2584-23 INSTRUMENT WITH LONG TAG NUMBER	15 INSTRUMENTS SHARING COMMON HOUSING*
16 PILOT LIGHT	17 C 12 PANEL MOUNTED PATCHBOARD POINT 12	18 P ** PURGE OR FLUSHING DEVICE
19 R ** RESET FOR LATCH-TYPE ACTUATOR	20 DIAPHRAGM SEAL	21 I ** *** UNDEFINED INTERLOCK LOGIC

* It is not mandatory to show a common housing.

** These diamonds are approximately half the size of the larger ones.

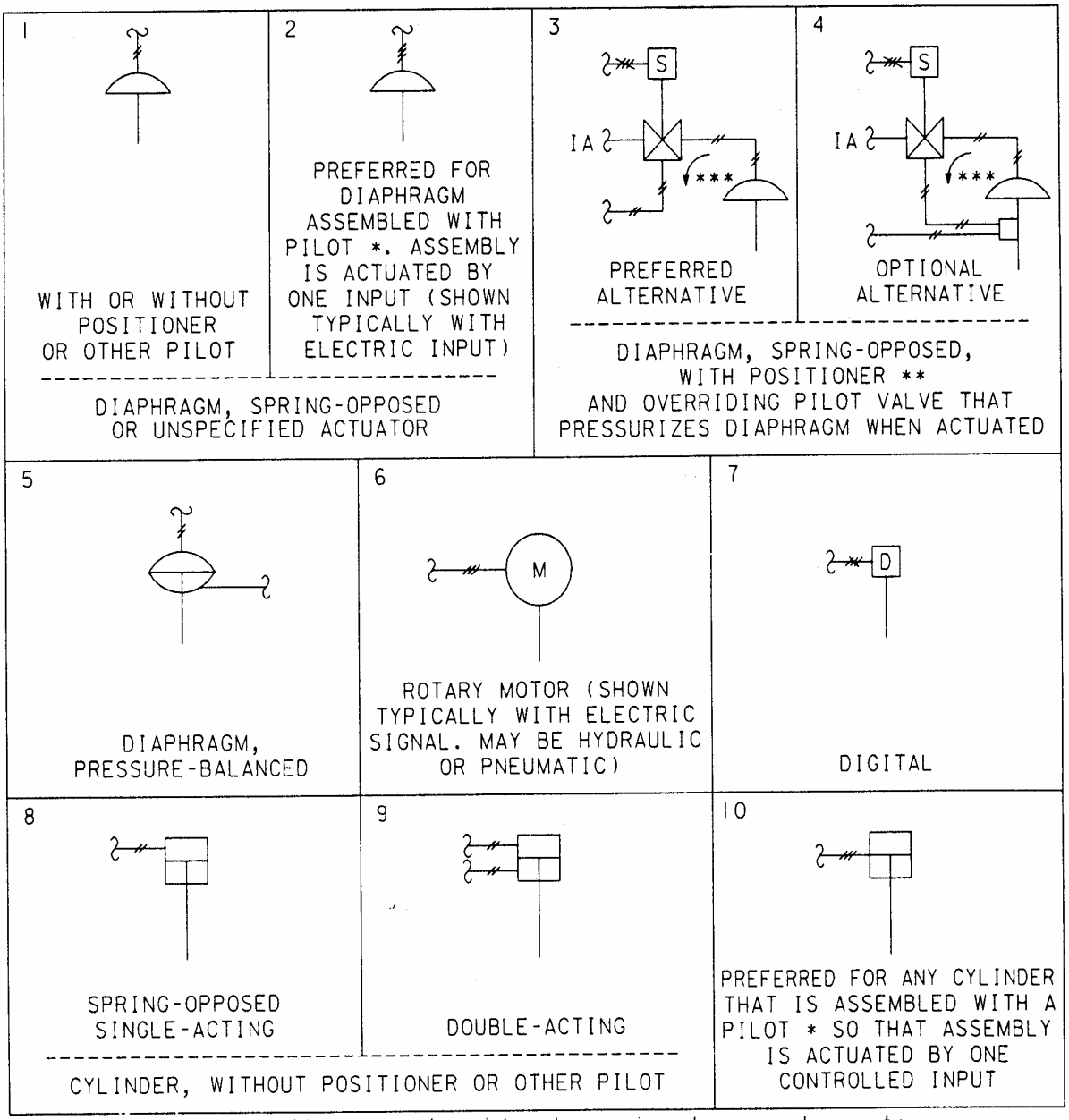
*** For specific logic symbols, see ANSI/ISA Standard S5.2.

CONTROL VALVE BODY SYMBOLS, DAMPER SYMBOLS

1  GENERAL SYMBOL	2  ANGLE	3  BUTTERFLY	4  ROTARY VALVE
5  THREE-WAY	6  FOUR-WAY	7  GLOBE	8
9  DIAPHRAGM	10 	11 	12 
	DAMPER OR LOUVER		

Further information may be added adjacent to the body symbol either by note or code number.

ACTUATOR SYMBOLS

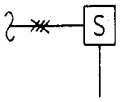
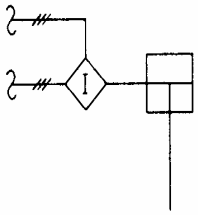
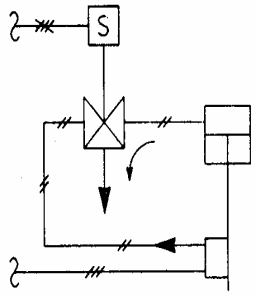
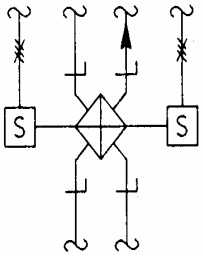
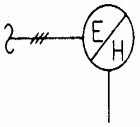
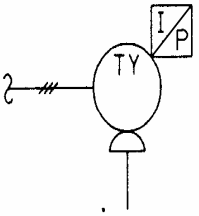
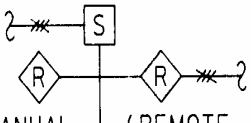


* Pilot may be positioner, solenoid valve, signal converter, etc.

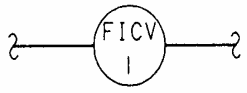
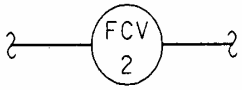
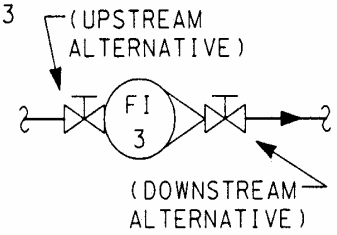
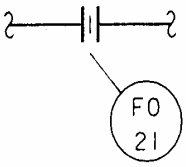
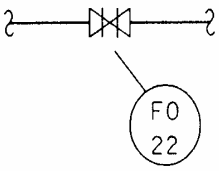
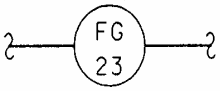
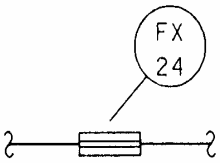
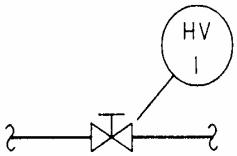
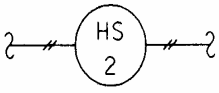
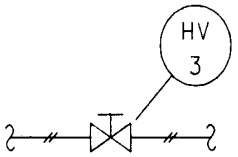
** The positioner need not be shown unless an intermediate device is on its output. The positioner tagging, ZC, need not be used even if the positioner is shown. The positioner symbol, a box drawn on the actuator shaft, is the same for all types of actuators. When the symbol is used, the type of instrument signal, i.e., pneumatic, electric, etc., is drawn as appropriate. If the positioner symbol is used and there is no intermediate device on its output, then the positioner output signal need not be shown.

*** The arrow represents the path from a common to a fail open port. It does not correspond necessarily to the direction of fluid flow.

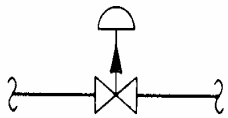
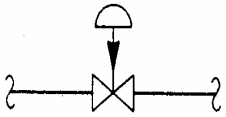
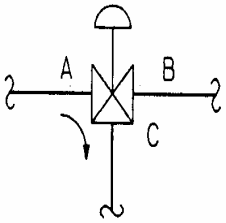
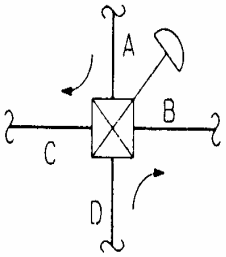
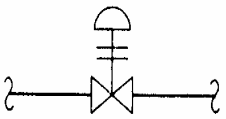
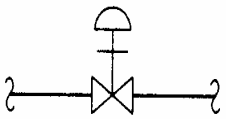
ACTUATOR SYMBOLS (Contd.)

11  SOLENOID	12  PREFERRED ALTERNATIVE. A BUBBLE WITH INSTRUMENT TAGGING, E.G., TY-1, MAY BE USED INSTEAD OF THE INTERLOCK SYMBOL  CYLINDER WITH POSITIONER AND OVERRIDING PILOT VALVE	13  SINGLE-ACTING CYLINDER (IMPLIED I/P)
14  DUAL SOLENOIDS SWITCHING 4-WAY HYDRAULIC VALVE	15  ELECTROHYDRAULIC	16  VALVE ACTUATOR WITH ATTACHED ELECTRO-PNEUMATIC CONVERTER
17  (MANUAL RESET) (REMOTE RESET) LATCH-TYPE ACTUATOR WITH RESET (SHOWN TYPICALLY FOR SOLENOID ACTUATOR AND TYPICALLY WITH ELECTRIC SIGNAL FOR REMOTE RESET, WITH MANUAL RESET ALTERNATIVE)	18  FOR PRESSURE RELIEF OR SAFETY VALVES ONLY: DENOTES A SPRING, WEIGHT, OR INTEGRAL PILOT	19  HAND ACTUATOR OR HANDWHEEL

SYMBOLS FOR SELF-ACTUATED REGULATORS, VALVES, AND OTHER DEVICES

FLOW	1  AUTOMATIC REGULATOR WITH INTEGRAL FLOW INDICATION	2  AUTOMATIC REGULATOR WITHOUT INDICATION	3  INDICATING VARIABLE AREA METER WITH INTEGRAL MANUAL THROTTLE VALVE
	4  RESTRICTION ORIFICE (ORIFICE PLATE, CAPILLARY TUBE OR MULTI-STAGE TYPE, ETC.) IN PROCESS LINE	5  RESTRICTION ORIFICE DRILLED IN VALVE (INSTRUMENT TAG NUMBER MAY BE OMITTED IF VALVE IS OTHERWISE IDENTIFIED)	6  FLOW SIGHT GLASS, PLAIN OR WITH PADDLE WHEEL, FLAPPER, ETC.
	7  FLOW STRAIGHTENING VANE (USE OF TAG NUMBER IS OPTIONAL. THE LOOP NUMBER MAY BE THE SAME AS THAT OF THE ASSOCIATED PRIMARY ELEMENT)	8	9
HAND	1  HAND CONTROL VALVE IN PROCESS LINE	2  HAND-ACTUATED ON-OFF SWITCHING VALVE IN PNEUMATIC SIGNAL LINE	3  HAND CONTROL VALVE IN SIGNAL LINE

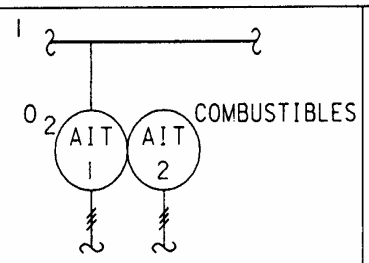
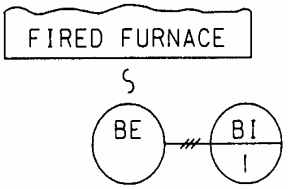
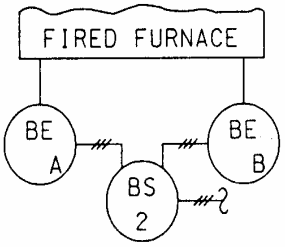
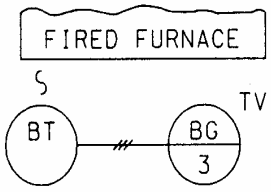
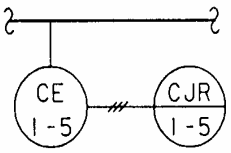
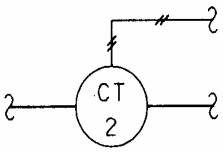
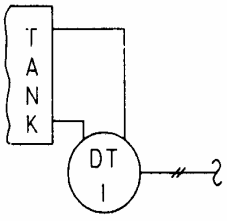
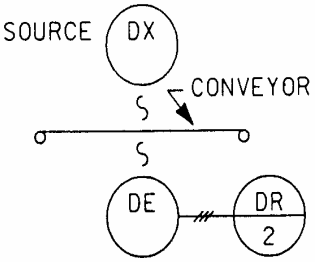
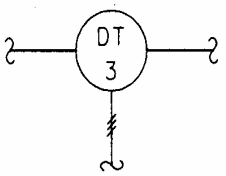
SYMBOLS FOR ACTUATOR ACTION IN EVENT OF ACTUATOR POWER FAILURE. (SHOWN TYPICALLY FOR DIAPHRAGM-ACTUATED CONTROL VALVE)

1  TWO-WAY VALVE, FAIL OPEN	2  TWO-WAY VALVE, FAIL CLOSED	3  THREE-WAY VALVE, FAIL OPEN TO PATH A-C
4  FOUR-WAY VALVE, FAIL OPEN TO PATHS A-C AND D-B	5  ANY VALVE, FAIL LOCKED (POSITION DOES NOT CHANGE)	6  ANY VALVE, FAIL INDETERMINATE

The failure modes indicated are those commonly defined by the term, "shelf-position". As an alternative to the arrows and bars, the following abbreviations may be employed:

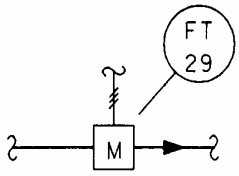
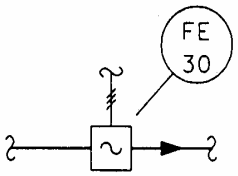
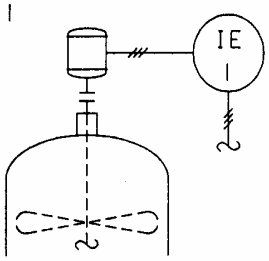
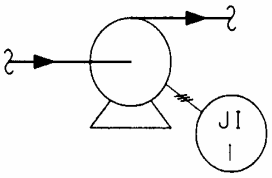
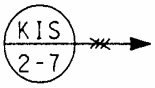
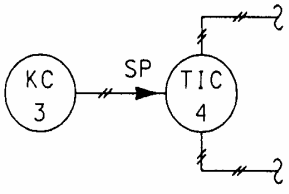
FO - Fail Open
FC - Fail Closed
FL - Fail Locked (last position)
FI - Fail Indeterminate

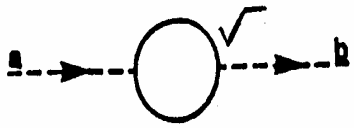
PRIMARY ELEMENT SYMBOLS

	1	2	3
A ANALYSIS	 DUAL ANALYSIS INDICATING TRANSMITTER FOR OXYGEN AND COMBUSTIBLES CONCENTRATIONS		
B BURNER/COMBUSTION	 ONE BURNER ULTRA-VIOLET FLAME DETECTOR CONNECTED TO ANALOG-TYPE FLAME INTENSITY INDICATOR	 TWO BURNER FLAME ROD SENSORS CONNECTED TO COMMON SWITCH	 TELEVISION CAMERA AND RECEIVER TO VIEW BURNER FLAME
C USER'S CHOICE	 CONDUCTIVITY CELL CONNECTED TO POINT 5 OF MULTIPOINT SCANNING CONDUCTIVITY RECORDER	 INLINE CONSISTENCY TRANSMITTER	
D USER'S CHOICE	 DENSITY TRANSMITTER, DIFFERENTIAL-PRESSURE TYPE, EXTERNALLY CONNECTED	 RADIOACTIVE-TYPE DENSITY ELEMENTS CONNECTED TO RECORDER ON PANEL	 SPECIFIC GRAVITY TRANSMITTER, FLOW-THROUGH TYPE

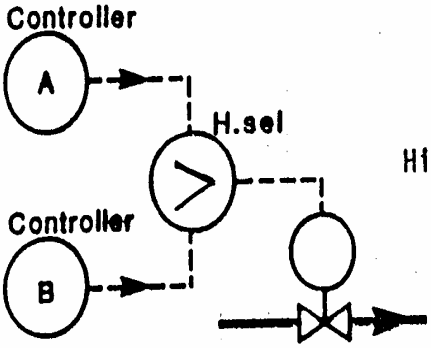
USE OF LETTER C AND D DEFINED ON USER'S LEGEND SHEET

PRIMARY ELEMENT SYMBOLS (Contd.)

F FLOW RATE (Contd.)	22  MAGNETIC FLOWMETER WITH INTEGRAL TRANSMITTER	23  SONIC FLOWMETER "DOPPLER" OR "TRANSIT TIME" MAY BE ADDED	24
I CURRENT	1  CURRENT TRANSFORMER MEASURING CURRENT OF ELECTRIC MOTOR	2	3
J POWER	1  INDICATING WATTMETER CONNECTED TO PUMP MOTOR	2	3
K TIME OR TIME-SCHEDULE	1  CLOCK	2  MULTIPOINT ON-OFF TIME SEQUENCING PROGRAMMER POINT 7	3  TIME-SCHEDULE CONTROLLER, ANALOG TYPE, OR SELF-CONTAINED FUNCTION GENERATOR



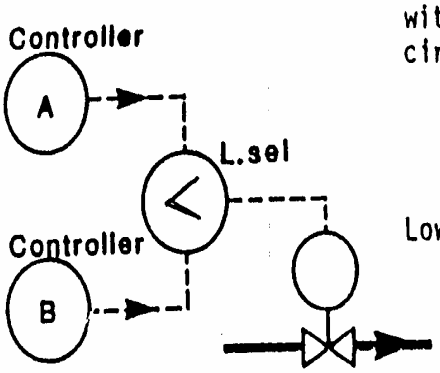
Square root relay



High selector relay

chooses highest signal

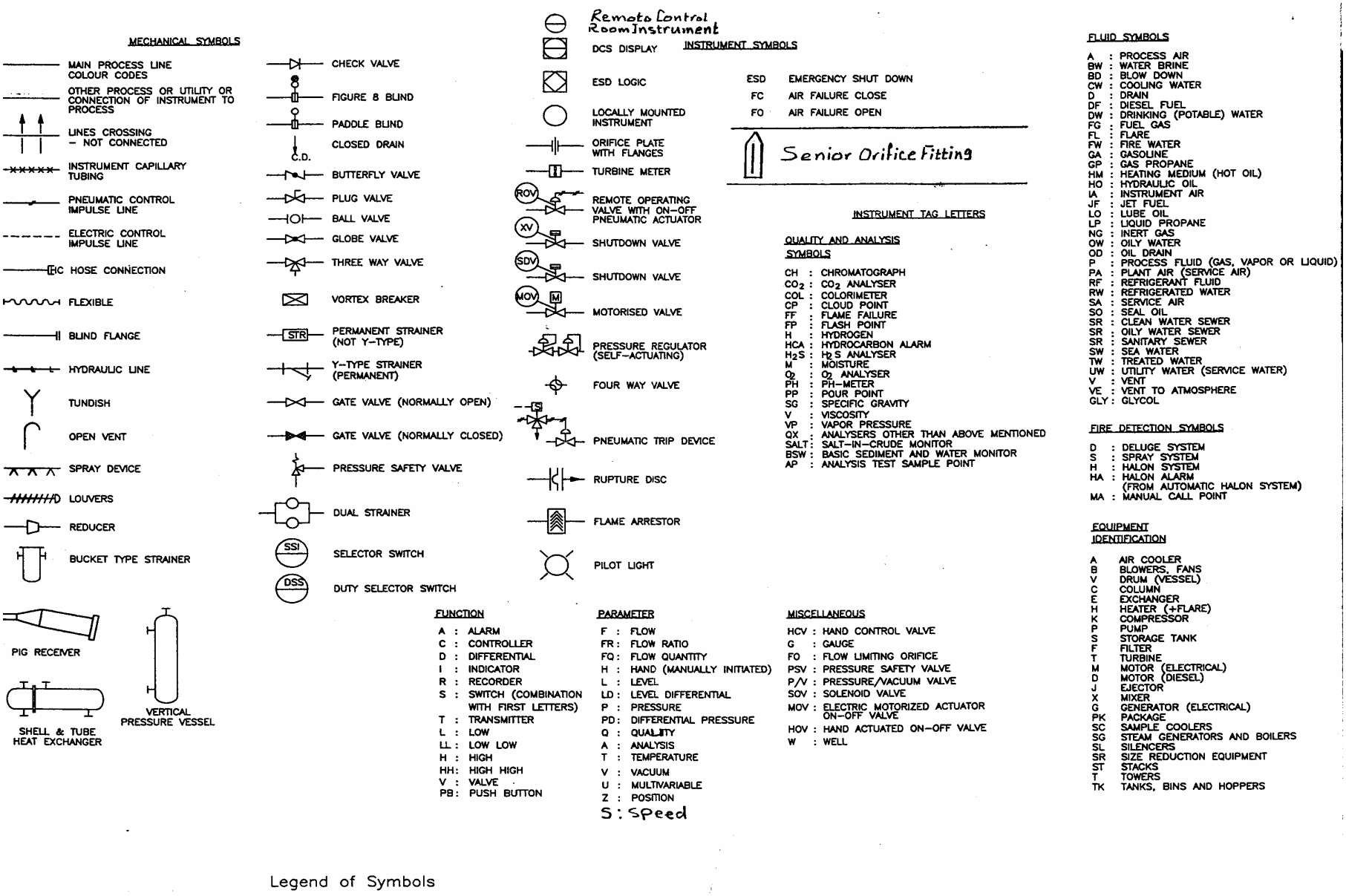
The high selector relay chooses the highest signal from two control instruments and passes this on to a third controller or to a control valve actuator. The Shell symbol for this relay is a 12 mm circle with the abbreviation 'H. sel' written outside the circle and close to its upper right hand (RH) side.



Low selector relay

chooses lowest signal

The low selector relay chooses the lowest signal from two control instruments and passes this on to a third controller or control valve actuator. The Shell symbol for this relay is a 12 mm circle with the abbreviation 'L. sel' written outside the circle and close to its upper RH side.



Legend of Symbols

MODULE 2:

PRESSURE MEASUREMENTS

PRESSURE MEASUREMENT

Objectives

- At Completion of this module, the trainee will have understanding of:
- Pressure definition, types and units.
- Pressure sensing elements.
- Principles of pressure sensing elements; bourbon tubes, bellows, diaphragms, vibrating wires, strain gauges and capacitance sensors.
- Protection devices for pressure measuring elements.
- Pressure measurement devices.
- Function of pressure measurement devices.
- Select a pressure device for a service.
- Identify the types of pressure gauge errors.
- Identify the parts and function of pneumatic and electronic pressure transmitters.
- Describe the difference between electronic and smart transmitters.
- How to Convert 4-20 mA signal to 1-5 vdc signal and why.
- Calculate an output signal of a pressure transmitter at certain input.
- Definition of range and span of a transmitter.
- Field-wiring connection methods of the electronic pressure transmitter.
- Pressure switches types and function.
- Pressure regulators construction parts and function.

Related Safety Regulations for Module I-1: PRESSURE MEASUREMENT
Trainee have to be familiarized with the following **SGC HSE** regulations, while studying this module:
Regulation No. 6: Permit to Work system.
Regulation No. 7: Isolation
7.18 (1-10) control systems procedures and isolations.
Regulation No. 22: Hot and Odd Bolting.
Regulation No. 23: General Engineering Safety.

Pressure Measurement

Oil and gas production operations require that system operating pressures be regulated to specific pressures in order for the system(s) to work properly.

In addition, safety considerations dictate that system operating pressures be monitored and controlled to ensure that the pressure limitations of equipment and piping are not exceeded. In order to meet these objectives, the industry relies on a variety of devices to generate an output signal which may be used to adjust or change the observed pressure, The devices used by the oil and gas industry for sensing operating pressures and generating the needed output signals are described in this manual. The purpose of this document is to provide the reader with an understanding of how the different types of device functions and how they should by applied, in order to satisfy the requirements of system monitoring and control.
Pressure is defined as the force exerted per unit area of surface.

$P = F/A$

P = pressure

F = force

A = surface area exposed to the force

In processing plants the hydrocarbon gases and liquids handled in pipes and vessels exert pressure on the surface area.

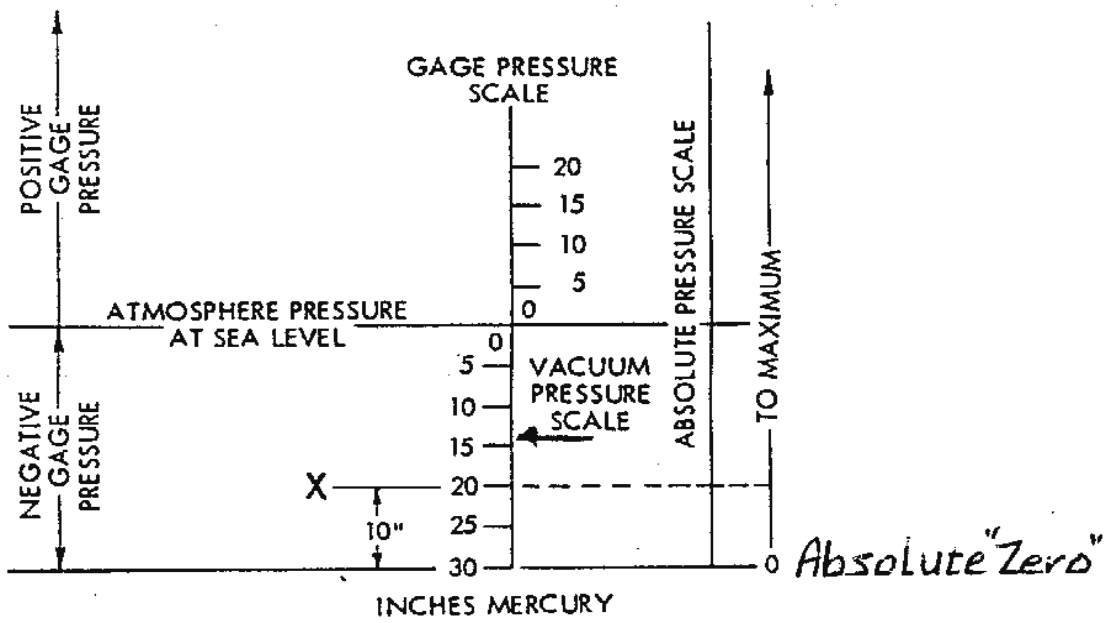
Types of Pressure

In order to understand various types of pressure the following will be considered: Pressure Scale reference points, there are two reference points, the zero point of pressure which is assumed to a perfect vacuum, another point is atmospheric pressure which varies with altitude above sea level and with weather conditions.

Absolute pressure scale starts from a zero reference point representing the full vacuum and extends through atmospheric pressure to the highest limit of measurable pressure.

Gauge pressure scale starts zero reference point representing the local atmospheric pressure and extends to a chosen limit applicable to the specific process system.
Vacuum scale starts from the absolute zero reference point and extends to a maximum represented by atmospheric pressure.

The above can be expressed as following:
Zero of absolute pressure = perfect vacuum
Absolute Pressure = Pressure above Absolute zero
Gauge Pressure = Absolute Pressure – Atmospheric pressure
Vacuum gauge Pressure = Atmospheric Pressure – Fluid Pressure

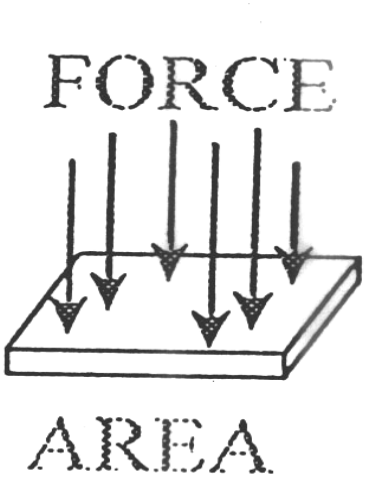


* The pressure at point X can be expressed as 10 inches of mercury absolute, or as 20 inches of mercury vacuum, or as —20 inches of mercury gage.

Pressure Units:

SGC uses a variety of pressure units but the two main systems are the Imperial (British and American) units and the S.I. (System International).

As pressure can be expressed as FORCE divided AREA then the units of pressure can by expressed as the units of force divided by the units of area.



a) Imperial units

In the Imperial system the unit of force is pound force (lbf) and the unit of area is the inch square (in^2). It follows that the unit of pressure in the Imperial system is the pound force divided by the inch square (lbf/Sq. in) (pounds per square inch). This is often abbreviated to PSI.

b) S.I. Unit

In the S.I. system the unit of force is the Newton (N) and the unit of area is the meter square (m2). Therefore the unit of force in the S.I. system is the Newton per square meter (N/m2). This is a very small unit of pressure and the S.I. unit that is more commonly used on the plant is bar. One bar is equal to 100000 N/m^2.

c) Liquid Column

Pressure can also be expressed in terms of liquid column height. The Imperial units are inches water column (in Wc) and the S.I. units are millimeters water column (mm Wc). Imperial units are inches Wc (or Hg) S.I. unitus are mm Wc (or Hg).

Pressure Conversions

The table below gives a few examples of different pressure:

IMPERIAL		S.I.	
Lbf/in^2	lnch Wc	bar	mm Wc
1	27.73	0.06895	703.1
0.03613	1	2.487x10^{-3}	25.4
14.504	402.1	1	10.22x10^3
1.422x10^{-3}	0.03937	97.98x10^{-6}	1

Examples:

1. Change 20 psi to bar

1 psi = 0.06895 bar

20 psi = 20x0.06895 bar

20 psi = 1.379 bar

2. Change 1.6 bar to psi

1 bar = 14.504 psi

1.6 bar= 1.6 x 14.504 psi

1.6 bar= 23.2064 psi

3. Change 100 in Wc to mm Wc

1 inch = 25.4 mm

100 inch = 100 x 25.4 mm

100 in Wc = 2540 mm Wc