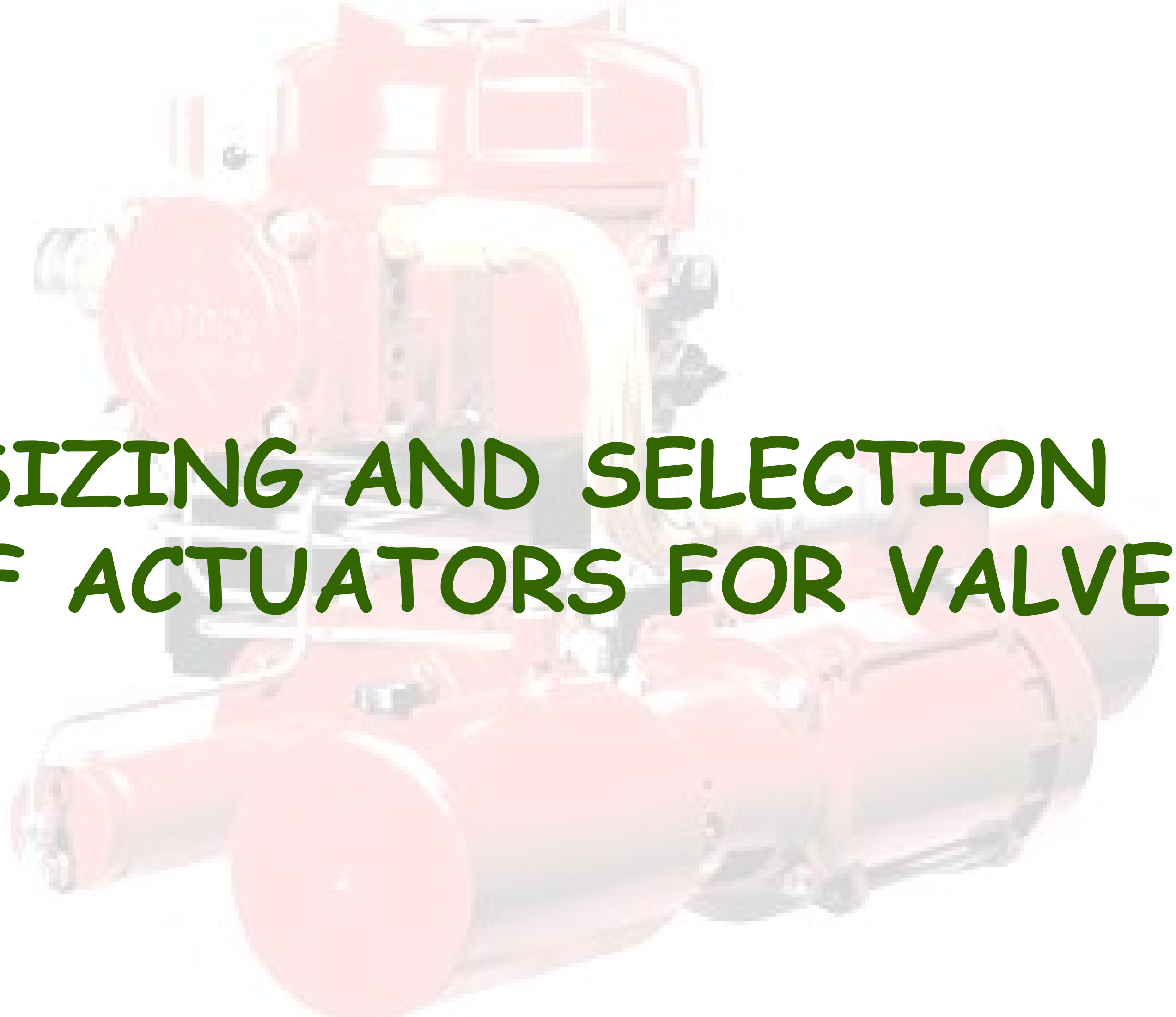
एफ.सी.आर.आई.



SIZING AND SELECTION OF ACTUATORS FOR VALVES

NIDHIN MANOHAR

एफ.सी.आर.आई.

Different types of actuators

Advantages & Disadvantages

Selection of Actuator

Sizing of Actuator

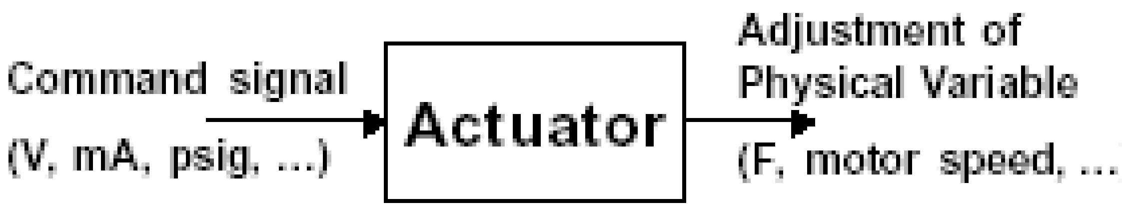
Performance Tests on Actuators

Force / Torque Demanded by valves

S.Rammohan, CRE, Fluid Control Research Institute

ACTUATOR

- **What is actuator?**
  - Actuator converts the command signal from controllers or higher-level components into physical adjustment in adjustable process variable



- **Actuator types**
  - Control valve: pneumatic, electric, hydraulic
  - Electric heater output: SCR, thyristor
  - Pump/Motor speed: inverter
  - Displacement: pneumatic, electric, hydraulic

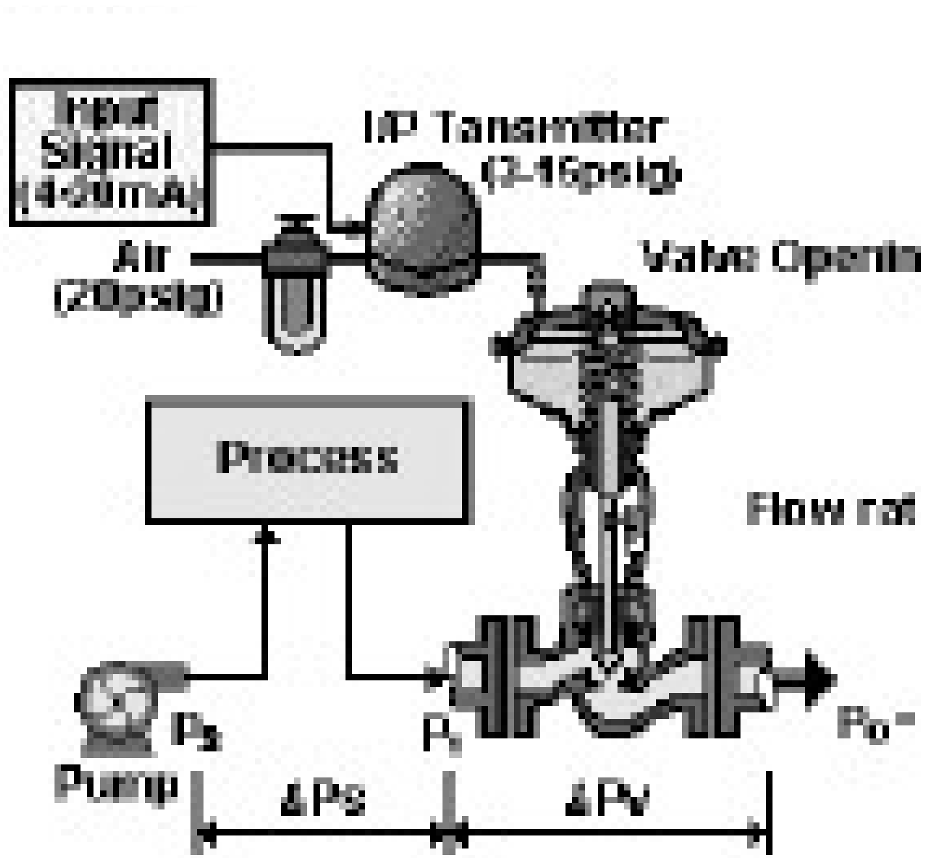
VALVE ACTUATOR

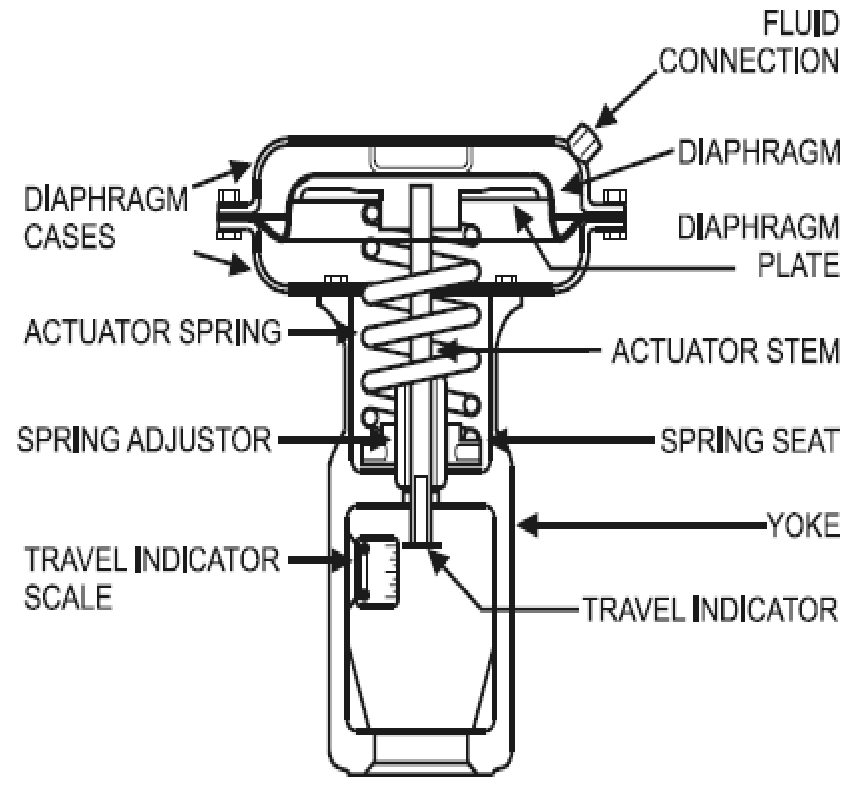
A powered valve operator used to open or close a valve, energised manually or by pneumatic, electric or hydraulic power source.

BASIC FUNCTIONS

- Provide enough thrust/ torque to operate the valve
- Hold the valve gate / plug / disc / ball in required position
- Operate the valve through its full travel at rated speed
- Provide fail safe mode in the event of power failure
- Prevent excessive forces under unfavorable conditions

VALVE ACTUATOR

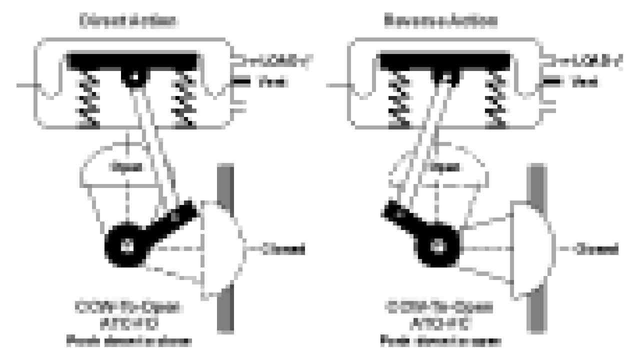


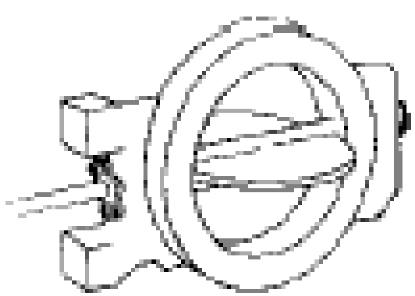


(A) Fluid-to-Extend Stem

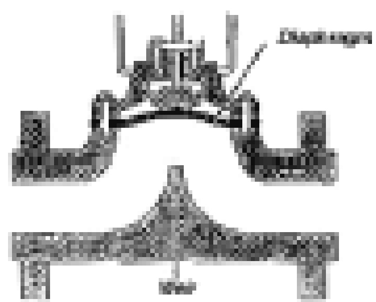
CONTROL VALVE CLASSIFICATION

- Control Valve
  - Linear motion
    - Globe
      - 2 way
      - angle
      - 3 way
        - Single seated
        - Double seated
        - Split bodied
    - Diaphragm
    - Pinch or clamp
    - Gate
  - Rotary motion
    - Eccentric plug
    - Butterfly
    - Ball

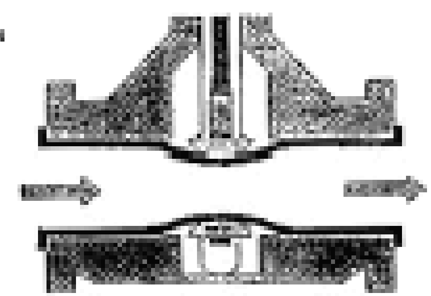




Butterfly



Diaphragm

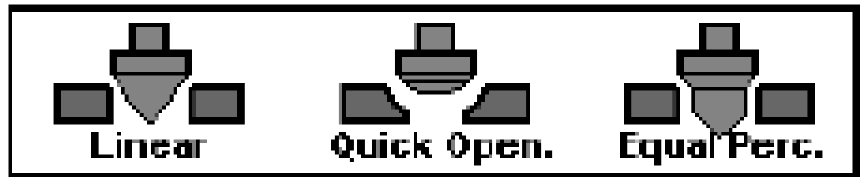


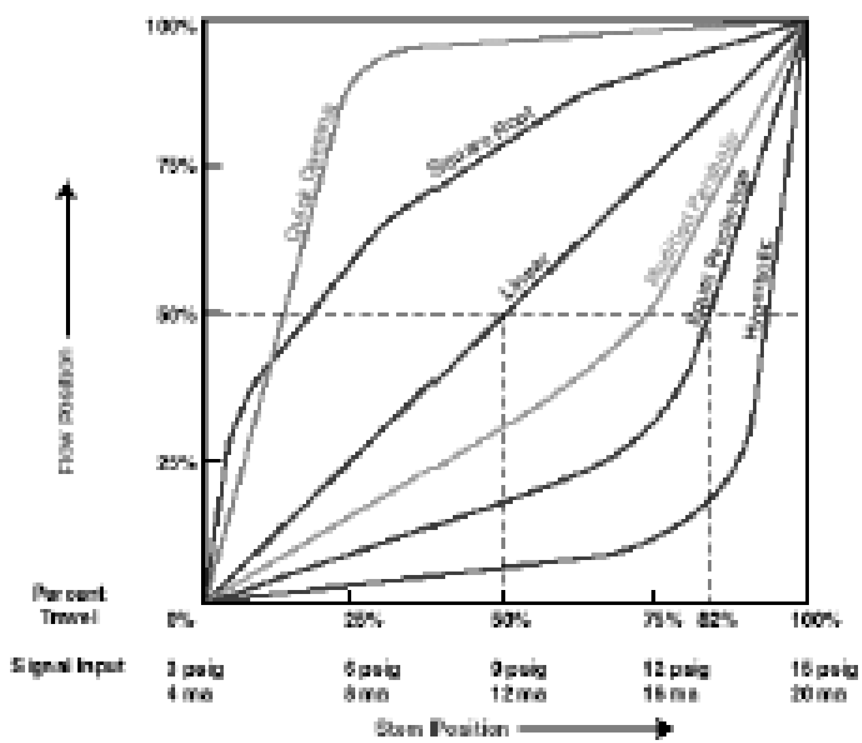
Pinch

Gate

VALVE TRIM(PLUG) TYPE

- Equal Percentage
  - **Most commonly used**
  - **Used where large pressure drop is expected**
- Linear
  - **Used where fairly constant press. drop is expected**
  - **Used for liquid level or flow loop**
- Quick Opening
  - **Used for frequently on-off service**
  - **Used where instantly large flow is needed**





Actuator

Linear

Rotary

Manual

Lever
Hand wheel
Gear box

Electric

Motor
Solenoid

Pneumatic

Diaphragm
Piston
Cam, Vane

Hydraulic

Fail safe
Fire safe

PNEUMATIC ACTUATOR

Uses compressed air as the source of energy

Actuator o/p force proportional to air pressure

Capacity decided by

- Operation time
- Force demanded
- Size of piping required to deliver air

Diaphragm

Piston

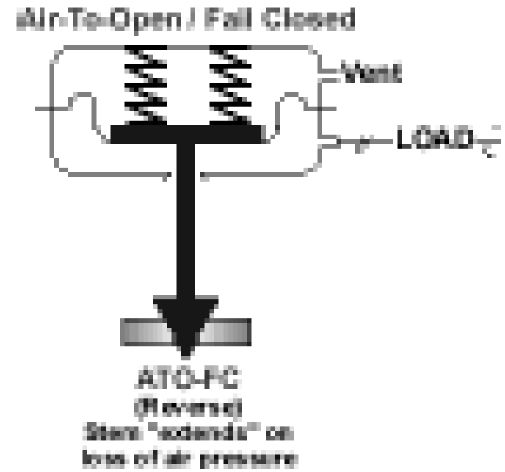
Cam

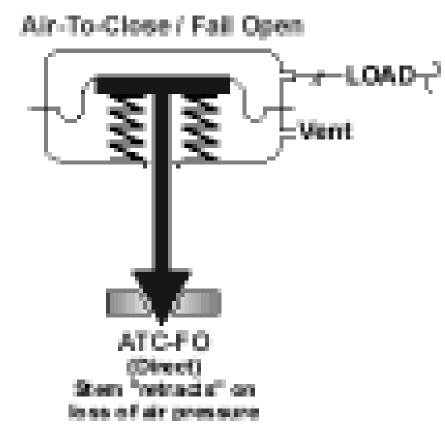
Actuator types - operation

- **As air pressure increases, the valve opening can   becomes larger or smaller**

- **Air-to-open (normally closed, fail close): as the air P increases, the valve opening gets larger**

- **Air-to-close (normally open, fail open) as the air P increases, the valve opening gets smaller**





PNEUMATIC ACTUATOR

ADVANTAGES

Compressed air economical and convenient for use

Self locking can be achieved by a spring

At elevated temperature assist valve operation

Exhaust air can be vented to atmosphere

DIS ADVANTAGES

No hammer blow to unseat the valve

Limitation for holding at required position

Material of construction is vulnerable for heat

Manual provision create high lock in force while declutching

Susceptible to seizure due to corrosion & dirt

Air consumption very high

Electric Actuators

Comprises an electric motor and a gear arrangement

- Electrical limit switches
- Torque sensor

Self locking features- Threaded spindle and nut . Thread of the lead screw should be self locking

Manual Operation- Normally Provided with hand wheel lever operated clutch

Duty cycle

Motor will be heated when put in operation

- Isolation - Valve operation Few times a day
- Regulating - Valve operation 30 - 60 starts/hr
- Modulating - Valve operation 600 - 1800 /hr

Electric Actuators

ADVANTAGES

High rotational speed so high kinetic energy
Good positioning accuracy - Reduction gearing
Easy interfacing with computers
No dirt or moisture
Operate instantaneously over great distances
Complete system can be tested w/o moving valve position
Sequencing of valve operation is easy

DIS ADVANTAGES

Vulnerability to high temperature
Vulnerability to moisture
Precludes mechanical means of storing energy in the event of power failure

Hydraulic Actuators

Used for high torque / thrust applications

Different mechanisms employed

- Rack and pinion
- Hydraulic motor
- Piston and cylinder
- Rotary piston

Similar to pneumatic actuation

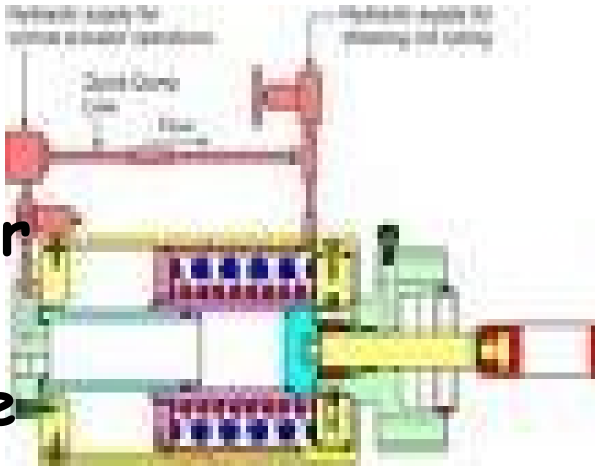
Needs energy source - Hydraulic power pack

Torque output depend on fluid pressure

Greater flexibility of energy source

Widely used with the following

- Large sliding gate valves
- Large globe valves
- Penstock valves



एफ.सी.आर.आई.

Hydraulic Actuators

Advantages

Very high operating torque suitable for large sized valves

Fail safe operation is easy - Hydraulic pressure stored

Incompressible - easy for hydraulic lock

Good positional accuracy

Hydraulic system is compact

Disadvantages

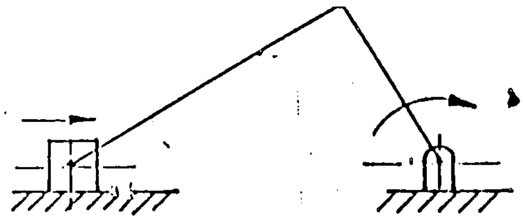
Piping pressure drop limits distance of hydraulic control

Hydraulic system is costly

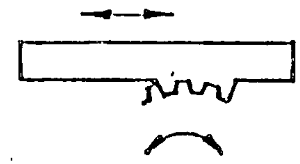
No kinetic energy for hammer blow unseating

High thermal expansion rate - thermal insulation required

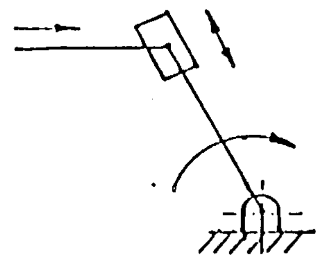
Close machining tolerances -susceptible to malfunction



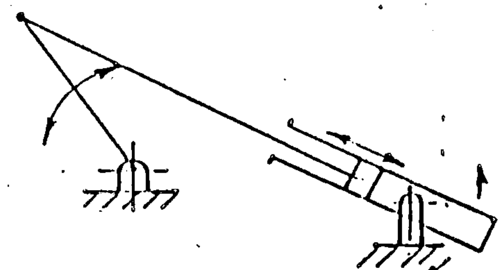
Slider crank mechanism



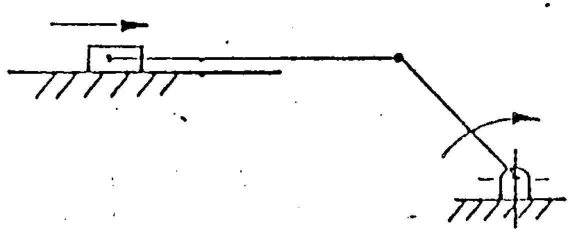
Rack and pinion



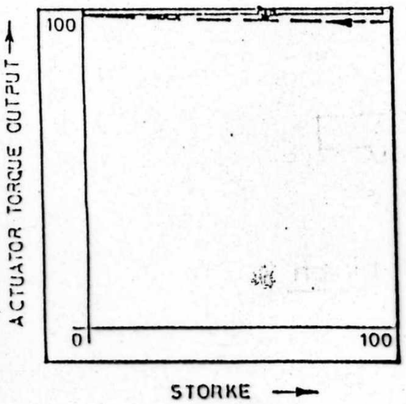
Scotch Yoke mechanism



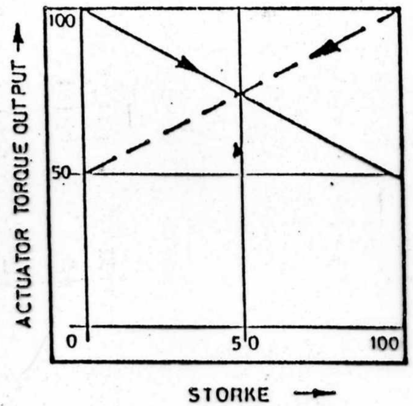
Oscillat'ng cylinder mechanism



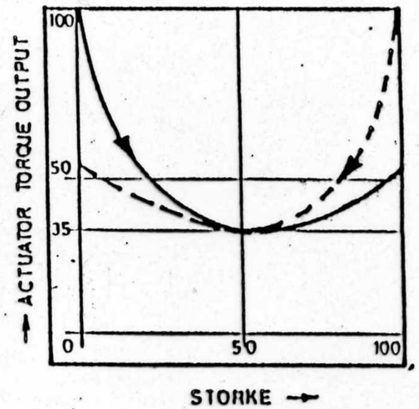
Off_set slider crank mechanism



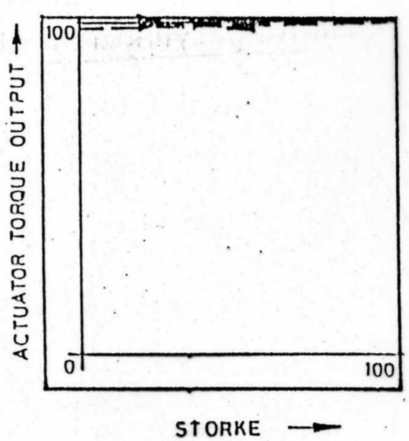
PNEUMATIC DOUBLE_ACTING
RACK AND PINION ACTUATOR

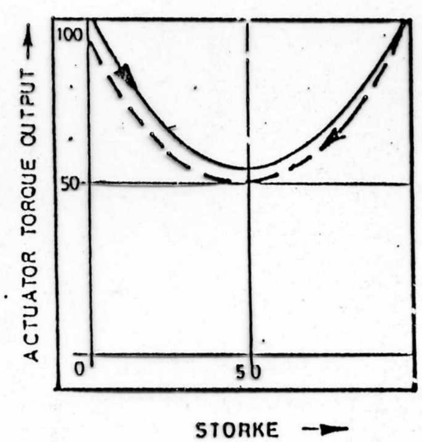


PNEUMATIC SPRING RETURN
RACK AND PINION ACTUATOR



PNEUMATIC SPRING RETURN
ACTUATOR





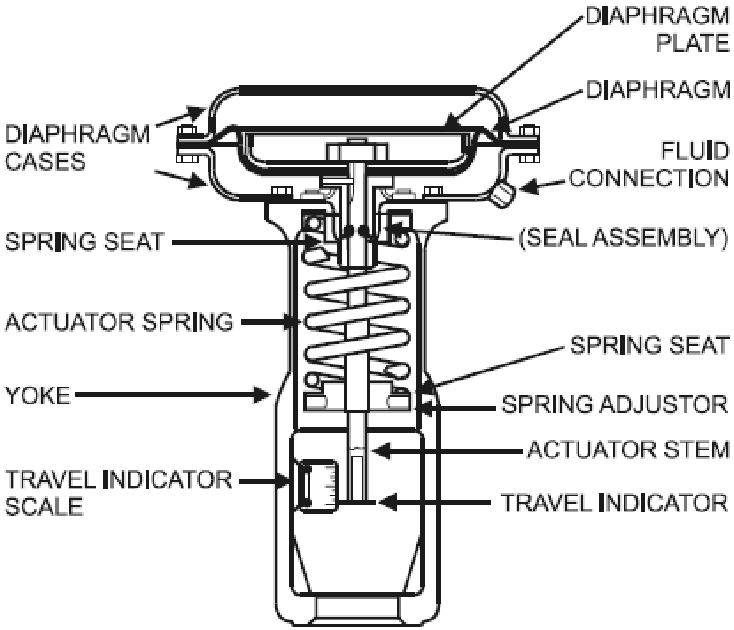
PNEUMATIC DOUBLE ACTING

एफ.सी.आर.आई.

Diaphragm Actuator

A piece of Fabric reinforced elastomer sandwiched between casing connected to a linear shaft

- Double acting or with spring return
- Air pressures upto 4 bar only
- Fast response to signal change
- Stroke limited to 150 - 200 mm
- Widely used with control valve



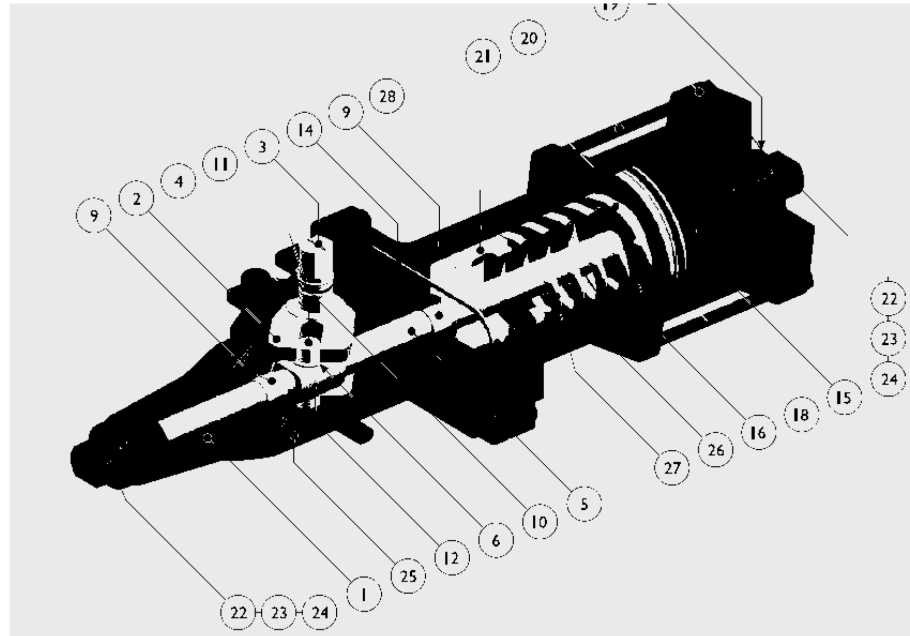
Piston Actuator

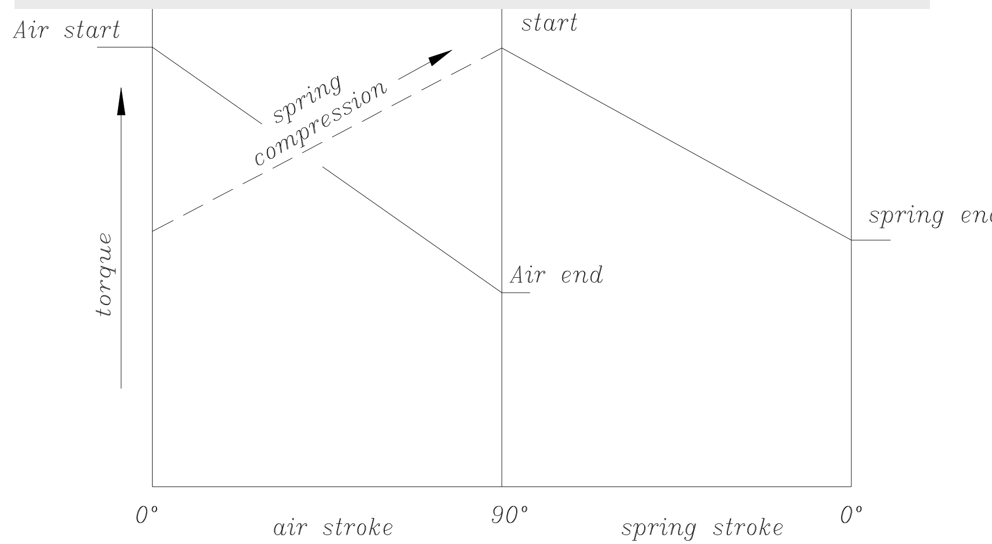
A cylinder and a piston with an O ring

Double acting or with spring return

Air pressure upto 10 bar

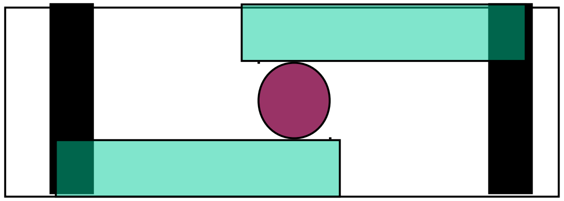
Different mechanisms to convert linear motion to rotary motion





Torque characteristic for spring return piston actuator

Rack & Pinion



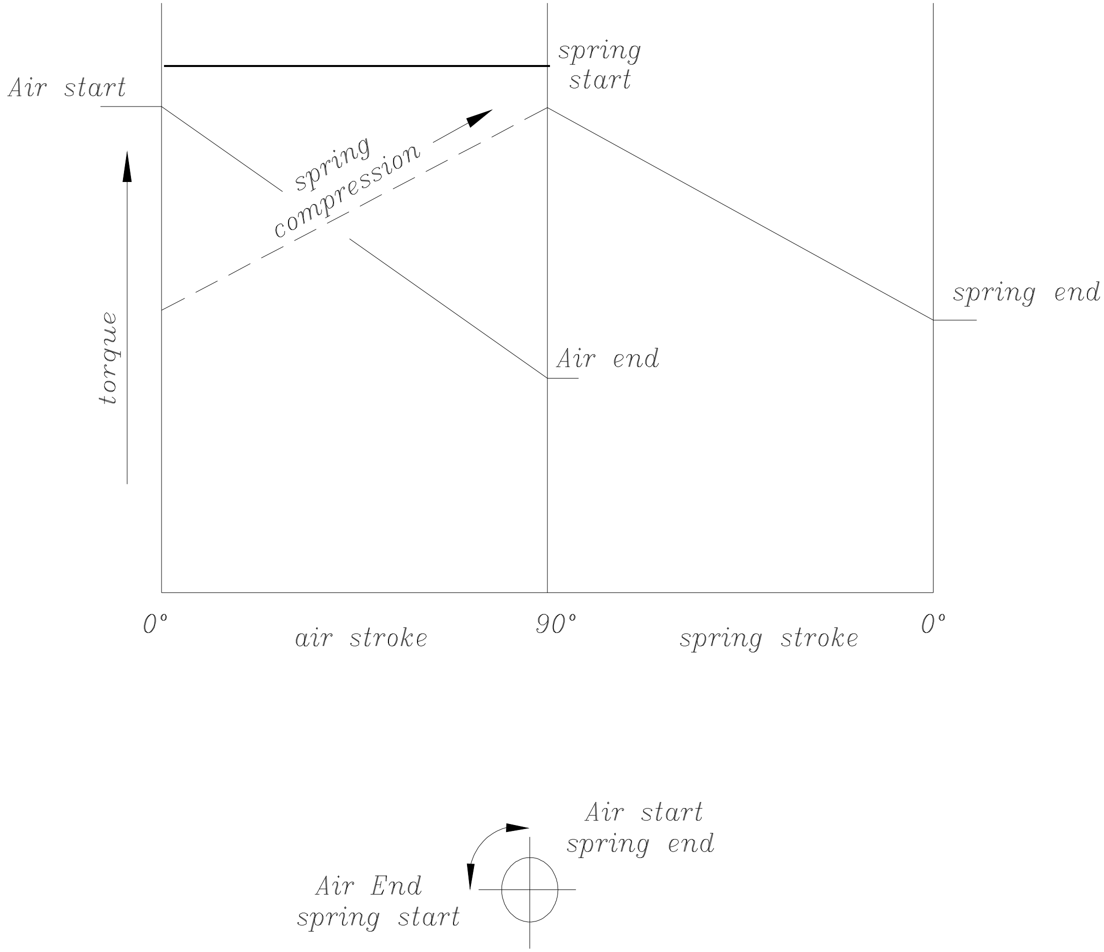
Single or Double piston

Integral rack drivers the pinion

Available for 90 or 180° rotation

Torque output is constant

Suitable for plug valves



Torque characteristic for rack and pinion actuator

Cam

Double piston by a spacer with a cam and shaft between them

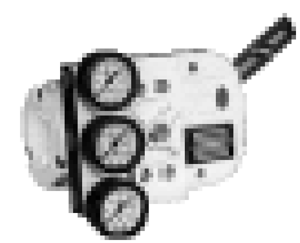
Rotational style determined by cam profile

Mechanical stop are not required

Torque varies with profile

HYSTERESIS AND VALVE POSITIONER

- **Hysteresis**
  - Due to friction between the stem and packing, loose linkage, pressure drop, stiction or etc.
  - When the command signal (pneumatic signal) is going up and down, the flow rate will not be same even though the command signal is same depending on the direction of signal change.
  - Remedy
    - Change the command signal with the same direction by lowering or increasing it momentarily
    - Use valve positioner



- **Valve positioner**
  - The valve positioner is a controller which can synchronize the command signal and its corresponding valve step position.
  - By use of valve positioner, hysteresis can be overcome.

SELECTION OF VALVE ACTUATOR

1. Calculation of force requirement
2. Selection of Power source
3. Selection of mechanism
4. Sizing of actuator & components
5. Selection of accessories.

एफ.सी.आर.आई.

Actuator Selection Chart

1. Calculation of force requirement 2. Selection of Power source
3. Selection of mechanism 4. Sizing of actuator & components
5. Selection of accessories.

Sl.No.	Parameter	1	2	3	4	5
1	Valve size and Type	**			**	
2	Pressure Drop	**			**	
3	Operating Condition	**	**		**	
4	Flow medium	**			**	
5	Sealing	**				
6	Fire safety		**			**
7	Fail safe Operation	**			`	**
8	Operating Temperature	**				
9	Cyclic Speed & rate		**	**		**
10	Stem Orientation	**				
11	Aging	**				
12	Response Time		**	**		**
13	Type of Control		**	**		**

एफ.सी.आर.आई.

Actuator Selection Chart

1. Calculation of force requirement 2. Selection of Power source
3. Selection of mechanism 4. Sizing of actuator & components
5. Selection of accessories.

Sl.No.	Parameter	1	2	3	4	5
1	Valve size and Type	**			**	
2	Pressure Drop	**			**	
3	Operating Condition	**	**		**	
4	Flow medium	**			**	
5	Sealing	**				
6	Fire safety		**			**
7	Fail safe Operation	**			`	**
8	Operating Temperature	**				
9	Cyclic Speed & rate		**	**		**
10	Stem Orientation	**				
11	Aging	**				
12	Response Time		**	**		**
13	Type of Control		**	**		**

Actuator Selection

Parameters to be considered while selection

1. **Valve Type and size**

   The torque / force requirement of the valve

2. **Pressure Drop**

   Torque / axial force - function DP

3. **Services & operating condition**

   Whether On/Off, Regulating, Modulating duty

   Regulating duty - based on Break away torque

   For part turn, actuator should counter balance the force due to unbalance

Actuator Selection

4. Flow medium

Lubrication property of operating fluid

Whether fluid is slurry or contain solid particles

Erode the sealing surfaces

Wear and tear depends on the operating fluid

Actuator output decreases with time which needs additional capacity for actuator

5. Sealing - Bi directional

Force depends on flow past the valve disc.

50% in case of BFV if seat is placed down stream

Less force if the flow is from bottom of disc

Actuator Selection

6. Fire safety

Fire safety needs additional metal seat

Requirement is 50 - 100 % more normal torque

7. Fail safe operation

Automatic fail safe operation - more energy to be stored

Needs additional torque / force

8. Operating temperature

Provided with metallic bearing higher temperature

Higher friction coefficient for elevated temperature

Cryogenic application needs more torque due to higher friction of plastic seat & bearing

Actuator Selection

9. Cyclic speed & rate

Fast cyclic speed needs special actuators

Large diaphragm,solenoid valves and large size tubing, quick exhaust valves

Pneumatic actuation is preferred

10. Stem orientation

Plays a major role in deciding the force requirement in gate valves

Stem other than vertical prone to seat leakage and falling of the stem

Actuator Selection

11. Ageing and un accounted factors

Normally 25 - 40% margin is provided

12. Response Time

Major factor in deciding type of actuation

Fast response Pneumatic actuators are preferred

Hydraulic & Electric actuators - sluggish response

13. Type of Control

Positional accuracy

ON / OFF or control application

Especially in the case of Part turn valves

SIZING OF VALVE ACTUATOR

Valve thrust or torque = Port area * Differential pressure * Valve factor * Stuffing box friction * pressure effect on stem

---

a) Valve type

b) Valve size

c) Maximum differential pressure

d) Minimum pneumatic / hydraulic pressure (for Pneumatic/hydraulic system only)

e) Valve stem diameter

SIZING OF VALVE ACTUATOR

Valve factor

- Cage type or double guided stem
- ON/OFF or throttling (control)
- Seating is metal to metal or soft seat (with soft seat material)
- Liquid or gas with operating temperature
- Whether fail safe

Stuffing box friction

- Stem diameter
- Stuffing element used
- Maximum operating pressure

SIZING OF VALVE ACTUATOR

Pressure effect on stem

- Stem diameter
- Maximum differential pressure

For fail safe system

whether with spring or not : if spring type

a) Valve stroke

b) Actuator thrust w/o spring

c) Spring factor

- Spring wire diameter
- Spring diameter
- Length of spring

SIZING OF VALVE ACTUATOR

Accumulator type

a) Valve thrust at beginning & end of stroke

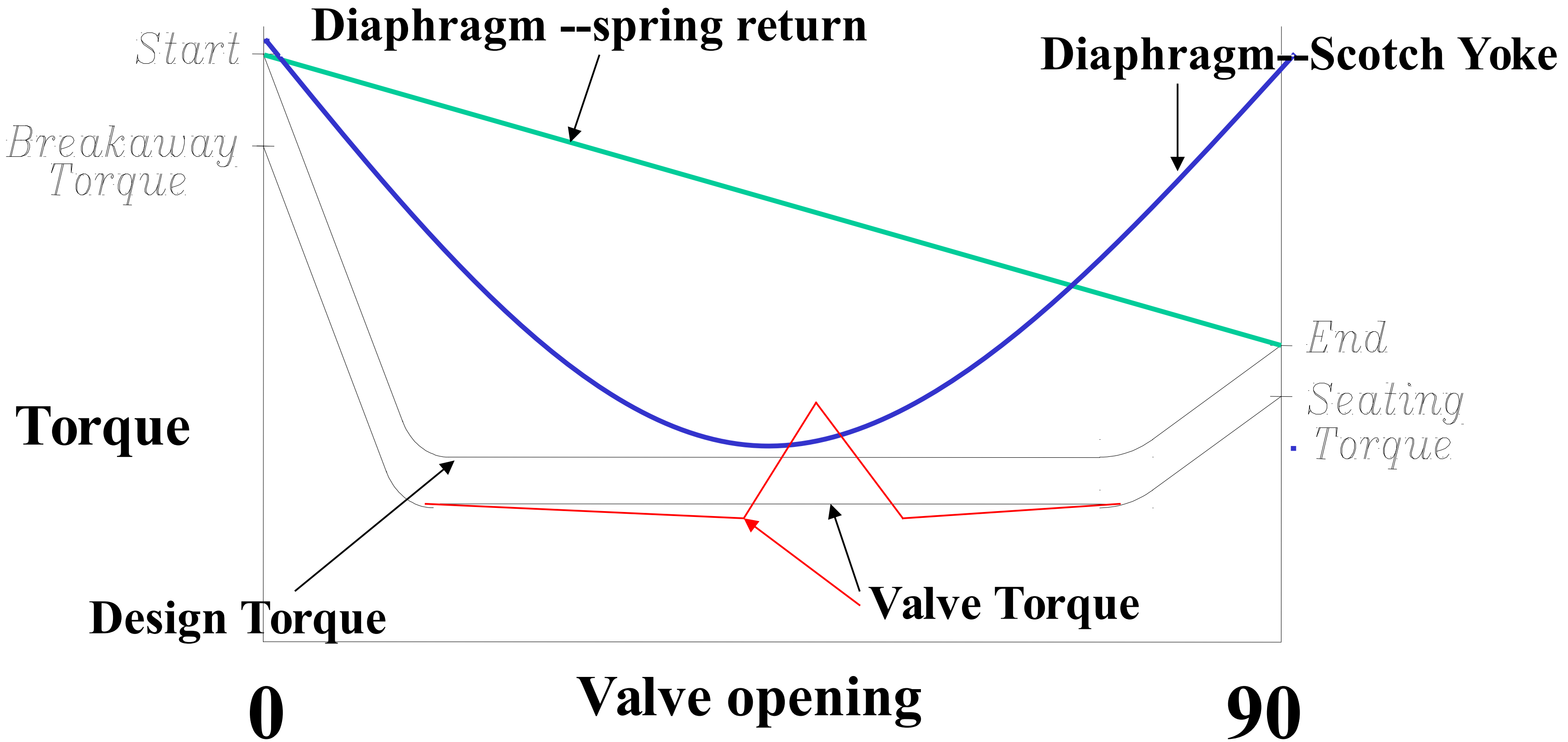
b) Supply air pressure

c) Mode of closure for air failure

d) Volume of actuator

e) No. of strokes required after air failure

Actuator sizing procedure

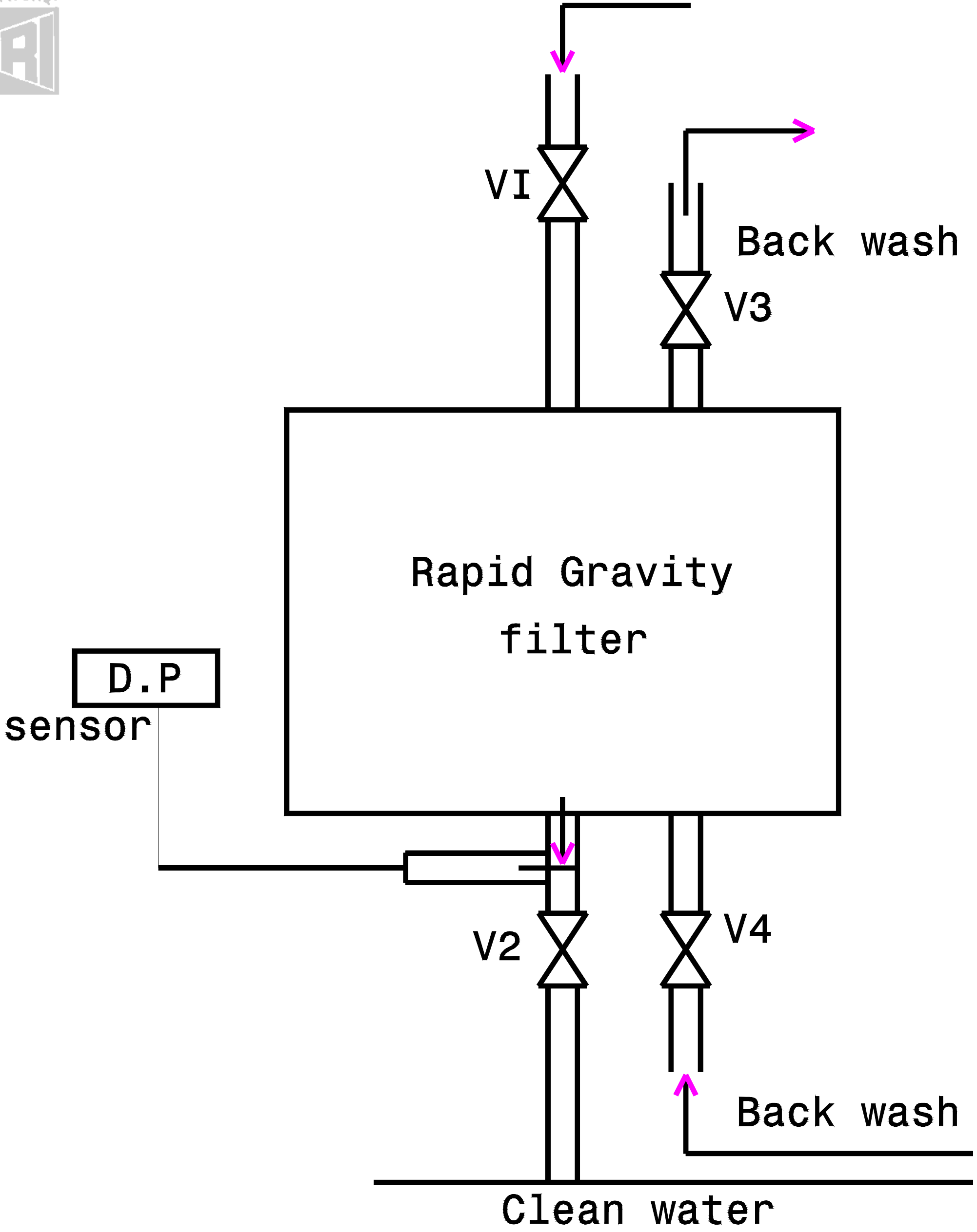


Actuator torque curve matched with rotary valve curve.

एफ.सी.आर.आई.

CASE STUDY

Actuators for a Filter bed of a water treatment plant



Clean water line

Type of valve : Gate
Fluid : Water
Pressure : 1 bar
Line size :
Operation : ON/OFF
Quantity : 2Nos.
Duty : Continues

Back wash water

Type of valve : Butterfly
Fluid : Water
Pressure : 2 bar
Line size :
Operation : ON/OFF
Quantity : 2Nos.
Duty : Continues

RGFilter in a water treatment plant

Selection of actuator

Duty	Contineous	Contineous	Contineous	Contineous
Bidirectional sealing	N.A	N.A	N.A	N.A
Fire safety	N.A	N.A	N.A	N.A
Fail safe	N.A	N.A	N.A	N.A
Cyclic speed & rate				
Stem orientation	Vertical	Vertical	Vertical	Vertical
Ageing & related factors	NEW	NEW	NEW	NEW
Response	Medium	Medium	Medium	Medium

Cost consideration	Economical		
Location			
Compressor available			
Electricity available			

Sizing of Actuator

Valve type	Gate	Gate	Butterfly	Gate
Valve size	12"	12"	12"	12"
Operating pressure	1.5 bar	1.5 bar	1.5 bar	1.5 bar
Operating temperature	Ambient	Ambient	Ambient	Ambient
Shut off pressure	1.5 bar	1.5 bar	1.5 bar	1.5 bar
Pressure drop-opeartion	Nil	Nil	0.1 bar	Nil
Operating condition	ON/OFF	ON/OFF	ON/OFF	ON/OFF
Flow meduim	Water	Water	Water	Water
Torque / Force required				
Actuator Torque/ force				

Testing of Actuators

Standards related to testing of Actuators

- **ANSI/AWWA/C 504 Soft seated butterfly valves**
- **ANSI/AWWA/C 540 Power actuating devices for valves**
- **BS 4151 Method of evaluation of pneumatic positioners**
- **ISA S 26 Dynamic response testing**
- **IS 9334 Specification of electric motor actuators**
- **CEGB 569701 Electric actuators - Multi turn**
- **IEEE 382 Qualification of actuators for nuclear power plants**
- **IS 8935 Specification of electric solenoid actuators**

Table 1

Sl. No.	Code No.*	Test	Type of Tests **	IS 10169	BS 6755	ANSI B 16.41	BS 5155	AWWA C504	BS 5146	BS 5351	API 598	API 607 API 589	JIS B 2003	DIN 3230	BIS 4151	ISA S 26	AWWA C540
1	V.1	Visual Inspection	T	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	-	-	-
2	V.2	Dimensional Check	T	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-
3	V.3	Hydraulic Pressure Test (Shell)	R	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	-	-	-
4	V.4	Gland Leakage Test	R	Yes	-	Yes	-	-	-	-	-	-	-	-	-	-	-
5	V.5	Seat Leakage Test	R	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	-	Yes	Yes	-	-	-
6	V.6	Determination of flow coefficient	T	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-
7	V.7	Determination of inherent characteristics	T	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-
8	V.8	Back Seat Leakage Tests	T	-	Yes	-	-	-	-	-	-	-	-	-	-	-	-
9	V.9	Disk strength test	T	-	-	Yes	Yes	Yes	-	-	-	-	-	-	-	-	-
10	V.10	Fire Test	T	-	-	-	Yes	-	Yes	Yes	-	Yes	-	-	-	-	-
11	V.11	Anti Static Testing	T	-	-	-	Yes	-	Yes	Yes	-	-	-	-	-	-	-
12	A.1	Accuracy Test	R	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
13	A.2	Dead Zone Test	T	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
14	A.3	Supply Pressure Variation	R	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
15	A.4	Vibration Test	T	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
16	A.5	Drift Test	T	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
17	A.6	Accelerated Life Test	T	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
18	A.7	Gain	T	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
19	A.8	Hunting	T	-	-	-	-	-	-	-	-	-	-	-	Yes	-	-
20	A.9	Dynamic Response Test	T	-	-	-	-	-	-	-	-	-	-	-	-	Yes	-
21	A.10	Hydro Static Test	T	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes
22	A.11	Endurance Test	T	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes
23	A.12	Torque Test	T	-	-	-	-	-	-	-	-	-	-	-	-	-	Yes

* V stands for Tests on Valves
A stands for Tests on Actuators

** T stands for Type Tests
R stands for Routine Tests

एफ.सी.आर.आई.

Performance Evaluation of Actuators

Type tests for pneumatic actuators - BS 4151

A.1. Accuracy test

a. Linearity: b. Hysterisis : c. Repeatability

A.2. Dead zone test

A.3. Supply pressure variation

A.4. Vibration test

A.5. Drift test

A.6. Accelerated life test

A.7. Gain

A.8. Hunting

A.9. Dynamic response test

A.10. Hydrostatic test

A.11. Endurance test

A.12. Torque test

एफ.सी.आर.आई.

Routine tests for actuators

a) Accuracy test (A.1)

b) Supply variation test (A.3)

c) Hydrostatic test (A.10)

एफ.सी.आर.आई.

CYLINDER ACTUATOR

Standard AWWA C 540

Type test

- **Endurance test**

  No of cycles 5000

  One stroke --

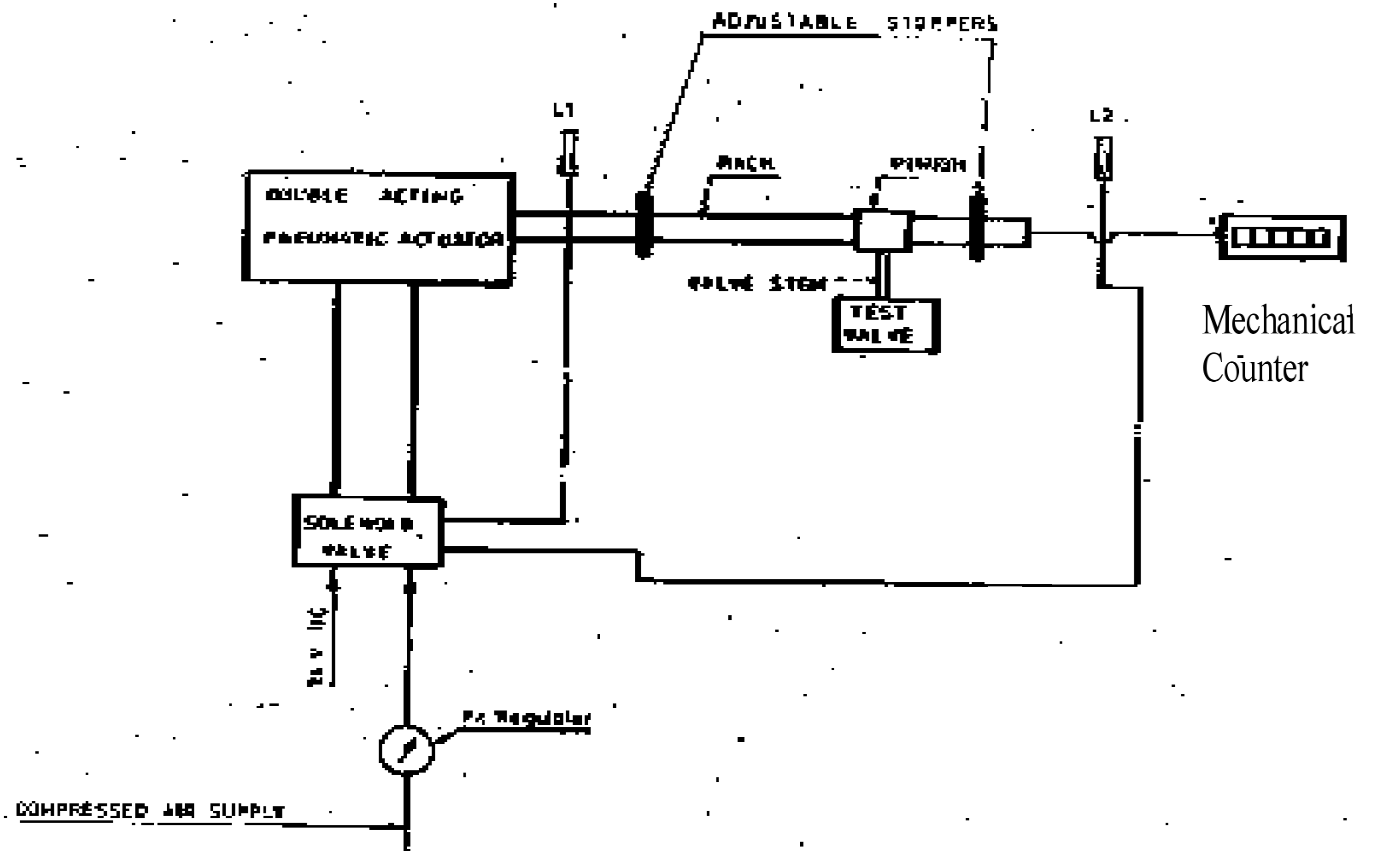
  One cycle Two stroke (Open-Close-Open)

  OFF time 10 min. maximum

  Pressure reach the rated at the end of stroke

- **Hydrostatic test**

  3 times rated pressure before and after the endurance test


ADJUSTABLE STOPPERS
L1
L2
TEST VALVE
SOLENOID VALVE
COMPRESSED AIR SUPPLY
Mechanical Counter

एफ.सी.आर.आई.

CYLINDER ACTUATOR

Standard AWWA C 540

Performance test

Maximum no load driver pressure   7 psi for pneumatic
Maximum no load driver pressure   15 psi for hydraulic

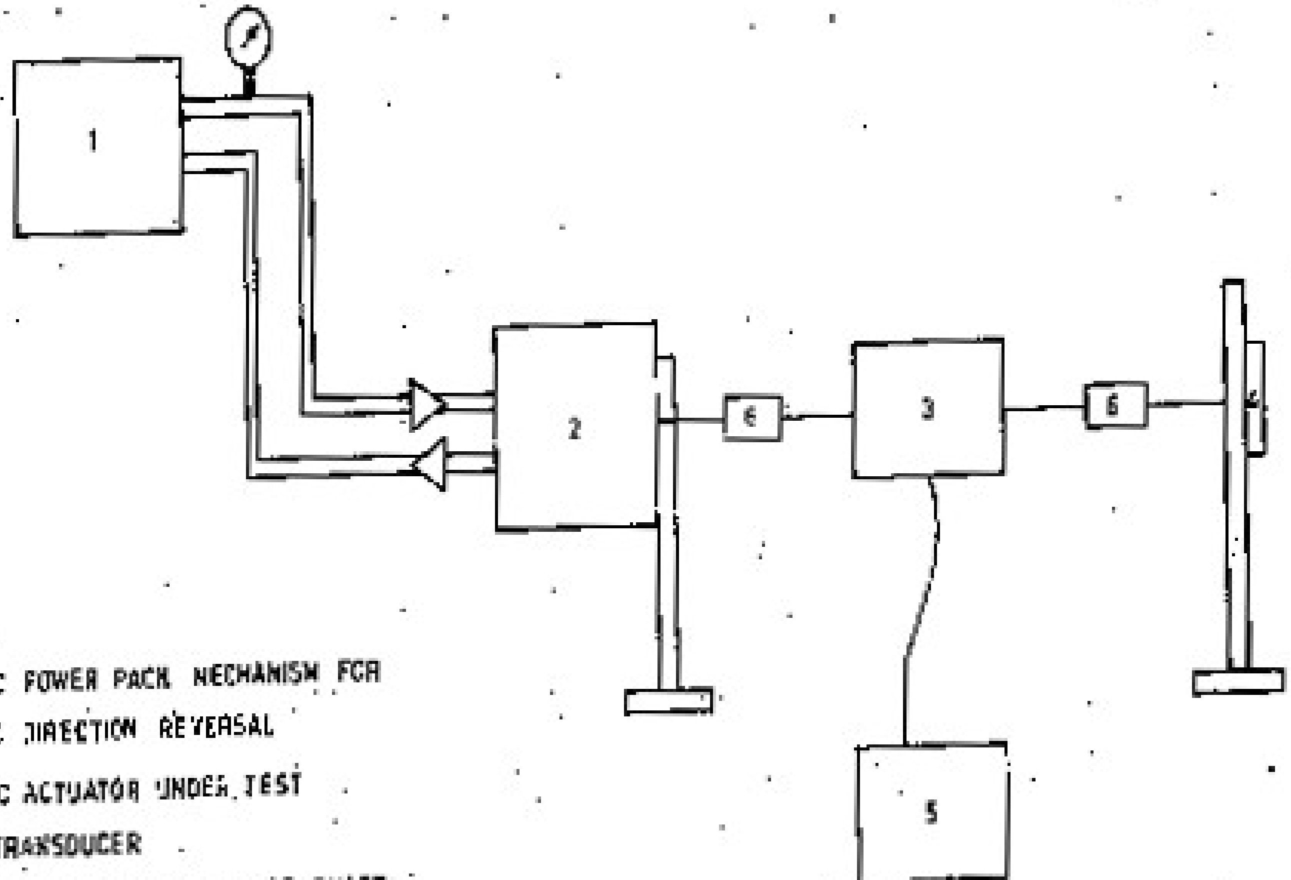
Quarter turn actuators

Torque test

Torque applied - Twice the rated

Endurance test

No. of cycles - Depend on torque_
Full rated torque at seating
30% of rate during rest of stroke



1. HYDRAULIC POWER PACK MECHANISM FOR AUTOMATIC DIRECTION REVERSAL
2. HYDRAULIC ACTUATOR UNDER TEST
3. TORQUE TRANSDUCER
4. LOCKING MECHANISM OF ACTUATOR SHAFT
5. TORQUE INDICATOR
6. COUPLINGS
7. STANDS

Schematic of torque test set-up

एफ.सी.आर.आई.

ELECTRIC MOTOR ACTUATOR

Standard :AWWA C 540

Power supply variation

- Input voltage
- Frequency
- Current consumed

Performance test

- Actual stroke time 90 - 110 % of rated
- Torque switch to limit output torque by 120% of seating torque
- Limit switch to limit travel by 110% of rated

एफ.सी.आर.आई.

ELECTRIC MOTOR ACTUATOR

Standard :AWWA C 540

Endurance test

No of cycles	5000
One stroke	30sec.
One cycle	Two stroke (Open - Close - Open)
OFF time	10 min. maximum
Seating Torque	Rated Torque (10% at the ends)
Running Torque	30% rated torque (10 -90% of stroke)

एफ.सी.आर.आई.

ELECTRIC MOTOR ACTUATOR

Standard : CEGB 569701

- Working check
  - Wiring for continuity & correctness
  - Correct phase rotation of motor
- Pressurisation
  - Gear box to be filled with oil at 1 bar for 15 minutes
- Insulation resistance
  - Motor winding & transformer primary with dc voltage
- High voltage test
  - As per Bs 4999 part 60
- Torque characteristics
  - As per Bs 4999 part 32   Max. operating time for specified torque
  - Ambient temperature of 20 40 and 70 degree C

ELECTRIC MOTOR ACTUATOR

Standard : CEGB 569701

Power supply variation

Input voltage 80 % rated - at max torque switch setting

Running with 75% rated voltage for 2 minutes

Torque switch setting

Torque switch to max. setting and design torque applied on the actuator sleeve

Increase till torque switch operates

Repeat this with minimum torque settings

Consecutive starts

Over heating test

As per Bs 4999 part 60

एफ.सी.आर.आई.

ELECTRIC MOTOR ACTUATOR

Standard : CEGB 569701

Stall torque test

Torque switch setting overridden and torque applied on the actuator sleeve increase till motor stalls at 100 % & 75 % rated voltage

Humidity Test

70 deg. And 95 % RH for 18 hours then 50 for 24 hours

repeated for 28 days

Endurance Test

500000 revolutions with 24 rpm Cycling period 4 min.

33 % torque during 95 % of travel

95 % rated torque at 5 % of travel

After each 500 cycles manual check of operation

ELECTRIC MOTOR ACTUATOR

Standard : IS 9334

Life test

- Mounted on the valve
- Operated for 500 operations
- Check the performance

Response time test

- Response time verified at rated voltage & Frequency

Variation in supply voltage Test

- Supply voltage varied by 6 %
- No change in performance

Variation in Frequency

- Frequency varied by 3 %

एफ.सी.आर.आई.

ELECTRIC MOTOR ACTUATOR

Standard : IS 9334

Tests for motor
- AS per IS 325
- Insulation resistance
- High voltage test
- Full load voltage, current, power input & slip
- Temperature rise test

Tests for limit switches
- Endurance test
- No of cycles depends on the breaking current
- Function properly after endurance

Tests on output shaft
- Tested for an axial force equivalent to rated torque

Tests on Terminal boxes

Damp heat cycling test

एफ.सी.आर.आई.

ELECTRIC MOTOR ACTUATOR

Standard : IS 9334

Tests on Terminal boxes

IS 2147

Damp heat cycling test

IS 9000 part 5/ section 1

Upper temperature 55 C

No. of cycles 6

एफ.सी.आर.आई.

Pneumatic Positioner Testing

Standard BS 4151

Static Behavior

Average departure from Linearity

Hysterisis

Repeatability

3 psi - 9 psi for full stroke

9 psi - 15 psi for full stroke

3 psi - 15 psi for full stroke

Dead zone

Forward path : Largest change in input signal without a detectable change in valve position

Feed back path : Largest change in stem position without causing a feed back

एफ.सी.आर.आई.

Pneumatic Positioner Testing

Standard BS 4151

CONSTANCY

Pressure supply variation

10% of normal value — Accuracy test

Temperature variation

-20, 0, 20, 40°C — Accuracy test

Mounting position

10° from vertical (4 dir.) — Accuracy test

Vibration

Shaker table - resonance search 5 - 150 Hz

Displacement 0.05” 1 - 10 Hz

Acceleration 0.5g 10 150 Hz

Frequency rate one octave in two minutes

To be conducted 4 and 14 psi input pressure

एफ.सी.आर.आई.

Pneumatic Positioner Testing

Standard BS 4151

STABILITY

Drift

14 psi input pressure for 168 hours

Each 24 hours, position for 3 & 15 psi to be measured

Accelerated life test

Sine wave input with mid point at 9 psi and

peak to pack of 6 psi (6 - 12 psi)

Frequency of 10 cycles per minute

15000 cycles of operation

Position corresponding to 3 & 15 psi to be checked before and after the test

एफ.सी.आर.आई.

DYNAMIC RESPONSE TESTING

Standard ISA S 26

Two types of input

a) Sine wave - Mid point at arithmetic mean of actual input

Peak to peak - 10% of actual input

Signal frequency 0.001 - 20 Hz

Minimum 20 points in 3 decade

Amplitude of input and output signal

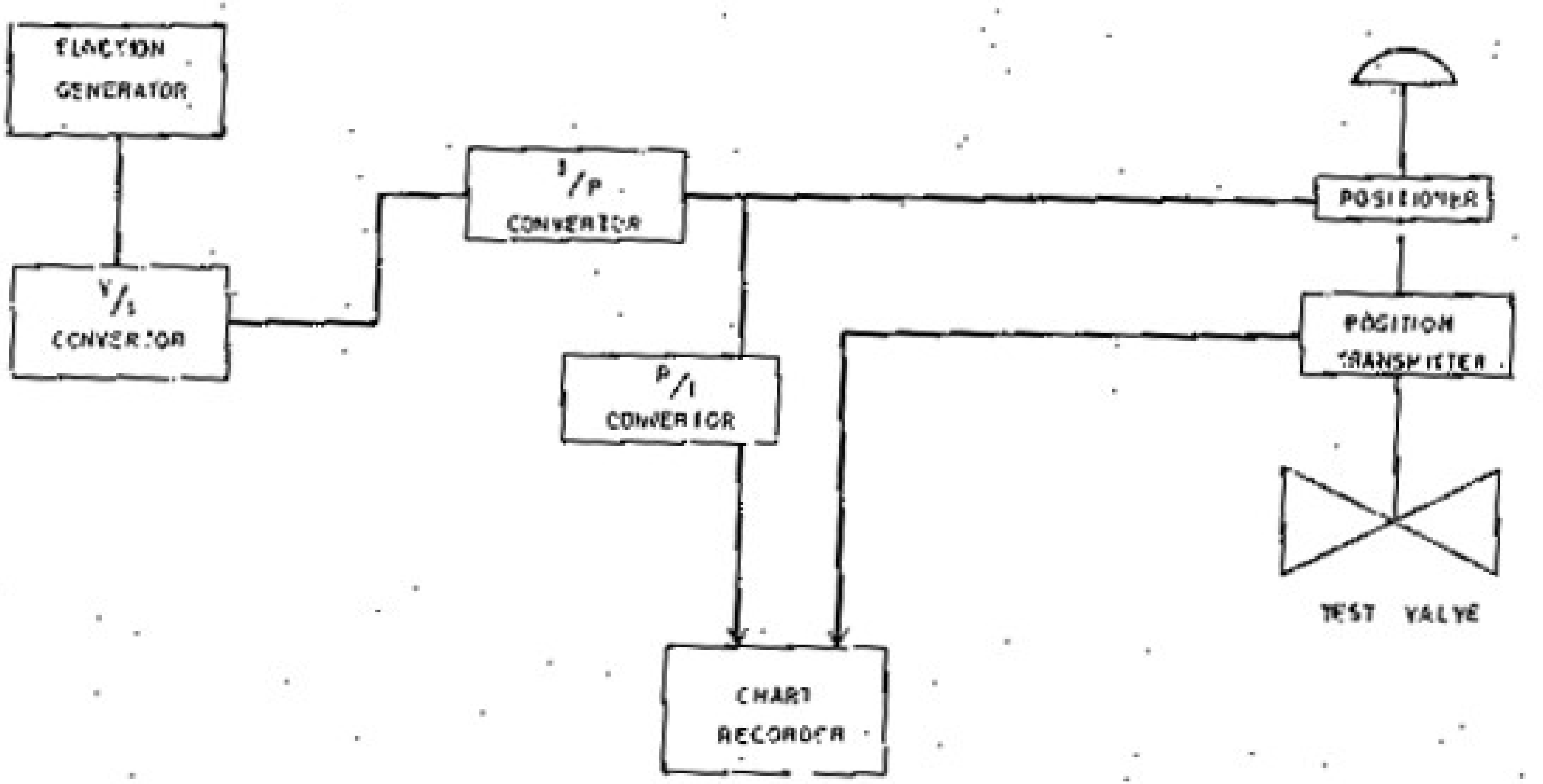
Phase relationship of i/p and o/p signal

At initial frequency, o/p is same as steady state value with same input and no phase difference

At maximum frequency,o/p is 10% of same signal at steady state or the phase lag is more than 300°

Input signal Amplitude 1db from 0.001 - 20 Hz

DYNAMIC RESPONSE TESTING
Standard ISA S 26



एफ.सी.आर.आई. FCRI

DYNAMIC RESPONSE TESTING

Standard ISA S 26

Phase shift **<5°**

Drift **<5% of full span in 4 hours**

Procedure

Blank Run **Static Calibration**

Actual Testing

Out put

Magnitude Plot - Semi log - Signal freq. Vs Gain

Phase Plot - Semi log - Signal Freq. Vs Phase lag

b)Step input

Input **10% step or 90% step of mean**

Output **Magnitude Plot - Time Vs input signal**

Time Vs output signal