N4

INDUSTRIAL INSTRUMENTS N411

(One 3-hour paper)

(With effect from January 1980)

1. Pressure and vacuum measurements: Units of pressure. Absolute and gauge pressure. Pressure instruments, descriptive treatment, with elementary calculations, where applicable, of the following instruments: Simple U-tube manometers with equal and unequal legs; the well type manometer and the inclined tube manometer. Bourdon tube; bellows and diaphragm-operated instruments. Ring balance instruments. Bell type instruments. Elementary vacuum instruments, such as the McLeod gauge. Test instruments, dead weight tester.

   Electrical methods of pressure measurement: Descriptive treatment giving basic operating principles of the following types of instruments: Strain gauge pressure transducers with bonded and unbonded strain gauges. Other electrical transducers, such as resistive, magnetic, capacitive and piezo-electric types.

2. Level measurement: General descriptions of the following methods (where applicable, elementary calculations to be included): dip-stick and direct vision gauge glass; differential pressure level instruments on open and closed vessel applications; float-operated instruments; float buoyancy type instruments, using torque tube transmission; static pressure and purge systems.

3. Flow measurement: Units of flow. Primary flow elements. Descriptive treatment of the venturi and Dall tube orifice plate, Pitot tube. Installation requirements for primary flow elements.

   Flow instruments. Descriptive treatment with calculations such as the conversion of wet into dry calibration of mercury manometer flowmeters of the following: Differential pressure instruments. Mercury manometer flowmeters including shaped chamber types having square law corrected scales. Bell type flowmeters. Ring balance flowmeters. Quantity (volumetric) meters. Displacement type liquid flowmeters such as oscillating piston and rotating disc types. Dry and wet gas flowmeters. Inferential meters of the deflecting vane, rotating vane and helical vane types. Descriptive treatment of turbine flowmeters. Area flowmeters (rotameters). Description and operating principle of area flowmeters.

4. Temperature measurement: A brief introduction stating, amongst others, temperature scales. Absolute temperature. Expansion and vapour pressure instruments. Descriptive treatment including all important practical details of the following instruments: liquid expansion types; gas expansion types; vapour pressure types; bimetallic types. Electrical temperature instruments. Primary temperature elements.

Fundamental theory, construction materials and calibration characteristics of the following elements: resistance thermometers; thermocouples; thermistors; radiation pyrometers, lens and mirror types.

Temperature instruments: The millivoltmeter. Descriptive treatment of this instrument, including details of circuits, principle of operation and, where applicable, cold-junction compensation, standard cells and standardisation methods. Advanced treatment with calculations of the Wheatstone bridge and the potentiometer. Descriptive treatment of automatic and null-balance instruments including their electronic amplifiers. Descriptive treatment, including fundamental theory of optical pyrometers of the variable filament current and optical wedge types.

5. Telemetering (Transmission): Pneumatic telemetering. Descriptive treatment of the flapper-nozzle system with feedback bellows and relay valve. Operation and construction of force balance and position balance systems including receiving instruments. Electrical telemetering; descriptive treatment with typical examples of the following telemeters: voltage: current position or ratio: impulse and frequency types.

6. Automatic control: The automatic process control system, its purpose, elements and their functions (closed control loop). Types of control action (control nodes): two step (on-off) control; proportional control; integral (reset) control; derivative (rate) control.

Pneumatic controllers: descriptive treatment of one type of position balance controller and one type of force balance controller.

Electric and electronic controllers: descriptive treatment of the operation of one type of electric controller and one type of electronic controller. Control valves and valve positioners: description of the operation of various types.

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INDUSTRIAL INSTRUMENTS N521
(One 3-hour paper)

1. Flow

(i) Positive displacement: Bellows type; turbine type; nutating disc type; reciprocating piston type; variable displacement pump (dosimeter), descriptive only.

(ii) Variable area: Deflecting disk and others - descriptive only, Rotameter - formula; density correction; float shape (viscosity); linearity; calibration.

(iii) Variable differential pressure: Equation - Bernoulli (energy balance). Use of gas laws; use of practical equations for mass volume and gas to calculate (d, h, D)

(iv) Differential pressure producing devices: orifice plates; dall tube; venturi tube; venturi nozzle; quadrant edge orifice.

(v) Installation (requirements): Tappings; position of instrument; sealing fluids; condensate chambers.

(vi) Square root extraction: pheumatic; electronic; built into differential pressure cell.

(vii) Flowmeters: Magnetic flowmeter - theoretical basic equation; methods of compensation. Ultrasonic, vortex and target flowmeters (descriptive only)

(viii) Integration: Mechanical continious; mechanical intermittent; electrical; pheumatic.

(ix) Heat transfer flow measurement (descriptive)

(x) Flow in open channels: Weir plates including use of equations; flumes including use of equations; descriptive advantages and disadvantages; end suppression, aeration and requirements upstream.

2. Analytical instruments

(i) In-line measurement of density and relative density: l Bubbler, buoyancy types; hygrometer; changing floats; submersed float.

(ii) Humidity: Definitions and terminology (relative, absolute, dew point and partial pressure); wet and dry bulb temperature, calculations; hygrometric - dew cell; hygrometric - Gregory cell; short descriptions - other methods - capacitive and piezo-electric.

(iii) Viscosity: Definitions and terminology; Laboratory type measuring instruments including the associated calculation i.e. falling sphere.

(iv) Continuous viscosity measurement: Rotating cylinder; rotating vane (descriptive); use and definition of Reynolds number.

(v) Conductivity: Ionic dissociation in relation with concentration. (ionisation). Cell constants; polarisation; temperature compensation; practical measuring circuits.

(vi) pH Measurement: Theory - definitions, emf equation, isopotential, temperature and compensation. Electrodes and reference electrodes. Measuring circuits - requirement. block diagram. Practical installations - special precaution on reference supply. Special earthing and special screening precautions.

(vii) Gas sampling systems: Requirements; practical execution; sources of error.

3. Control (hardware):

(i) Revise proportional, integral and derivative action.

(ii) Combine three term control; graphical and mathematical for step changes and sinusoidal inputs.

(iii) Interaction in practical controllers.

(iv) Pneumatic controllers: Flapper nozzle; discrimination linkages; proportional action generation; integral acti generation; derivative action generation; booster relay position balance; force balance; stack type controller with action generation; fluidic relays (Foxboro M100 series). One practical example of each type above.

(v) Electronic controllers: Discrimination.

(vi) C.A.T. (current, adj. type): Cain or proportional band on transfer function; feedback; integral action generation; derivative action generation; output requirements. Block diagramatical representations. One example.

(vii) P.D.T. (Pulse duration type): Basic principle (on off rat

(viii) P.A.T. (Position adjusting type): Basic principle (Integral action only).

(ix) Hydraulic controllers: Jet pipe principle (integral only); boosters; proportional feedback linkage; system requirement (air, leakage, low supply pressure)

INDUSTRIAL INSTRUMENTS N631

(One 3-hour paper)

1. Emmision spectroscopy: Methods of excitation - prismatics; gratings; gratings mountings; Qualitative and quantitative analysis. X Ray fluorescent spectrometer. X Ray diffraction spectrometer. Mass spectrometer.

2. Gas analysers: Chemical absorbtion; thermal conductivity; paramagnetic; infrared; heat reaction.

3. Calorimetry: inferential; direct measurement.

4. Chromatography: terminology and definitions; column packings; qualitative and quantitative analysis; detectors.

5. Automatic control: Closed loop control; open loop control; block diagrams. Complete treatment of the normalised three term control equation, including definitions and proof of gain and proportional band, reset action time and differential action time. Practical calculations based on this equation. Potential values. Inherent regulation. Frequency response.

6. Control valves: Materials of construction; application to the plant; valve sizing; valve characteristics; fail safe operation.

7. Process reaction: Step changes in supply and demand side; process capacity - simple and multi capacity; controller adjustment. Sinusoidal disturbances; normalised gain; phase change for single and multi-capacity processes; Controller adjustment (for latter).

8. Instrumentation of plant: Drawing and reading of flow sheet - Complete treatment of distillation column; Complete treatment of a boiler.

9. Explosion hazard and intrinsic safety

   (i) Definitions for hazardous location. Class; group; devision.

   (ii) Explosions (requirement for explosion).

   (iii) Protection methods: Advantages and disadvantages; confine explosions (explosion proof); keep atmosphere away (purging, pressurasation, immersion, sealing and potting); limit energy level (instrinsic safety); miscellaneous (sandfilling, increased safety; dust ignition proof; non incendiary).

   (iv) Intrinsic safety: Definition of intrinsic safety; energy levels; loop concept; circuit analysis (determine worst possible fault); evaluation (ensure safety margin under above conditions); construction review (insure critical components.)

   (v) Application of intrinsic safety: Area classification (hazardous, limited voltage, general equipment); barriers - current barrier, voltage barrier.

   (vi) Auxillary equipment: Instrinsically safe contacts; instrumentation; computer interface; advantages of barrier approach.

END

I & N6