Radioisotope instruments in industry

United Kingdom Atomic Energy Authority

Radioisotope Instruments in Industry: a list of current applications

Extracts from a paper presented by C. G. Clayton and J. F. Cameron to the International Atomic Energy Agency Symposium on Radioisotope Instruments in Industry and Geophysics, Warsaw, October 1965.

References

1 Proceedings of the Symposium on Radioisotopes in Industry and Geophysics, I.A.E.A., Warsaw (1965).

2 Clayton, C. G. and Cameron, J. F. A Review of the Design and Application of Radioisotope Instruments in Industry; ibid. Paper SM-68/2.

3 Industrial Radiosotope Economics. Technical Report Series No. 40, I.A.E.A. Vienna (1965).

4 Radioisotopes in Industry, U.K.A.E.A., London (1965).

Acknowledgement

In October 1965 the International Atomic Energy Agency held a symposium at Warsaw on Radioisotope Instruments in Industry and Geophysics; the published proceedings (1) contain papers presented by leading authorities from many countries, and covering a wide range of topics. One such paper (2) contains list of current industrial applications of radioisotope instruments grouped according to industry; this is clearly of great interest to potential users of these devices. The list is reproduced here by kind permission of the authors and of the International Atomic Energy Agency.

Radioisotope instruments in industry

Most of the instruments whose uses are listed here operate by allowing isotope-produced radiations (beta-particles, gamma-rays, X-rays or neutrons) to fall upon the material being studied, and measuring the radiations that pass through (transmission) or come back (backscatter or fluorescence). The resulting electrical signal can be used to indicate or record the characteristic being measured, or it can be fed back into the controlling system. The most important characteristics measured by this kind of device are thickness, mass per unit area, density, position, surface-level, coating thickness and elemental composition. In addition, devices have been developed to measure such properties as flow rate, pressure, altitude, torque, speed of rotation, viscosity, particle size and the presence of smoke.

A wide variety of radioisotope instruments are now in routine use in many branches of industry. They are available in forms ranging from simple, portable backscatter gauges to complex units capable of controlling some of the world's largest rolling mills; there is no doubt about their economic importance (3) (4).

Further development is continuing both through improvements in the performance of established instruments and through the introduction of new techniques, and these have resulted in a wide range of new and important applications; this is particularly true in the field of analysis where significant advances are now being made.

Applications of radioisotope instruments in industry
listed according to industry

Gauge Types

T Thickness and mass per unit area

D Density

L Level (including package monitors and switches)

A Analysis and coating thickness (including moisture)

M Miscellaneous (pressure gauges, torquemeters, etc.)

Agriculture, Forestry and Fishing	**T**	Mass per unit area of leaves in studies of water economy and balance in plants.
	D	Silage; standing trees and structural timbers; vegetable products; permeability measurements of unsaturated columns of soil in the laboratory; density variations in cores from trees and in extraction of resin; control of moisture content of veneers.
	L	Grain level in silos and wells.
	A	Moisture content of grain and living trees; density-moisture gauges in studies of water balance; water storage capacities of soils; evapotranspiration; effect of crops on moisture profile; effects of fertilizer, soil composition and irrigation on crop yields; water movement and irrigation practice.
Mining and Quarrying	**T**	Gamma-backscatter gauge to measure the thickness of residual coal layer on floor and roof during automatic coal cutting.
	D	Slurries in ore processing plants and in grinding mills; transport of coal, ores and sand by hydraulic, pneumatic and conveyor belt systems; gamma-backscatter gauges are in use to obtain inventory of coal stocks.
	L	Switches on mine cars, hoppers, conveyor belts, storage bins; counting and controlling movement of wagons.
	A	Coal-ash measurement for washery control and coal blending operations; analysis of ores in mining and processing.
	M	Analysis of mine gases.
Manufacturing Industries, Food and Beverages	**T**	Foods in sheet form such as dough for biscuits and cakes before baking, chocolate, cheese, meat products, chewing gum, etc.
	D	Liquid foods in evaporators (fish, meat, fruit juice, tomato paste, syrup, condensed milk), raw washed sugar in melting vessels, sugar solution, milk of lime; fat content of baby meat food; pulp from evaporation distillery; air content of ice cream; mass flow of e.g. sugar.
	L	Package monitors for controlling contents (soup, meat, beans, coffee, beer, etc.) of cans, bottles, packets, etc; counting containers. Level gauges on silos, hoppers, storage vessels, process vessels, e.g. limestone and coke in lime for sugar refining; chemicals used in processing foods; grain, sugar beet, separation of fat from protein; evaporated grain syrup (whisky manufacture).
	A	Moisture content of lactose; K^{40} as indication of lean meat content of carcases; analysis of foods.
Tobacco	**D**	Monitoring and controlling average cigarette weight.

Textiles	**T**	Control of coating and impregnation processes in production of cellulose fabrics, tufted carpets, leathercloth, tyre fabric, artificial leather, linoleum, adhesive and abrasive cloth, etc. Control of warpknit fabrics in heat setting; thread mass per unit length; pick-up of moisture and extent of drying; wear of fabrics and garments.
	D	Polymer solutions and synthetic yarn solutions before spinning.
	L	Contents of process vessels, e.g. viscose fabric in dissolvers; fabric in steam chambers.
Wood and Cork	**T**	Plywood, chipboard, veneers; moisture and resin content of wood.
Paper and Paper Products	**T**	Paper of all qualities and thicknesses; paperboard, pulp; "bone-dry" weight of paper, when combined with a dielectric gauge; studies of paper formation; control of coating and impregnation processes, e.g. polyethylene on paper, gummed paper, laminated plastics.
	D	Process fluids including black lacquer, white lacquer, and slurries of calcium hydroxide, clay, clay-starch and lime.
	L	Storage and process vessels, e.g. wood chips in preheaters; pulp and chlorine in bleaching towers.
	A	Paper leaching; thickness of ink on paper.
Printing, Publishing and Allied Industries	**A**	Thickness of bi-metallic casts for offset printing, stereotypes and printing plates; thickness of ink and coatings on paper.
Rubber Products	**T**	Rubber sheet, foam rubber; rubber sheet on calenders; rubber coated or impregnated material such as tyre cords, floor covering, etc.; tyre wear.
	D	Latex solution used to make foam rubber.
	L	Variety of products and processed materials in storage; transport and process vessels.
Chemicals and Chemical Products	**T**	Plastic film from extruders; plastic-coated paper and fabrics; laminated products; wall thickness of plastic tubes and bottles; wall thickness of pipes and tanks in chemical plant.
	D	Many products and process solutions such as milk of lime, hot brine, organic materials, acids, alkalies, detergents, etc.; to control solvent extraction, blending, distillation, evaporation and the input to spray dryers.
	L	Level gauges on many product and process materials (e.g. acids, carbondioxide, sulphurdioxide, methanol, ammonia, asphalt, coal, coke, lime, cement, plastics, catalysts) in storage and

		process vessels; checking operation of distillation columns; package monitors on products such as soap powder, detergents, aspirins, toothpaste, cosmetics, etc.
	A	Moisture content and bulk density of products such as detergents; chlorine content of chlorinated hydrocarbons; potassium content of fertilisers; resin to glass ratio of glass-epoxy materials; concentration of uranium and plutonium in solution.
Products of Petroleum and Coal	**T**	Asphalt impregnated products (roofing paper and shingles).
	D	Interface detection in pipeline pumping operations; catalyst in cracking units; amount of catalyst in oil; fluidised catalytic processes.
	L	Coke level in continuous coking unit; interface location (e.g. kerosene to water); alignment of coke guide and coke car when pushing coke from ovens; hydrocarbons on trays in distillation columns; level of butane and propane in cylinders; hot oil in melting tanks; many other raw materials and products in storage and process vessels.
	A	S, Co, Pb, N, O and Cl and F content and carbon/hydrogen ratio of petroleum products; boron in boron compounds; moisture content
Non-Metallic Mineral Products	**T**	Paper and textiles coated with abrasives; glass sheet; glass and asbestos fibres; asbestos-cement sheet; slate; selection of refractory bricks.
	D	Sand, lime, cement; asbestos-cement slurries used in making pipes and shingles; lime mud slurries feeding to lime kilns; clay slurries in cement manufacture; refractory bricks.
	L	Molten glass in furnaces; silt in silt basins; sand, clay, cement, etc; switches control cutting of glass sheets.
	A	Glass/resin ratio in fibre glass; boron, potassium, lead, selenium, etc, in glasses; boron in a variety of forms; potassium in ores.
Basic Metals	**T**	Pipes in ingots; hot- and cold-rolled sheet metal, tubes and rods; steel sheet sorting; wear of furnace walls; wall thickness of pipes, tanks, etc.
	D	Powdered and slurried ores in processing plant.
	L	Charge in cupola and blast furnaces; liquid metal in crucibles and moulds; load level in electro-thermal kilns and furnaces; dust in electrostatic precipitators; coal, coke and ores in storage bunkers, hoppers and process vessels, etc.
	A	Elemental composition of metallic ores and furnace melts; moisture content of foundry sand; ores for sintering, blast-furnace coke, etc.; composition of exhaust gases from furnaces, etc.
	M	Density and temperature of exhaust gases.

Metal Products	**T**	Coated and laminated Metal products; bolts, collapsible tubes, etc.
	D	Detonating fuse.
	L	Alignment of critical parts in ammunition.
	A	Coated and laminated products.
Machinery	**T**	Sheet materials used in machinery such as strip metal, coated and impregnated papers and textiles, rubber and plastic sheet; condenser paper, porous rubber sheet and plates for batteries.
	D	Rubber latex; sulphuric acid for batteries.
	L	See basic metals.
	A	Thickness of coatings or platings on components.
Transport Equipment	**T**	Sheet materials used in transport equipment such as steel for car bodies and ships' hulls, leather cloth and other plastics for upholstery, tubes, etc.; plastic-coated radomes; thickness of cooling passages in turbines; engine wear research; wear of missile nose cones.
	D	Products used in transport equipment.
	A	Products used in transport equipment, e.g. S and Pb in hydrocarbons, metals, etc.
	M	Tachometer; altimeters; rotor-stator movement; location of tools.
Miscellaneous	**A**	Photographic emulsion; photographic base paper; coating of precious metal in jewellery.
Construction	**D**	Suction dredging; asphalt; cement-stabilized soils; backfilling of trenches; concrete; location of reinforcing bars; evaluation of efficiency of concrete vibrators and control of optimum vibration time; inspection of hollow concrete columns; fluidised coal.
	L	Filling of wagons and tank cars; sand and cement in hoppers, mixers, crushers, furnaces, etc.
	A	Soil density and moisture gauges in constructing buildings, dams, roads, airfields, etc; concrete.
Electricity, Gas, Water and Sanitary Services	**T**	Pipes, boiler tubes, hoppers; soot deposition.
	D	Water content of snow; sewage sludge; mass flow of coal, coke; research on steam; water ratios; coal in stockpiles.
	L	Blockages in ducts conveying powdered coal to furnaces; coal and coke in hoppers, wagons, conveyor belts, etc.; water in boilers.
	A	Ash content of coal.
	M	Clearance between turbine blades; direction and velocity of flow in boiler tubes; leaks, etc.
Community Services	**D**	Suspended sediment concentration and density of sediment deposited in oceans, lakes and dams.
	A	Ancient coins, relics; mineral content of bone.
	M	Altimeters.

Transport Storage and Communication	**D**	Suction dredging.
	M	Control of trains.

Further Information

Information on industrial radioisotope instruments commercially available in the United Kingdom can be obtained through SIRAID, South Hill, Chislehurst, Kent (Tel. No. IMPerial 0055).

Further information on the industrial applications of radioisotopes can be obtained from the Industrial Liaison Officer, Wantage Research Laboratory (A.E.R.E.), Wantage, Berkshire. (Tel. No. Wantage 2911).

Additional copies of this booklet are obtainable from the Wantage Research Laboratory or from the Public Relations Branch, U.K. Atomic Energy Authority, 11 Charles II Street, London, S.W.1. (Tel. No. WHItehall 6262).

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