A Glossary of Terms used in Measurement and Control Systems for the Water Industry
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INTRODUCTION

This glossary of terms used in automation in the water industry was prepared by Committee No. 3 Automation of Water Treatment NWC/DOE Working Party on Wastewater Treatment.

The working party directed that it should be prepared in the belief that it was necessary not only to facilitate proper and informed communication between its members and its committees but also because it believed that considerable misunderstanding took place between practitioners in the field, including researchers, designers, operators, managers of water treatment systems and those engaged in the supply industry. The committee who prepared this glossary considered that it would be most useful if it contained only those terms which are more frequently encountered by practitioners in the field and therefore the document should not be regarded as being a comprehensive list of all the terms that are likely to be met.

The committee worked on the basis that it would use definitions already established by accepted national and international authorities unless it felt that exceptionally good reasons existed for modification of these definitions. The sources used are listed. It has been impossible, however, to obtain the agreement of the British Standards Institution to reproduce the definitions contained in British Standards and where these definitions are preferred the relevant B.S. is indicated for reference purposes.

The glossary is divided into five parts, viz. control, computers, water treatment, general engineering, and administration, and each definition has been given a number for ease of reference. Where a term has required definition in more than one part this is provided. The index also provides enables a particular term to be quickly located.

The committee has not provided any definitions of terms relating to plant used in water treatment as it is considered that these have been adequately covered, with a few exceptions, in the "Glossary of Terms used in Water Pollution Control", published by The Institute of Water Pollution Control.

The committee has been at considerable pains to produce the best definition for each term after consulting many sources, authorities and opinions but it recognizes that it is not possible to produce a complete set of definitions which will be universally acceptable. Nevertheless it believes that the definitions provided will find very wide acceptance and their use will lead to considerably improved communication and understanding among the practitioners in the field of water treatment automation.

It has been considered necessary to provide special treatment of the definition of the term AUTOMATION, which has been found to give rise to the greatest confusion and disagreement of all the terms the committee has considered. This term, therefore, is dealt with selectively on page 6 at the start of the glossary and the committee would like to make a special plea for the acceptance of this definition and for its recommendations associated with this term.
COMMITTEE NO. 3 — MEMBERSHIP

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PUBLICATIONS CONSULTED DURING PREPARATION OF THIS GLOSSARY

British Standards Institution:

British Standards:
- Glossary of Terms used in Automatic Controlling and Regulating Systems. Part 1, Process and Kinetic Control. BS 1523.
- Glossary of Terms used in Metrology. BS 5233.
- Methods of Measurement of Liquid Flow in Open Channels. BS 3680.


The Institute of Water Pollution Control. Glossary of Terms used in Water Pollution Control. Manuals of British Practice in Water Pollution Control. Published by the Institute, 1975.

AUTOMATION

The word automation is a relatively modern one which is now widely used without a clear understanding of its meaning in most cases. In many instances it is used when a more appropriate word would be 'mechanization'. In the water industry it is most frequently used when 'automatic control' would be the correct term.

In industry at large 'automation' has wider implications than either 'mechanization' or 'automatic control' and the committee which has prepared this glossary has resorted to the view expressed by Sir Ben Lockspeiser in 1956* and most strongly commends the following definition in the interest of universal clarity:

The application of control systems to processes, machines or equipment, usually resulting in a reduction in the amount or level of human involvement with the processes, machines or equipment.

The committee also strongly recommends the use of the more specific restrictive term 'automatic control' (defined in the glossary) rather than 'automation' where this is appropriate, the word 'automation' being reserved for the more general meaning covered by the above definition.

*Automation. Published by H. M. Stationery Office for the Department of Scientific and Industrial Research, 1956.
I. CONTROL

1.1. **Alarm.** A device which provides a visual or audible warning of danger or of a predetermined state.

1.2. **Analogue modelling.** See **Simulation.**

1.3. **Anticipatory action.** An American synonym for derivative action (qv).

1.4. **Auto-correlation function.** Gives a measure, in statistical terms, of the similarity between a signal and a delayed version of itself, expressed as a function of the delay. See **Cross correlation function.**

1.5. **Automatic control.** 1. A control system which includes no human operator. 2. Direct operation in response to the measurement of parameters without the intervention of manual control.

1.6. **Bellman’s dynamic programming.** A mathematical technique applicable to problems of dynamic programming (qv).

1.7. **Boolean algebra.** An algebraic notation for logical relations named after the 19th century mathematician George Boole. By the use of symbols for ‘and’, ‘or’, ‘not-and’ an algebra is obtained which may be manipulated in very much the same manner as the more familiar common algebra.

1.8. **Calculus of variations.** A mathematical technique applicable to problems of dynamic programming (qv).

1.9. **Computer control.** Control of a process by means of a computer which may modify its control function on receipt of feedback information from sensors monitoring the process variables. Information may also be displayed, stored or processed by the computer to assist the correct human intervention if this should be necessary. See **Direct digital control.**

1.10. **Constraints.** Physical limitations, commands, etc., that impose definite limits on the way in which a process may be operated.

1.11. **Cross correlation function.** Gives a measure, in statistical terms, of the degree of similarity between two signals expressed as a function of the time shift between them. See **Auto-correlation function.**

1.12. **Cybernetics.** The science of control and communication in all its manifestations within and between machines, animals and organizations.

1.13. **Derivative action.** Possessed by a controller when its output signal includes a term proportional to the rate of change of the deviation.

1.14. **Desired value.** The value of the controlled condition which the operator desires to obtain.

1.15. **Differential equations.** Equations which relate not only variables, but also the rate at which these variables change with respect to time or other variables.

1.16. **Dynamic optimization.** Optimization in which the objective is not merely to get the controlled process to an optimum condition but also to arrive at this optimum condition by the most advantageous route.

1.17. **Dynamic programming.** In operations research, a procedure used in solving a multistage problem which involves decisions being made at each stage of the process.

1.18. **Element** (of a hierarchy). A general term for the units into which a hierarchy (qv) may be divided.

1.19. **Extremum control.** A type of control in which the objective is to maintain the controlled condition, not at a set constant value, but at an extreme value (ie a maximum or minimum value).

1.20. **Forcing function.** An external stimulus applied to a system. A forcing function may be used to characterize a system, eg an impulse could be applied to a servo mechanism to determine its response-time.

1.21. **Gross errors.** In a measuring system, the appreciable errors that result from malfunctioning, incorrect installation, inadequate calibration procedures etc., of the system. By their probable magnitude they must be distinguished from systematic errors (qv) and by both magnitude and characteristics from random errors (qv).

1.22. **Hamilton’s method.** A mathematical technique applicable to the solving of problems of dynamic optimization (qv).
1.23. **Hierarchy.** A pyramidal organization of plant, management, control, etc., in which, in general, each element provides commands for and receives information from several inferior elements.

1.24. **Hill climbing.** A descriptive term for the procedures involved in extremum control (qv).

1.25. **Input variables.** The mathematically expressed quantities of the materials, energy, information, etc., introduced into a process or system.

1.26. **Instability.** The tendency for deviations in values measured by an instrument to increase until some limit of the system is reached. Caused by over-corrections or attempts to correct in the wrong direction by an incorrectly adjusted controller.

1.27. **Integral action.** Possessed by a controller when its output signal includes a term proportional to the integral of the change of the deviation.

1.28. **Interaction.** The action of one body or system on another.

1.29. **Mathematical model.** A mathematical representation of a phenomenon, process, device, system or concept.

1.30. **Matrix.** A rectangular array of mathematical quantities. Matrices provide a convenient and concise means of expressing mathematical equations with many terms.

1.31. **Matrix algebra.** Procedures for manipulating matrix equations.

1.32. **Measured value.** The value presented by a measuring instrument. It is necessary to distinguish between the actual value of a process variable and the measured value since the two may be different as a result of errors and/or time lags in the system. It is desirable that any such differences should be acceptably small.

1.33. **Modal control.** A technique in which control is effected by making corrections to two or more correcting conditions at the same time. The object is to control one condition without disturbing other process conditions through interaction effects.

1.34. **Objective function.** A mathematical expression for the performance of a process or part of a process. It may, for example, be a cost function which is normally to be minimized in operating the process, or a profit function which is to be maximized. In general, the process must be run in a manner which gives the best possible value to the objective function, i.e., the objective function should be optimized.

1.35. **Operational amplifier.** A high-gain amplifier, usually a solid-state device, which, with suitable input and feedback networks, can perform mathematical operations such as summing, integration, etc. A fundamental part of electronic analogue computers and of many analog-type signal processing devices.

1.36. **Optimization procedures.** Control procedures which have the objective of bringing a process to a defined optimum, i.e., best state of operation.

1.37. **Output variables.** The mathematically expressed quantities of the materials, energy, information, etc., emerging from a process or system. See Input variables.

1.38. **Parameter.** A variable which is given a constant value for a specific purpose or process.

1.39. ** Pontryagin's maximum principle.** Also known as Pontryagin's minimum principle. A mathematical technique applicable to problems of dynamic optimization (qv).

1.40. **Proportional action.** The action of a control element whose output signal is proportional to its input signal.

1.41. **Proportional controller.** A controller with a proportional action only. The output signal \( V \) from such a controller is given by:

\[
V = -K_1 \theta
\]

where \( K_1 \) is the proportional action factor and \( \theta \) is the converted deviation.

1.42. **Random error.** An error which varies unpredictably, in magnitude and sign, when a large number of measurements are made of the same value of a quantity under identical conditions.

1.43. **Rate action.** Deprecated. An American synonym for derivative action (qv).

1.44. **Regression analysis.** A systematic statistical technique for estimating, with confidence limits, the constants of a new set of data or for testing whether new data are consistent with a particular hypothesis, e.g., the line of best fit to a set of points is usually found by the methods of least squares.
1.45. **Remote operation.** The control of the action of a system or device from a distance.

1.46. **Sensitivity.** The sensitivity of an instrument at any indicated value is the relation between the movement of the index and the change in the measured quantity that produces it. It may be expressed as a numerical ratio if the units of measurement of the index path and units of the measured quantity are stated.

1.47. **Sequence control.** Control of a series of actions in which the start of each action demands the satisfaction of appropriate prior conditions.

1.48. **Servo amplifier.** An amplifier used as part of a servo-mechanism (qv) that supplies power to the input terminals of a mechanical actuator.

1.49. **Servomechanism.** 1. A feedback control system in which at least one of the system signals represents mechanical action. 2. Any feedback control system. 3. An automatic feedback control in which the control variable is a mechanical position or any of its time derivatives.

1.50. **Servomechanism, positional.** A servomechanism in which a mechanical shaft is positioned usually in the angle of rotation, in accordance with one or more input signals.

1.51. **Servomechanism, repeater.** A positional servomechanism in which loop input signals from a transmitting transducer are compared with loop feedback signals from a compatible or identical receiving transducer mechanically coupled to the servomechanism to reproduce a mechanical shaft motion or the position of the transmitting transducer.

1.52. **Set point.** The command signal to a process control system.

1.53. **Simulation.** Representation of a system or part of a system by another more conveniently operated system which behaves in an analogous manner. Commonly a representation for purposes of studying system behaviour will be by means of an electronic analog or digital computer.

1.54. **Single-term controller.** A controller that has only one of the three actions of a three-term controller. In general, it may have proportional action or integral action, but not derivative action.

1.55. **Spectral power density.** The power density at a given frequency is the limiting value, as the bandwidth approaches zero, of 'the signal power within a certain bandwidth centred on the chosen frequency divided by the bandwidth'. By analogy, the concept may be applied to other signals which are not essentially of an energy-conveying nature.

1.56. **Standard deviation.** The mean square of the variable $x$ from the value $a$ is, as the name implies, the mean value of the square of the deviation of $x$ from $a$. It is therefore given by:

$$\frac{1}{N} \sum_{i} f_i \cdot \xi^2,$$

where $N$ is the total frequency, $f_i$ is a function, and $\xi$ is the deviation of $x$ from $a$.

The positive square root of the variance is called the standard deviation of $x$, and is denoted by $\sigma$.

$$\mu = \sigma^2 = \frac{1}{N} \sum_{i} f_i (x_i - \overline{x})^2,$$

where $\mu$ is the variance, $\sigma$ is the arithmetic mean of the $N$ values of the variables.

The variance, or alternatively the standard deviation, may be taken as an indication of the extent to which the values of $x$ are scattered. This scattering is called dispersion. The concepts of variance and standard deviation play an important part in statistical analysis.

1.57. **State equations.** A set of equations for a process which involves the values of all state variables (qv) and of all inputs to the process and which gives the rate of change (ie the derivatives with respect to time) of all the state variables. Thus the state equations completely define the dynamic behaviour of the process.

1.58. **State variables.** Of a process, etc., a set of conditions which, taken together, are sufficient to define the present conditions of the process. In general, the state variables can be chosen in several different ways, ie there is no unique set (qv) state equations.
1.59. **Statistical methods.** See Stochastic methods.

1.60. **Steady state optimization of process conditions.** Applied to an entire process with the object of ensuring that the process operates in a steady-state set of conditions that optimize some objective function. See Extremum control.

1.61. **Stochastic methods.** Also known as statistical methods. Mathematical methods suitable for studying the behaviour of processes, etc., which are under the influence of irregular or random inputs.

1.62. **Strategy.** A management or control procedure that is less concerned with the immediate performance of a process, etc., than with achieving the best performance when evaluated over a longer period of time. Often contrasted with tactics (qv).

1.63. **Systematic error.** An error which remains constant when measurements are made of the same value of a quantity under identical conditions or varies according to a definite rule when the conditions change.

1.64. **Tactic.** A management or control procedure that is less concerned with the long-term performance of the process, etc., than with its short-term operation. Often contrasted with strategy (qv).

1.65. **Telemetry.** The conveyance and interpretation of information at a distance, usually by electrical or electromagnetic means.

1.66. **Time lag.** The delay between a change in the input to a system, element, etc., and the consequent change in output.

1.67. **Two-state devices.** Circuits and other devices that have two stable states, as a switch may remain either on or off. Also known as binary elements or devices.

1.68. **Variable.** A quantity that can assume any of a given set of values.

1.69. **Variance.** See Standard deviation.

1.70. **Verification.** The process of ascertaining the truth of data or of a statement or fact.

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The following definitions relating to automatic controlling and regulating systems are given in British Standard 1523: Part 1: 1967:

1.71. Acceleration misalignment.
1.72. Acceleration misalignment coefficient.
1.73. Actuator.
1.74. Adaptive control system.
1.75. Amplification.
1.76. Amplifying element.
1.77. Aperiodic damping.
1.78. Attenuation.
1.79. Automatic closed-loop control system.
1.80. Automatic controller.
1.81. Automatic monitored control system.
1.82. Automatic regulating system.
1.83. Automatic regulator.
1.84. Stacklation.
1.85. Band width.
1.86. Broken loop amplification.
1.87. Cascade control system.
1.88. Closed loop control system.
1.89. Closed loop regulation.
1.90. Coefficient of stability.
1.91. Command signal.
1.92. Comparing element.
1.93. Compensating feedforward or feedback.
1.94. Compound regulating system.
1.95. Compounding feedforward or feedback.
1.96. Conditional stability.
1.97. Continuous action.
1.98. Continuous action servomechanism.
1.99. Control action.
1.100. Control system.
1.101. Controlled condition.
1.102. Controlled device.
1.103. Controller.
1.104. Converted command signal.
1.105. Converted controlled condition.
1.106. Converted deviation.
1.108. Correcting condition.
1.110. Correcting feedforward or feedback.
1.111. Correcting unit.
1.112. Critical damping.
1.113. Damped oscillation.
1.114. Damping.
1.115. Dead band.
1.116. Dead time.
1.117. Dead zone.
1.118. Definite-restitution action.
1.119. Derivative action.
1.120. Derivative action time.
1.121. Desired value.
1.122. Detecting element.
1.123. Deviation.
1.124. Direct disturbance.
1.125. Discontinuous action.
1.126. Discontinuous action servomechanism.
1.127. Distance/velocity lag.
1.128. Disturbance.
1.129. Dither.
1.130. Divided monitoring feedback.
1.131. Drive motor.
1.132. Droop.
1.133. Duplex controller.
1.134. Dynamic amplification (coefficient).
1.135. Dynamic misalignment coefficients.
1.136. Dynamic regulation.
1.137. Dynamic stability.
1.138. Effective dead time.
1.139. Environmental stability.
1.140. Exponential lag.
1.141. Feedback.
1.142. Feedforward.
1.143. Final controlling element.
1.144. Floating action.
1.145. Floating controller.
1.146. Forced oscillation.
1.147. Free oscillation.
1.148. Gain.
1.149. Harmonic regulation.
1.150. Harmonic response.
1.152. Harmonic response diagram.
1.152. Hunting.
1.154. Increasing oscillation.
1.155. Incremental regulation.
1.156. Indirect disturbance.
1.157. Inherent feedback.
1.158. Inherent proportional band.
1.159. Inherent regulation.
1.160. Input element.
1.161. Input signal.
1.162. Integral action.
1.163. Integral action time.
1.164. Integral controller.
1.165. Kinetic control system.
1.166. Limitation.
1.167. Limiting.
1.168. Limiting feedforward or feedback.
1.169. Linear control system.
1.170. Linear element.
1.171. Linear system.
1.172. Load.
1.173. Main closed loop.
1.174. Main forward path.
1.175. Manual closed-loop control system.
1.177. Measuring element.
1.178. Measuring unit.
1.179. Misalignment.
1.180. Modifying feedforward or feedback.
1.181. Monitored control system.
1.182. Monitoring element.
1.183. Monitoring feedback.
1.184. Monitoring loop.
1.185. Motor element.
1.186. Multi-step action.
1.188. Multi-step control servomechanism.
1.189. Natural frequency.
1.190. Offset.
1.191. On-off action.
1.192. On-off controller.
1.193. On-off control servomechanism.
1.194. One-way element.
1.195. (Open) loop amplification.
1.196. Open-loop control system.
1.197. Output signal.
1.198. Overshoot.
1.200. Peak transient regulation.
1.201. Plant.
1.203. Process control system.
1.204. Programmed controller.
1.205. Programmed controlling element.
1.206. Proportional action.
1.207. Proportional band.
1.208. Proportional control factor.
1.209. Proportional controller.
1.211. Reference element.
1.212. Reference quantity.
1.213. Regulation.
1.214. Regulating system.
1.215. Response/frequency diagram.
1.216. Response time.
1.217. Resonance frequency.
1.218. Sampling.
1.219. Sampling control system.
1.220. Saturation.
1.221. Scanning control system.
1.222. Self-acting controller.
1.223. Self-aligning control system.
1.224. Self-optimizing control system.
1.225. Self regulation.
1.226. Servomechanism.
1.228. Settling time.
1.229. Set point.
1.230. Set value.
1.231. Shaping network.
1.233. Signal processing.
1.234. Span.
1.235. Stabilization.
1.236. Stabilizing feedforward or feedback.
1.237. Stable state.
1.238. Steady oscillation.
1.239. Steady state.
1.240. Steady state regulation.
1.242. Step function response.
1.243. Step function response diagram.
1.244. Stiffness (coefficient).
1.245. Subsidence ratio.
1.246. Three-term controller.
1.247. Transient peak value.
1.248. Transient response.
1.249. Two-step action.
1.250. Two-step action with overlap.
1.251. Two-step controller.
1.252. Two-step controller with overlap.
1.253. Two-term controller.
1.254. Undamped natural frequency.
1.255. Under damping.
1.256. Unmonitored control system.
1.257. Unstable state.
1.258. Velocity misalignment.
1.259. Velocity misalignment coefficient.
2. COMPUTERS

2.1. Access time. 1. The interval between the time at which data are called for from a store and the time delivery begins. 2. The interval between the time at which a request is received from data to be stored and the time storage starts.

2.2. Accumulator. A storage register, used in conjunction with the adder (qv), which can store the result of the addition of its original content and another number.

2.3. ADC. See Analog/digital converter.

2.4. Adder. A device which sums two binary numbers.

2.5. Address. 1. The identifying name or number of a particular store location in a computer. 2. To select a store location.

2.6. ALGOL. A widely-used compiler language (qv) particularly suited to scientific work.

2.7. Algorithm. A set of rules defining a finite number of operations required to achieve a particular result.

2.8. Alphanumeric. Relating to a character set of alphabetic letters or numbers, but in practice it now includes a certain number of symbols, eg +, *, etc.

2.9. Analog computer. A machine designed to perform arithmetical functions upon numbers, where the numbers are represented by some physical quantity. Analog computers operate in real time mode and thus can be used to simulate various physical systems, to control industrial processes or for research into design problems.

2.10. Analog representation. Representation of a variable by a physical quantity (such as angular position or voltage) which is made proportional to the variable.

2.11. Analog/digital converter (ADC). A device which samples an analog signal and converts the sampled value to a digital number.

2.12. And. A Boolean (logical) operation.

2.13. Argument. In computation, (1) an independent variable, eg in looking up a table, the key (or any of the keys) which identifies the location of the required result, (2) an operand in an operation on one or more variables.

2.14. Arithmetic unit. A section of a computer where arithmetical, logical or shift operations are performed.

2.15. ASCII. An 8-bit code for representing alphanumeric characters as binary numbers. The most commonly used code for punched paper tape.

2.16. Assembler. A quality program for converting instructions written as mnemonics into binary machine code. The mnemonic assembly language differs from computer to computer.

2.17. Assembly language. A symbolic programming language which is closely related to machine language, but a program in assembly language must be put through an assembler to convert it into the corresponding machine code, the assembly usually generating machine instructions in a one-to-one correspondence with those in the assembly language program.

2.18. Asynchronous. Describes a mode of operation in which an event is started by the completion of another event. See Synchronous.

2.19. Autonomous data transfer. A facility by means of which data may be transferred to or from a computer (from or to external sources or receivers or backing stores) more or less independently of specific transfer programmes. Thus blocks of data may be transferred while the computer program is occupied with other work and time is saved.

2.20. Auxiliary register. A register used effectively to increase the capacity of an accumulator.

2.21. Back up store. Also known as backing store. Large capacity (bulk) storage, much cheaper but slower than memory, eg magnetic disk or tape.

2.22. Backing store. See Back up store.

2.23. Baud. A unit of signalling speed equal to the number of discrete conditions or signal events per second.

2.24. BCD. See Binary coded decimal.

2.25. Binary. A number system having base 2.

2.27. **Binary point.** Used with binary numbers as the equivalent to the decimal point with decimal numbers, is used to separate the characters that represent whole numbers from those that represent fractions.

2.28. **Bit.** A binary digit. A bit has only two possible states, 0 or 1.

2.29. **Bootstrap loader.** A very simple program which will activate the paper tape reader or other information processing device. For the purpose of initially loading a program usually loaded by hand or as a read-only memory (ROM) (qv).

2.30. **Buffer.** A store used to compensate for a difference in rate of flow of data, or time of occurrence of events, when transmitting data from one device to another.

2.31. **Bus.** A data link between various parts of a machine.

2.32. **Byte.** A binary element string operated upon as a unit and usually shorter than a computer word. Usually an 8-bit character.

2.33. **Central processing unit (CPU).** The operational part of the computer which interprets and executes instructions.

2.34. **Character.** A letter, digit, or other symbol which is used as part of the organization, control or representation of data. A character is often in the form of a spatial arrangement of adjacent or connected strokes.

2.35. **Clear.** To place one or more storage locations into a prescribed state, usually zero or the space character.

2.36. **Clock.** 1. A device that generates periodic signals used for synchronization. 2. A device that measures and indicates the passage of time. 3. A register whose content changes at regular intervals in such a way as to measure time.

2.37. **Clock rate.** 1. The frequency at which pulses are generated by a clock. 2. The time interval between regular pulses produced by a timing device used to synchronize operations within a system.

2.38. **COBOL.** A widely-used compiler language (qv) particularly suited to business and management computations.

2.39. **Coefficient potentiometer.** An adjustable potential-divider circuit as used in electronic analog computers for multiplication of signals by a preset factor in the range 0 to +1.0.

2.40. **Compiler.** A utility program for converting a high-level language, eg FORTRAN, into machine code. See Compiler language.

2.41. **Compiler language.** A programming language which permits the programmer to write as single program instructions expressions which will require many machine instructions. Well-known compiler languages are FORTRAN, ALGOL, COBOL and CORAL 66 (qv).

2.42. **Complement.** A number whose representation is derived from the representation of another in a radix notation. 1's complement changes all 0s to 1s and all 1s to 0s. 2's complement is the 1's complement plus 1, with the carry ignored. Used to represent negative numbers in the binary form.

2.43. **Computer.** A data processor that can perform substantial computation, including numerous arithmetic or logic operations, without intervention by a human operator during the run.

2.44. **Computer program.** A series of instructions or statements in a form acceptable to a computer, prepared to enable it to achieve a desired result.

2.45. **Conditional jump.** A jump that takes place only when the instruction that specifies it is executed and specified conditions are satisfied.

2.46. **Control register.** See Program counter.

2.47. **Control unit.** That part of the computer which decodes instructions and directs the closing of appropriate gates in the processor.

2.48. **Conversion algorithm.** A mathematical procedure for converting signals from measuring instruments, etc., say in milliampere, into engineering units, say units of flow-rate. In process control, usually associated with an on-line digital computer program.

2.49. **CORAL 66.** A compiler language (qv) particularly suitable for use in a control situation.

2.50. **Core store.** A high-speed storage device in a computer, so called because it consists of individual magnetic cores for the storage of individual bits of data.
2.51. CPU. See Central processing unit.

2.52. Cross assembler. A computer program enabling a source program in assembly language to be converted into an object program which will run on a computer of a different type from the originally intended one.

2.53. Cross compiler. A computer program enabling a source program written in a high-level language to be converted into an object program which will run on a computer of a different type from the original.

2.54. Cycle time. Of a core store (qv), the minimum time interval between the starts of successive read/write cycles. By analogy, in stores with separate reading and writing cycles, the read (or write) cycle time is the minimum time between the start of successive read (or write) cycles.

2.55. Cyclic shift. A shift in which data from one end of a storage device are re-entered at the other end, as in a closed loop.

2.56. DAC. See Digital/analog converter.

2.57. Data. All, or any selection of the operands and results involved in any operation or set of operations. Note 1. The word ‘data’, although plural in form, is commonly treated as a collective noun and may therefore be used with a singular verb. Note 2. It is often convenient to contrast data with instructions. Note 3. The use of the word ‘information’ to mean data is deprecated; in its ordinary sense the information associated with data is what the data convey to the person receiving them.

2.58. Data logger. An automatic device for performing data logging (qv).

2.59. Data logging. Recording of data (qv) about events which occur in time sequence.

2.60. Data processing. The execution of a systematic sequence of operations performed upon data (qv). Synonymous with information processing.

2.61. Data processor. A device capable of performing data processing (qv), including desk calculators, punched-card machines and computers (qv).

2.62. Data reduction. The condensation of a large quantity of data (qv) into a smaller quantity representing selected facts.

2.63. Debugging. The detection, location and removal of mistakes from a routine or malfunction from a computer. Synonymous with troubleshooting (qv).

2.64. Decode. To apply a set of unambiguous rules specifying the way in which data may be restored to a previous representation, i.e. to reverse some previous encoding.

2.65. Decoder. 1. A device that decodes (qv). 2. A matrix of logic elements that selects one or more output channels according to the combination of input signals present.

2.66. Digital/analog converter (DAC). A device which converts digital signals to analog voltages; See Analog/digital converter.

2.67. Digital clock. A clock (qv) which provides an output of digital signals and can thus give information to a digital computer. The on-line computer commonly needs to know the time and also needs to be able to measure intervals of time. Thus the digital clock is an essential item of hardware (qv) of the on-line computer.

2.68. Digital computer. See Computer.

2.69. Direct access store. See Random access memory.

2.70. Direct digital control. 1. The use of a digital computer for the control of a process in such a manner that the computer directly adjusts the correcting conditions of the process. 2. In a more restricted sense, the application of a digital computer in such a manner that it performs the same functions as could have been performed by conventional controllers. See Supervisory control. Note. A digital computer may perform on-line control of a supervisory nature, i.e. with other controllers between the computer and the correcting conditions of the process; this does not constitute direct digital control.

2.71. Direct memory access (DMA). A device or method for transferring blocks of contiguous data to or from memory at a high rate without the use of CPU registers.

2.72. DMA. See Direct memory access.

2.73. Double precision arithmetic. When numbers are each represented by single words in a computer the definite word-length imposes a limit to the precision with which numbers can
be represented and arithmetical operations performed. To overcome this limitation words
may be used in pairs, each pair of words, jointly forming a number of double length. The
facility for doing this and for performing mathematical operations on the double-length
words is termed 'double-precision arithmetic'.

2.74. Dummy instruction. An instruction which has no functional or organizational signifi-
cance. It is generally used to provide scope for future changes in a program or to fulfill some
prescribed condition, eg the completion of a block of instructions.

2.75. Editor. A routine used to edit program coding.

2.76. Encode. To apply a set of unambiguous rules specifying the way in which data may
be represented so that a subsequent decoding is possible.

2.77. Executive routine. A routine that controls the execution of other routines.

2.78. Fixed-point arithmetic. Arithmetical calculations performed without regard to the
position of the radix point. The numbers are treated as integers, but the relative position of
the point is controlled during calculations.

2.79. Fixed-point representation. A method of representing a number by a single set of digits,
the values and positions of which determine the value of the number. The radix point is
located at a predetermined fixed position in the set.

2.80. Floating-point arithmetic. Arithmetical calculations based on floating-point numbers,
the position of the decimal point not depending on the relative position of the digits in the
numbers.

2.81. Floating-point representation. A method of representing a number by two sets of digits,
known as the fixed point part and the exponent part. A number n is represented as:

\[ n = a \cdot r^b, \]

where \( a \) is the fixed point part and \( r \) is the radix or base to the exponent \( b \).

2.82. Flow diagram. Of a computer program, outlines the main course of the program and
what it does. It is a useful first step in preparing a program since it is general in nature and
lacks the detail of every separate instruction. Synonymous with 'flow chart'.

2.83. FORTRAN. A widely-used compiler language (qv), particularly suited to scientific work.

2.84. Four address instruction code. See Instruction code.

2.85. Gate. A device having one output channel and one or more input channels such that the
output channel state is completely determined by the input channel states, except during
switching transients.

2.86. Hardware. The physical equipment of a computer system. This includes the computer, its
store and its peripheral equipment. In a computer control system this is generally taken as
including also the process instrumentation that is directly linked to the computer.

2.87. Hexadecimal. 1. Pertaining to a characteristic or property involving a selection, choice
or condition in which there are sixteen possibilities. 2. Pertaining to the numeration system
with a base of 16.

2.88. High-level language. A programming language in which each instruction corresponds
to several machine code instructions. This allows a programmer to write instructions in a
familiar notation, these then being converted (by the use of a suitable program) to the much
greater number of instructions of the low-level machine language (qv).

2.89. Hybrid computer. A computer using both analog representation and discrete
representation of data.

2.90. Index register. A register whose content may be added to or subtracted from the operand
address prior to or during the execution of a computer instruction.

2.91. Indexed instruction. Instructions in a computer program may be expressed in such a way
that the operand addresses given in the instructions are to be modified, eg reduced, by an
amount equal to the number that happens to be in the index register when the computer
obeys the instructions. Then if the computer is programmed to follow the instructions with
successively different numbers in the index register the same program will be performed on
successively different sets of data. See Index register.

2.92. Indirect address. An address that specifies a storage location that contains either a direct
address or another indirect address. Synonymous with multi-level address.
2.93. Information retrieval. Recovery of particular items from a storage medium in which a large quantity of information has been categorized and filed. It is essential that access time should be short and that additional items can be added to the store as and when necessary.

2.94. Input/output. The process of transmitting data to and from the computer and its peripherals.

2.95. Instruction. An expression that specifies one of the elementary operations which can be performed by a computer either directly or by a programming system such as an interpretive routine.

2.96. Instruction code. A full computer instruction requires an operation code (which says what is to be done) and one or more addresses. These may variously be addresses of operands, of the location in which the result of the operation is to be stored, and of the next instruction. Some computers, particularly in the past, have used as many as four addresses in the instruction code, i.e. four-address instruction code. It is now more economical to use instruction codes with only one or perhaps two addresses even though the programs may be longer, i.e. single- and two-address instruction codes (qv).

2.97. Instruction register. Part of the control unit used in storing an instruction for decoding.

2.98. Interface. A boundary or common point to two or more entities through which information flow takes place.

2.99. Interpretive loader program. See Assembly language.

2.100. Interrupt. To stop a process in such a way that it can be resumed.

2.101. Iterative loop. A sequence of program instructions which is repeated successively until some criterion is met for the sequence to be left. The criterion might, for example, be that the loop had been traversed a certain number of times, or that successively better approximations to a numerical answer showed acceptably small changes from one iteration of the computation to the next.

2.102. Jump. An instruction for altering the normal sequential operation of a program.

2.103. K. The analogous term in computer terminology to the S.I. prefix ‘k’ for kilo (1000). In computer design and operation it is the abbreviation for 210 which represents 1024.

2.104. Language. A set of characters and the rules for allowing their grammatical and syntactic combination into words and expressions so as to provide an ordered method of communication with the computer.

2.105. Least significant bit. See Most significant bit.

2.106. Loader. A utility program which transfers data from a peripheral device to computer memory. Varying degrees of complexity allow for loading multiple programs and subprograms, including linking and relocation.

2.107. Logic element. A device that performs a logic function, e.g. an and element. Also known as a gate.

2.108. Low-level language. A language in which each instruction has a single corresponding machine code equivalent.

2.109. Machine code. An operation code that a machine is designed to recognize.

2.110. Machine language. A language that is used directly by a machine.

2.111. Macro-instruction. An instruction in a source language that is equivalent to a specified sequence of machine instructions.

2.112. Magnetic core. A configuration of magnetic material that is, or is intended to be, placed in a spatial relationship to current-carrying conductors whose magnetic properties are essential to its use.

2.113. Magnetic disc. A flat circular plate with a magnetic surface on which data can be stored by selective magnetisation of portions of the flat surface.

2.114. Magnetic drum. A right circular cylinder with a magnetic surface on which data can be stored by selective magnetisation of portions of the curved surface.

2.115. Magnetic tape. 1. A tape with a magnetic surface on which data can be stored by selective polarization of portions of the surface. 2. A tape of magnetic material used as the constituent in some forms of magnetic core.

2.116. Main frame. See Central processing unit.
2.117. **Mask.** 1. A pattern of characters that is used to control the retention or elimination of portions of another pattern of characters. 2. A filter.

2.118. **Mathematical utilities.** A set of programs for calculating algebraic and trigonometric functions. Also, conversions from a binary number to a sequence of ASCII characters and vice-versa.

2.119. **Matrix.** 1. In mathematics, a two-dimensional rectangular array of quantities. Matrices are manipulated in accordance with the rules of matrix algebra (qv). 2. In computers, a logic network in the form of an array of input leads and output leads with logic elements connected at some of their intersections.

2.120. **Matrix algebra.** Procedures for manipulating matrix equations.

2.121. **Memory.** See Storage.

2.122. **Micro instruction.** The simplest basic instructions of the machines e.g. logical and, shift, one bit, etc.

2.123. **Micro program.** A program of micro instructions (qv) which executes a standard or macromachine instruction. Often stored in a read-only memory (ROM) (qv).

2.124. **Most significant bit.** In a decimal number, e.g. 1,234, the most significant digit is that on the left (representing 'thousands' in the example) and the least significant digit is that on the right (representing 'units'). In a binary number, consisting of the binary characters 0 and 1, each character may correspond according to its position, to a certain different power of 2. The character corresponding to the highest power of 2 is the most significant bit, and that corresponding to the lowest power of 2 is the least significant bit.

2.125. **Multi-level address.** See Indirect address.

2.126. **Multiplexing.** Interleaving or simultaneously transmitting two or more messages on a single channel. See Scanning.

2.127. **Notation.** A set of symbols, and the rules for their use, for the representation of data.

2.128. **Object program.** A fully compiled or assembled program normally in machine code ready for loading into a computer, but when some high-level languages are in use the object program may need further translation before it can be understood by the computer. A program written in the source language is translated to an object program through the use of a compiler.

2.129. **Octal.** Pertaining to a characteristic or property involving a selection, choice or condition in which there are eight possibilities.

2.130. **Octal notation.** The number representation system with a base of 8.

2.131. **Off-line control.** Operations, equipment or devices not under the control of the central processing unit.

2.132. **On-line control.** Control in which the computer or any other controlling equipment is permanently committed to the control of a process to which it is directly linked by instruments.

2.133. **Operand.** That which is operated upon. An operand is usually identified by an address part of an instruction.

2.134. **Operating system.** Software which controls the operation of computer programs and which may provide scheduling, debugging, input-output-control, accounting, compilation, storage assignment, data management and related services.

2.135. **Operation code.** A code that represents specific operations. Synonymous with instruction code (qv).

2.136. **Or.** A boolean (qv), i.e. logical operation.

2.137. **Overflow.** 1. That portion of the result of an operation which exceeds the capacity of the intended unit of storage. 2. Pertaining to the generation of overflow.

2.138. **Page.** A continuous section of memory which can directly be addressed in an instruction.

2.139. **Parallel operation.** See Serial operation.

2.140. **Parallel transfer.** Transfer of data in which each element of a unit of data is transferred simultaneously.
2.141. **Parallel transmission.** In telecommunications, when a certain number of signal elements forming part of the same data signal are transmitted simultaneously.

2.142. **Parity bit.** A check appended to an array of binary digits to make the sum of all the binary digits, including the check bit, always odd or always even.

2.143. **Parity check.** A check that tests whether the number of one (or zeros) in an array of binary digits is odd or even. Synonymous with odd/even check.

2.144. **Peripheral.** Any device in the system which is not part of the computer itself.

2.145. **Power fail restart.** A hardware feature which causes an interrupt when power failure is detected. Voltages will hold up long enough for the (corruptible) register contents to be taken off or stored in the (non-corruptible) memory. Restart resets the registers.

2.146. **Printer.** A machine which produces a printed record of the data with which it is fed.

2.147. **Priority indicator.** A code determining the order of importance of a message, and therefore the order of transmission of the message.

2.148. **Priority interrupt.** A facility which is essential for the on-line control computer. With it, the computer, which may be working on a particular program item, can be interrupted from an outside source if priority demands that the computer should attend to the interruption in preference to its prior activity.

2.149. **Process control system.** A control system, the purpose of which is to control some physical quantity or condition of a process.

2.150. **Program counter.** A register used to store the address of the next instruction to be executed. Synonymous with control register (qv).

2.151. **Programmed data transfer.** See Autonomous data transfer.

2.152. **Programming.** The design, writing, testing and documentation of a program.

2.153. **Punched card.** A card punched with a pattern of holes to represent data.

2.154. **Punched tape.** A tape on which a pattern of holes or cuts is used to represent data.

2.155. **RAM.** See Random access memory.

2.156. **Random access.** An access mode in which specific logical records are obtained from or placed into a mass storage file in a non-sequential manner.

2.157. **Random access memory (RAM).** A storage device in which the access time is effectively independent of the location of the data. Synonymous with direct access store (qv).

2.158. **Read.** To acquire or interpret data from a storage device, a data medium or any other source.

2.159. **Read-only memory (ROM).** A store which can be read from but not written into under program control.

2.160. **Rotate.** An instruction in machine code or assembly language which shifts bits within a word or number of words either left or right, bit by bit. The bits removed from the last location are placed at the other end of the word. See Cyclic shift.

2.161. **Routine.** An ordered set of instructions that may have some general or frequent use.

2.162. **Scanning.** A procedure by which a number of variables may be sampled in sequence by a single measuring device; the application of a single output device to a number of receivers in turn. See Multiplexing.

2.163. **Segments.** Parts into which a computer program is divided so that the program can be executed without the entire program being in internal storage at any one time.

2.164. **Serial.** Pertaining to the sequential or consecutive occurrence of two or more related activities in a single device or channel.

2.165. **Serial operation.** The arithmetic unit of a computer operates in a serial manner if it performs mathematical and other operations on data words one bit at a time, taking all the bits in succession. More elaborate circuits, but less time, are required for parallel operation, in which all the bits of a word are manipulated at the same time. Similar considerations apply to the transmission of digital-data signals, outside the computer as well as within it. A data word may be transmitted ‘bit by bit’ in succession along a single communication line, ie a serial transmission, or all the bits may be transmitted at the same time along parallel lines, ie parallel transmission.
2.166. **Serial transfer.** A method of data transfer in which the units of data are transferred in succession over a single channel.

2.167. **Serial transmission.** In telecommunications, when data elements forming part of the same data signal are transmitted at successive intervals of time.

2.168. **Set.** To place a device into a specified state, usually other than that denoting zero or space character.

2.169. **Sexadecimal notation.** Synonymous with hexadecimal notation (qv).

2.170. **Shift.** A movement of data to the right or left.

2.171. **Single address instruction code.** See Instruction code.

2.172. **Software.** A set of computer programs, procedures and possibly associated documentation concerned with the operation of a computer system, eg compilers, library routines, manuals, circuit diagrams.

2.173. **Source code.** The code input to a compiler or assembler.

2.174. **Source language.** The programming language from which an object program must be derived before it can be understood by a computer, eg ALGOL, FORTRAN.

2.176. **Source program.** A computer program written in a source language.

2.176. **Standard interface.** An interface (qv) for electrical and other signals and with standardized arrangement of connections and functions, so designed that the one arrangement can be utilized for the interfaces by many different pairs of inter-connecting parts of a system, computer, etc.

2.177. **Storage.** 1. Pertaining to a device in which data can be entered, in which they can be held, and from which they can be retrieved at a later time. 2. Loosely, any device that can store data.

2.178. **Store.** See Storage.

2.179. **Sub-routine.** A sequenced set of statements that may be used in one or more computer programs and at any one or more points in a computer program.

2.180. **Supervisory control.** A system of control in which information on the particular process or processes is at a central location but controlling action is taken by the operator.

2.181. **Synchronous.** Describes a mode of operation in which events are controlled by a clock.

2.182. **Teleprinter.** 1. Descriptive name for telegraphic terminals. 2. Generally an electrically operated typewriter that can be operated by reading a paper tape or manually through a keyboard. 3. The typewriter usually connected to a leased or dial-switched telegraph grade circuit for transmitting text or data. 4. An input/output terminal device, normally used on low-speed circuits and which includes a printer.

2.183. **Time sharing.** Pertaining to the inter-leaved use of the time of a device.

2.184. **Transfer rate.** The rate at which data can be transmitted from one device to another. Measured in words/second or bauds (qv).

2.185. **Troubleshooting.** Synonymous with debugging (qv).

2.186. **Unconditional jump.** An instruction for the computer to proceed immediately to another specified instruction. See Conditional jump.

2.187. **Utility.** General support software for a computer.

2.188. **Verify.** To determine whether a transcription of data, or other operation, has been accomplished accurately.

2.189. **Word.** Unit of data used within the computer. Information within a computer, or presented to it, etc., is commonly in the form of standard length sequences of characters, eg 16 characters. The characters are generally of a binary nature. Each standard-length sequence is termed a 'word'.

2.190. **Write.** To record data in a storage device or a data medium. The recording need not be permanent and can, for instance, be written on a cathode-ray tube display device.
3. WATER TREATMENT

Terms relating to water treatment may be considered under the following headings:

- Processes
- Plant and equipment
- Instruments
- Analysis

Terms relating to processes, plant and equipment have with a few exceptions, been defined in a 'Glossary of terms used in water pollution control', published in 1975 by The Institute of Water Pollution Control. In this glossary, therefore, only terms relating to instruments and analysis are defined.

3.1. INSTRUMENTS

3.1.1. Accuracy. An indication of the error of an instrument based upon the degree of closeness between the instrument reading and the true value of the quantity being measured; often expressed as a percentage of the full-scale reading.

3.1.2. Acoustic meters. A range of instruments utilizing the velocity of an acoustic signal:
(a) for level measurement when the time period between the transmission and receipt of a signal reflected from the surface is measured, or (b) for flow measurement, when the time periods for signals to traverse the medium with and against the flow are measured and the difference is related to the velocity.

3.1.3. Air reaction method. A method of measuring liquid level. The static pressure in a vertical tube which has air or gas bubbling from the submerged open end is equal to the hydrostatic head of liquid above the open end in which it is submerged. Measurement of this pressure is then an indication of level.

3.1.4. Ammeter. An instrument which measures and displays the current passing through an electrical circuit.

3.1.5. Analogue. A continuously variable signal which represents a measured variable.

3.1.6. Anemometer. An instrument for measuring the speed of a fluid, usually air or wind.

3.1.7. Annunciator panel. A panel in a control room or similar location which displays the state in a plant, process or system. A particular or abnormal state is sometimes indicated by flashing lights and/or an audible warning.


3.1.9. Average flowrate. The volumetric flow per unit time averaged over a specified period of time, eg one day.

3.1.10. Average velocity. The velocity in a conduit obtained by dividing the average rate of flow by the cross-sectional area of the wetted area of the wetted portion of the conduit. In practice, it may be necessary to calculate the average from several measured velocities in the cross-section.

3.1.11. Barograph. A recording barometer usually with a cylindrical chart using a transducer such as a series or 'stack' of evacuated capsules.

3.1.12. Barometer. An instrument for measuring the pressure of the atmosphere. (a) An aneroid barometer uses an evacuated capsule which deforms under pressure changes. (b) A mercurial barometer uses a column of mercury in an evacuated tube to balance the atmospheric pressure.

3.1.13. Bell type meter. An instrument which measures low differential gas or air pressures using a bell suspended in a liquid contained in a sealed chamber. Differential pressure applied between the inside and the outside of the bell causes it to rise or fall, and this motion is conveyed by linkage to a pen or pointer.

3.1.14. Bi-metallic strip. A sensor which measures temperature by the differential expansion or contraction of two dissimilar metals bonded together, resulting in bending of the composite element. The amount of bending which occurs can be calibrated in terms of changes in temperature.

3.1.15. Bottom contraction. See Contraction.

3.1.16. Bubbler method. See Air reaction method, Liquid level meter.
3.1.17. **Calibration.** The process of determining the relationship between the value indicated on an instrument and the true value being measured.

3.1.18. **Capacitance level method.** A method of measuring liquid or solids level by detecting the change in electrical capacity between an electrode and the containing vessel, or between two electrodes, as the level varies.

3.1.19. **Carbon dioxide meter.** An instrument using one of a number of techniques for determining the percentage of carbon dioxide in a mixture of gases.

3.1.20. **Channel.** An open conduit which conveys liquid from a body of water to another location.

3.1.21. **Chemical injection method.** A method of injecting a tracer into a flowing fluid to determine its velocity. See Flowmeter, Tracer method.

3.1.22. **Chemical tracer.** See Tracer.

3.1.23. **Chopper bar recorder.** See Recorder, autographic.

3.1.24. **Chromal/alumel thermocouple.** See Thermocouple.

3.1.25. **Cipolletti weir.** See Weir, thin-plate.

3.1.26. **Circular chart recorder.** See Recorder, autographic.

3.1.27. **Circular indicator.** See Indicator.

3.1.28. **Coefficient of discharge.** See Discharge coefficient.

3.1.29. **Compensating cable.** 1. A cable having characteristics designed to compensate for changes in electrical properties in another part of an associated circuit. 2. A special cable used with a thermocouple, having thermo-electrical characteristics which match the thermocouple for which it was designed to compensate for errors introduced by differences in temperature between various joints.

3.1.30. **Conductance.** (Of a conductor or an electrolyte). The reciprocal of ohmic resistance.

3.1.31. **Conductivity, electrical.** The conductance at a specified temperature between the opposite faces of a cube of the material having sides of unit length. The reciprocal of volume resistivity. Formerly known as specific conductance.

3.1.32. **Conductivity meter.** An instrument which measures the electrical resistance of a liquid under specified conditions.

3.1.33. **Conduit.** 1. A tube or trough for protecting electrical cables. 2. A duct for carrying a liquid; it may be closed or open.

3.1.34. **Contraction.** The reduction in cross-sectional area of an open channel due to a hump in the invert (bottom contraction) or protuberances on the side walls (side contractions) resulting in a change in the depth of flow. See Flume.

3.1.35. **Copper/constantan thermocouple.** See Thermocouple.

3.1.36. **Correction.** The adjustment made to an instrument or the figure to be added to, or subtracted from, the instrument reading to present a true interpretation of information.

3.1.37. **Correlation method** (applied to measurement of flow). If a source of disturbance can be detected at one point in a system and the identical disturbance again detected at a point some distance from the first, then the time period between these two disturbances is a measure of the velocity of flow. The automatic recognition of the disturbance pattern and the measurement of this time period is termed the correlation method of velocity measurement. See Auto-correlation function, Cross-correlation function.

3.1.38. **Crest.** In an open channel, the upper surface of a weir over which water is flowing. The slope and dimensions of the crest determine the relationship between the upstream depth and rate of flow.

3.1.39. **Critical flow.** Is the state of flow in an open channel at which the specific energy (gdv) is a minimum for a given discharge. At this condition, the depth of flow is the critical depth and the velocity is the critical velocity. Critical flow normally occurs at one section in a channel and the liquid surface profile changes rapidly near this section so that a standing wave is formed. See also Flow, sub-critical; Flow, super-critical.

3.1.40. **Culvert.** An open channel, used for conveying a liquid.

3.1.41. **Current meter.** An instrument used to determine the velocity of flow of liquids. Generally, propeller types are used in open-flow conditions.
3.1.42. **Dial tube.** A proprietary primary device (qv) for measuring flow, which creates a differential pressure across itself, dependent upon the rate of flow of a fluid passing through it. It consists of a circular section of pipe in which two thin-walled hollow cones are mounted axially on the inner surface of the pipe with their narrow openings adjacent but not touching. The flowing section is thereby first reduced and then expanded to the original area, pressures being measured upstream and at the center portion of the device.

3.1.43. **Damping.** The reduction of oscillations in an instrument or system. Natural damping reduces the free oscillation in a system, but damping may be introduced as part of the design.

3.1.44. **Dead band.** The portion of the operating range of an instrument over which small changes in the measured variable have no perceptible effect. Dead band is sometimes introduced deliberately.

3.1.45. **Dead weight tester.** A device for calibrating pressure measuring instruments using the principle of a known weight acting over a known area.

3.1.46. **Depth gauge.** An instrument which measures liquid level in relation to a fixed datum, or which measures the depth of immersion.

3.1.47. **Desired value.** The value of the measured variable to which an automatic controller is set.

3.1.48. **Dew point.** The temperature at which a body of moist air would be saturated and a visible deposit of moisture occur if the body with its existing moisture content were reduced to that temperature.

3.1.49. **Diaphragm level gauge.** A method of level measurement based upon a closed system comprising a diaphragm connected by a capillary tube to a pressure gauge, but calibrated in terms of liquid level.

3.1.50. **Differential pressure device.** A differential pressure measuring device employing a diaphragm mounted in a closed chamber is termed a differential pressure cell. Movement of the diaphragm is conveyed by mechanical means to an electrical or pneumatic transducer which provides a signal for transmission purposes.

3.1.51. **Digital indicator.** An indicator which displays information in the form of alphanumeric characters (qv).

3.1.52. **Discharge coefficient.** The actual rate of flow through a flow-measuring instrument divided by the theoretical rate of flow.

3.1.53. **Dissolved-oxygen meter.** An instrument which measures the concentration of oxygen dissolved in a liquid by relating the electrical output of an electrochemical sensor to the molecular activity of oxygen surrounding it. Of the many types of sensors available, the most commonly used are membrane-covered to exclude dissolved solids and retain an electrolyte of known composition.

3.1.54. **Downstream total head.** The total head measured downstream of a construction in a channel.

3.1.55. **Drowned flow.** If the flow in a channel through a flume or over a weir is affected by the downstream level, the flow is said to be 'drowned'. The flow is partially or totally drowned as according to whether or not the flume or weir controls the upstream level.

3.1.55A. **Effective depth.** The total depth of flow measured upstream of any restriction in a channel.

3.1.56. **Electrical bridge circuit.** An arrangement of components in a network for the precise measurement of electrical quantities. For example, Wein bridge, Wheatstone bridge, PO box, potentiometer bridge.

3.1.57. **Error.** Of a measuring instrument, the difference between an indicated value and the true value which it represents. See BS 5233.

3.1.58. **Event recorder.** A device for recording on various media such as paper chart, magnetic tape or mechanical counter, the occurrence of an event; optionally with display facilities.

3.1.59. **Flat-bed recorder.** See Recorder autographic.

3.1.60. **Float-type level meter.** See Level meter.

3.1.61. **Flow.** The progressive movement of a substance, especially a fluid.

3.1.62. **Flow, critical.** See Critical flow.
3.1.63. Flow integrator. A device for the summation of measured quantities of flow in any
given period of time.

3.1.64. Flow integrator, electronic. An electronic calculator for summatng measured
quantities of flow.

3.1.65. Flow integrator, mechanical. A mechanical device for summatng measured quantities
of flow. It may be (a) continuously variable, (b) intermittent, or (c) impulse. When
‘continuously variable’, the integrator rotates continuously, its speed of rotation depending
upon the rate of flow. When ‘intermittent’, the speed of rotation is constant but the period
of rotation depends upon the rate of flow. When ‘impulse’, each measured increment of
flow is summed by the increase of one unit on a mechanical counter.

3.1.66. Flow meter. A general term for an instrument which measures rate of flow. Devices
in common use for providing the physical change necessary to produce a signal proportional
to flow may be used in connection with an open channel or a closed conduit. Flow devices
used with an open channel include flumes, weirs, current meters and acoustic devices (qv).
Tracer methods (qv) may also be used. Devices used with a closed conduit include venturi’s,
orifice plates, flow nozzles, positive displacement meters, magnetic flow meters, Dall tubes
and turbine meters (qv in each case).

3.1.67. Flow nozzle. A primary device (qv) intermediate in characteristics between the
venturi and the orifice plate for flow measurement in closed conduits.

3.1.68. Flow rate. The movement of a volume of liquid past a point of measurement or a
reference point, per unit of time.

3.1.69. Flow, sub-critical. In an open channel, occurs when the velocity of flow is less than
the critical velocity and the depth of flow is greater than the critical depth.

3.1.70. Flow, super-critical. In an open channel, occurs when the velocity of flow is greater
than the critical velocity and the depth of flow is less than the critical depth.

3.1.71. Flow recorder. See Recorder, autographic.

3.1.72. Flow tube. A special section of a pipe which has a primary device (qv) and associated
tapping points mounted on it. Essentially for small-bore pipework, available in several
sizes.

3.1.73. Flow velocity. The linear movement of a fluid per unit of time.

3.1.74. Flume. A primary device (qv) for measuring the flow rate in a channel. It consists
basically of contractions which reduce the cross-sectional area of the channel. These con-
tractions result in differences of level, measurement of which can be related to the flow
rate. There are many types, the principal ones being (a) standing wave, in which a standing
wave (qv) is formed by the fluid achieving a critical velocity (qv); (b) venturi, in which a
critical velocity is not achieved, when it is necessary to determine the depth at the throat in
addition to the upstream depth; (c) rectangular, in which the sides and invert are rectangular;
(d) trapezoidal, in which the cross-sectional area is trapezoidal; (e) Parshall, in which the
flume is inclined downwards in the throat section and then inclined upwards, in addition to
side wall contractions; (f) semi-circular or U-shaped, in which the bottom is of semi-circular
construction (suitable for U-shaped channels); (g) hump, consisting of a rectangular flume
with side contractions and a raised invert in the throat. See BS 3680, Part 4, for drawings
and dimensions of each type.

3.1.75. Gauge. 1. A measuring device. 2. A device for measuring the level of a liquid.

3.1.76. Gauge datum. Any agreed level from which other level measurements are taken.

3.1.77. Gauge well. A large diameter vertical tube or chamber connected to an open channel
by a much smaller tube or channel. Its function is to provide suitable conditions for the
location of a float or level gauge.

3.1.78. Gauging station. An installation adjacent to a stream, comprising the necessary
instrumentation for the determination and recording of liquid level. Sometimes containing
telemetry facilities.

3.1.79. Geiger counter. An instrument able to measure β and γ radiation. Used inter alia
for the detection of radioactive tracers when these are employed in the injection method
of velocity measurement.

3.1.80. Hook gauge. A pointed U-shaped hook which is used to determine the level of a
liquid surface. When the pointer moves upwards relative to the water surface it appears
from below as a dimple on the surface, the level being read from an associated scale.
3.1.81. **Horizontal edgewise indicator.** See Indicator.

3.1.82. **Horizontal strip chart recorder.** See Recorder.

3.1.83. **Hydraulic jump.** The standing wave (qv) caused when the flow in an open channel changes from supercritical to sub-critical.

3.1.84. **Hydraulic mean depth.** See Hydraulic radius.

3.1.85. **Hydraulic radius.** In an open channel, the value obtained by dividing the effective cross-sectional area by the wetted perimeter.

3.1.86. **Hydrometer.** An instrument for measuring specific gravity.

3.1.87. **Hygrometer.** An instrument for measuring the relative amount of moisture in the atmosphere, ie relative humidity, and for measuring the dewpoint. The most common types are (a) the psychrometer (qv); (b) the hair hygrometer, in which strands of human hair mounted under tension lengthen with increasing humidity and vice versa. The change of length is magnified mechanically to cause a pointer to move over a calibrated scale: (c) the dewpoint hygrometer, which indicates the temperature at which dew just forms or evaporates (which occurs at 100 per cent relative humidity).

3.1.88. **Indicating instrument.** See Indicator.

3.1.89. **Indicator.** An instrument with a visual presentation which displays the value of a measured variable. It may be of the following types; (a) circular scale, in which the scale is circular and the pointer accordingly moves in an arc; (b) horizontal edgewise, in which the pointer moves horizontally; (c) vertical edgewise, in which the pointer moves vertically; (d) ribbon, in which a coloured band extends to the indicated value (it may be either vertical or horizontal); (e) multipoint, in which there is a single indicator for several inputs incorporating a switchbox to enable each point to be selected separately at will, or (f) digital, in which the measured value is shown as a series of alphanumeric characters.

3.1.90. **Inferential flow meter.** An instrument for metering flow in which the rate is inferred from a measured velocity, knowing the size of pipe.

3.1.91. **Instrument.** A tool, or more specifically a tool which measures. Hence a mechanical, electro-mechanical or electronic device which: (a) measures an unknown quantity and displays and/or records the value so determined, (b) being a defined sub-unit in an inter-linked series of such units, enables a process to be carried out, eg an automatic dialling unit.

3.1.92. **Legend.** 1. A key to a display device of any kind. 2. A label associated with an instrument designating its function, type number, etc. 3. The marking on a meter dial.

3.1.93. **Level meter.** An instrument which measures and displays the position of a physical interface with respect to a datum. It may be one of the following types: (a) float type in which the level is detected by a float the position of which is conveyed to the instrument mechanically or electrically; (b) acoustic type, in which the interface is detected by the time interval between the transmission and receipt of a pulse of ultrasonic sound energy (qv) acoustic meter; (c) bubbler type (qv) in which the static pressure in a vertical tube which has air or gas bubbling from the submerged open end is related to the hydrostatic head of liquid in which it is submerged, measurement of this pressure being an indication of level; (d) pressure bulb type, in which there is a closed system comprising a diaphragm box and pressure instrument connected by a capillary; when the diaphragm assembly is submerged in a liquid, the static head above it is displayed by the instrument; (e) electrode probe, in which the level is detected by a change of electrical properties of a probe (See No fute); (f) γ radiation, in which the change in absorption of γ radiation brought about by the movement of an interface between a suitable radioactive source and detector enables the position of the interface to be determined.

3.1.94. **Liquid density meter.** An instrument for measuring the specific gravity of a liquid by one of several methods, for example: (a) by continuously weighing a U-tube through which the flow is passing, (b) by using the attenuation of ultrasonic waves passing through the liquid, or (c) by using the attenuation of radiation passing through the liquid.

3.1.95. **Magnetic flow meter.** An electrical type of flow meter based on Faraday’s laws of electromagnetic induction. The absence of restriction in the flowing stream makes it suitable for measuring sludge and slurry.

3.1.96. **Manometer.** An instrument for directly measuring positive pressure, vacuum or differential pressure, operating on the principle of displacing a liquid column by the unknown
pressure to be measured. There are three main types, viz. (a) U-tube, (b) vertical, and (c) inclined (micro-manometer or draught gauge).

3.1.97. Mercury manometer. An indicating device comprising a steel U-tube filled with mercury, used in conjunction with a differential-pressure device such as a venturi or orifice plate for flow measurement.

3.1.98. Meter, maximum demand. An instrument which records the maximum electrical power consumed during a fixed time period, in order that a supplementary charge may be levied if the agreed maximum demand is exceeded.

3.1.99. Metrication. A general term for converting existing units of measurement to SI units (qv).

3.1.100. Mimic diagram. An annunciator panel (qv) superimposed on a diagram of a plant or process. It may include various types of indicating instruments.

3.1.101. Modular flow. Exists when the level above a weir is independent of the downstream level.

3.1.102. Multipoint indicator. See Indicator.

3.1.103. Multipoint recorder. See Recorder, autographic.

3.1.104. Nappe. The free discharge sheet formed by the flow of liquid over a weir.

3.1.105. No flute. A level alarm or control device using fixed probes which operate a relay when the level rises or falls below the ends of the probes. A trade name now generally accepted as a generic term.

3.1.106. Noise level meter. An instrument for measuring the frequency-weighted perceived sound pressure, eg in a power house.

3.1.107. Null balance indicator. 1. A sensitive current meter, usually with a centre zero, which at its balance point indicates that there are equal voltages at the points in a circuit to which it is connected. 2. A potentiometric system in which an amplified input signal is used to drive a servomechanism to a balance point with reference to a voltage of known amplitude (qv self-balancing instrument).

3.1.108. Orifice meter. A form of fluid flow meter which uses an orifice plate as the primary measuring device.

3.1.109. Orifice plate. A primary flow measurement device that produces a pressure difference when a flow is passing through it, from which the rate of flow is determined. It consists of a sharp-edged plate with an opening mounted at right angles to the flow in a section of the pipe. The opening is normally concentric with the pipe bore, but it can be eccentric or segmented, usually near the bottom of the pipe to prevent build up of solids.

3.1.110. Oxygen electrode. An electrochemical sensor used for measuring the concentration of oxygen present in a liquid or gas. The sensor consists of two electrodes immersed in an electrolyte which is sealed in the sensor by a gas-permeable membrane. When suitably polarized, the electrode system produces a current directly proportional to the activity of the oxygen in the fluid surrounding the membrane.

3.1.111. pH meter. An instrument for measuring hydrogen ion activity in a solution. The potential developed between an electrode sensitive to hydrogen ions (usually a glass membrane type) and a reference electrode is electronically scaled and displayed as pH value.

3.1.112. Pitot tube. A primary device for flow measurement, consisting of two relatively small tubes which are placed in the fluid, one facing upstream and the other downstream. The differential pressure generated is a measure of flow rate.

3.1.113. Planimeter. A mechanical device for measuring areas on a plan or graph.

3.1.114. Platinum resistance thermometer (PRT). A temperature measuring device in which the change in resistance of a platinum wire is calibrated in terms of temperature.

3.1.115. Point gauge. See Hook gauge.

3.1.116. Positive displacement meter. A flow meter in which a chamber of known volume is swept by closely fitting vanes, pistons or disks. One cycle of operation displaces a specified volume of fluid, and hence the total flow can be measured.

3.1.117. Potentiometer. 1. A device used in electrical circuits for dividing an electrical potential. 2. An instrument which operates on the principle of comparing an unknown potential with a known potential. Used for checking thermocouples, etc.
3.1.118. **Power factor.** The ratio between real power (kW) and apparent power (kVA) in an AC circuit. If \( \phi \) is the angle of lead or lag between the voltage and current in a circuit, then \( \cos \phi \) is the power factor.

3.1.119. **Power factor meter.** An instrument which measures the power factor in an electrical circuit.

3.1.120. **Pressure capsule.** 1. The diaphragm assembly at the end of the capillary in a level measuring instrument or similar filled system. 2. The diaphragm assembly used in the aneroid type of barograph.

3.1.121. **Pressure gauge.** A generic term covering indicators calibrated in terms of fluid pressure. There are many types, e.g. bellows, Bourdon, diaphragm and manometric.

3.1.122. **Primary element** (of a primary flow metering device). A constriction incorporated in a closed pipe or open channel which alters the velocity of the fluid, creating a change in pressure which bears a known relationship to the rate of flow.

3.1.123. **Primary standard.** A standard having the highest class of metrological qualities in a specified field.

3.1.124. **Psychrometer.** An instrument used for the precise measurement of relative humidity based on the difference in temperature reading between wet and dry bulb thermometers. Air flow is induced past the thermometer bulbs by hand or a motor-driven propeller. From the readings, dewpoint and vapour pressure may be calculated. See Hygrometer.

3.1.125. **Pyrometer.** A non-contact temperature measuring instrument that senses temperature, usually by indirect means e.g. radiation and optical pyrometers. The term no longer implies high temperature capabilities.

3.1.126. **Rain gauge.** A device for measuring the total quantity of rain, snow, sleet or hail which has fallen during a given period. The precipitation is collected in a funnel of known cross-section area and is measured either manually on a daily basis or instrumentally by a tipping or siphoning device which marks a chart.

3.1.127. **Range.** The scale of values an instrument is capable of measuring.

3.1.128. **Rate value** (of performance characteristics). Also termed rating value. The value (or one of the values) of a quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the apparatus.

3.1.129. **Rated operating conditions.** The whole of the effective ranges for performance characteristics, and rated ranges of use for influence quantities, within which the performance of the apparatus is specified.

3.1.130. **Rated range** (of performance characteristics). The range of a quantity to be measured, observed, supplied or set, which the manufacturer has assigned to the apparatus.

3.1.131. **Recorder, autographic.** An instrument which automatically plots on a chart the present and past condition of one or more variables, usually against time. It may be one of the following types: (a) vertical strip chart, in which the chart moves vertically downwards and the pen moves horizontally; (b) horizontal strip chart, in which the chart moves horizontally and the pen moves orthogonally; (c) circular chart, the chart being of circular form; (d) chopper bar, being a strip recorder in which the pointer is pressed onto the chart paper at regular intervals by a bar lowered on top of it; (e) multichannel, which may be (i) multipen, the recorder having more than one pen but each covering the whole width of the chart, (ii) multizone, the recorder having two or more pens each having its own section of chart, or (iii) multipoint, the recorder having a numbered wheel which prints the value of each input sequentially on a time-sharing basis; (f) flat bed, in which the chart is mounted horizontally and moves horizontally with the pen moving over the surface orthogonally (also called an x-y recorder; (g) u/V recorder, in which a ray of ultra-violet light acts as the pen on specially sensitized photographic paper; (h) drum type, in which the chart is wrapped round a revolving cylinder (much less common than strip or circular chart recorders).

3.1.132. **Rectangular weir.** See Weir.

3.1.133. **Reference conditions.** A set of values with tolerances, or of restricted ranges of influence quantities, specified for making comparison and calibration tests.

3.1.134. **Repeatability** (of measurement). The closeness of the agreement between successive measurements of the same quantity, carried out by the same observer using the same method and the same apparatus, at the same location under the same environmental conditions at suitably short intervals of time.
3.1.135. Resistivity electrical. Another name for specific resistance. The reciprocal of electrical conductivity.

3.1.136. Resolution (discrimination). The minimum change of input which an instrument is able to indicate.

3.1.137. Rotameter. See Variable-area flow meter.

3.1.138. Running hour meter. A device which indicates the total hours of operation of a machine.

3.1.139. Running light. An indicating light showing the operating condition of an item of plant at any time. Often used in pairs for increased reliability.

3.1.140. Safety lamp. A device used to detect the presence of dangerous fumes or gas in an enclosed environment, before entry. It incorporates a naked flame within a gauze envelope which, if the lamp is placed in an explosive mixture of gases, prevents the flame from igniting them.

3.1.141. Sampler, automatic. An automatic device which produces individual samples of a fluid from a large volume. The simplest form takes samples of approximately equal volume at fixed time intervals, and is suitable for situations not requiring a sample volume/fluid flow ratio, e.g. sampling from lakes, large tanks. There are two types (often combined in one sampler) which give weighted samples: (a) samples are taken at regular intervals of time and are sized in relation to the rate of flow; (b) samples of equal volume are taken at fixed increments of flow.

3.1.142. Scale. The array of indicating marks, together with any associated quantitative values, against which the position of an index can be observed.

3.1.143. Sealed bell meter. See Bell-type meter.

3.1.144. Secondary standard. A standard which is determined by comparison with a primary standard.

3.1.145. Self-balancing instrument. An instrument in which the applied signal is referred to a standard signal generated within the instrument. The resultant error signal is used in a servo system to balance the potentials and so move the pen or pointer.

3.1.146. Semi-circular flume. See flume.

3.1.147. Sensitivity. Relation between the change of response and the change in input which brings it about.

3.1.148. Sensor. The transducer of a measuring instrument which reacts directly to the input.

3.1.149. Servo. Short for servomechanism (qv).

3.1.150. Servo system. A dynamic closed-loop automatic control system, where the output element or quantity follows the input to the system as closely and as rapidly as is required. The main difference from other automatic control systems is the presence of at least one feedback loop which provides an error signal proportional to the difference between the actual output and the desired output.

3.1.151. Set point. See Desired value.

3.1.152. Set value. See Desired value.

3.1.153. Shunt meter. A flow meter in which an orifice plate is fitted into the line and an inferential or variable-area meter is installed across it. The flow through the meter then bears a known relationship to the total flow in the line and it is calibrated accordingly.

3.1.154. SI units. See Système International des Unités.

3.1.155. Side contractions. See Contraction.

3.1.156. Signal/noise ratio. The ratio of magnitude of desired signal to that of the unwanted radiation or other signal received with it. Usually expressed in decibels and qualified in terms of frequency and nature of both, i.e. signal may be in terms of peak voltage and noise may be in terms of rms voltage.

3.1.157. Slackdiaphragm. A form of differential pressure device (qv) for low pressure measurement in which the pressure is applied to either side of a diaphragm which has a relatively large movement.

3.1.158. Sludge density meter. An instrument which measures a property of sludge, such as attenuation of ultrasonic energy, opacity to radiation, etc., which can be related to the
density of the sludge. In this context, sludge density relates to the dry solids content of wet sludge.

3.1.159. Specific energy (Of a liquid in an open channel) is equal to the sum of the depth of flow and the velocity head.

3.1.160. Stability. The ability of a measuring instrument to maintain constant its designed metrological performance.

3.1.161. Standard instrument. An instrument against which other instruments are calibrated.

3.1.162. Standing wave. The surface wave formed in a channel when the flow conditions change from sub-critical to super-critical, or vice versa.

3.1.163. Standing wave flume. See Flume.

3.1.164. Still well (or chamber). See Gauge well.


3.1.166. Système International des Unités (SI). A coherent system of units of measurement, approved internationally. Founded on seven base units: metre, kilogramme, second, ampere, kelvin, candela and mole. From these and the supplementary units, radian (plane angle) and steradian (solid angle), all other units may be derived.

3.1.167. Tachometer. A device, of which several types exist, for measuring rotational speed. Contact types may be: (a) a device fixed to a machine and used for determining the number of events occurring in a given time, or (b) a portable instrument with a sensor which is placed in contact with a rotating member. Non-contact types may be: (a) those in which impulses are counted from a proximity switch mounted adjacent to a wheel and calibrated in revolutions per unit of time, or (b) those in which a light beam is reflected from a rotating member back to the instrument which is calibrated in revolutions per unit of time.

3.1.168. Tapping, electrical. A series of electrical terminations which permits a choice or selection of connections to a system or network; often used on transformers.

3.1.169. Tapping, hydraulic. A device which permits access to a hydraulic system for transmitting information about pressure or level, or for sampling purposes.

3.1.169A. Thermistor. An abbreviation for thermal resistor. A solid-state semi-conductor whose resistance changes a relatively large amount for small differences of temperature. Used for temperature measurement and in many applications requiring action when a large change of temperature is detected, eg protection against overheating of electric motor windings.

3.1.170. Thermocouple. A temperature-measuring system in which two dissimilar metals are joined at one end. When a difference in temperature exists between this junction and the other ends of the metals an emf is produced which is related to the temperature difference between the junction and the ends. Common combinations of metals are: (a) iron-constantan, ie iron and an alloy of nickel and copper; (b) copper-constantan, ie copper and an alloy of nickel and copper; (c) chromal-alumel, ie an alloy of nickel-aluminium and nickel-chromium; (d) platinum-rhodium. This may be platinum 90 per cent and rhodium 10 per cent or platinum 87 per cent and rhodium 13 per cent.

3.1.171. Thermometer. A general term for a temperature-measuring device. Types in common use are: (a) thermocouples, (qv); (b) bi-metallic strip (qv); (c) filled systems, in which expansion or contraction of a gas or liquid in a closed system causes a pointer to move over a scale calibrated in terms of temperature; (d) liquid expansion, in which temperature is indicated against a scale, by the expansion or contraction of a mercury or alcohol column. eg glass thermometers; (e) platinum resistance (qv); (f) thermistor types, which employ as detectors, solid state devices whose electrical resistance varies with temperature. Measurement of the resistance change is displayed in terms of temperature.

3.1.171A. Thermostat. A transducer and actuator which is part of a control system designed to maintain a set temperature in its own or other environment.

3.1.172. Thin plate orifice plate. See Orifice plate.

3.1.173. Throat. The reduction in cross-sectional area of a closed system or an open channel which is used as a primary device for flow measurement.

3.1.174. Total head. In a hydraulic system, the sum of the static, velocity and friction heads at a specified location.
3.1.175. **Tracer method.** A method of determining the velocity and/or distribution of liquid flow in a hydraulic system. A substance (the tracer) which can be identified at a subsequent time and location is introduced at a measured rate into the fluid. Analysis of the concentration appearing at measured time intervals at another location enables velocity, volume and distribution to be determined. The tracer may be a chemical or radioactive material. This method may be used to determine basin or tank volumes, and the single shot or 'gulp' method can be used to determine the degree of short-circuiting occurring or how closely plug flow has been attained.

3.1.176. **Transducer.** A device which converts the measured process variable into an electrical-pneumatic signal for transmission or other purposes. See **Sensor**.

3.1.177. **Trapezoidal flume.** See **Flume**.

3.1.178. **Triangular weir.** See **Weir**, **thin-plate**.

3.1.179. **Turbidimeter.** An optical instrument designed to detect material suspended in a liquid. The degree of absorption (qv absorptiometry) or scattering (nephelometry) of an incident beam of light or the ratio of absorption to scattering can be related to the turbidity of a particular type of suspension.

3.1.180. **Turbine meter.** An inferential meter in which a fan-type device is mounted in a system of known geometry. The number of revolutions per unit of time can be related to rate of flow.

3.1.181. **Two-pen instrument.** See **Recorder**, **autographic**.

3.1.182. **Two-zone instrument.** See **Recorder**, **autographic**.

3.1.183. **Ultrasonic density meter.** See **Sludge density meter**.

3.1.184. **Ultrasonic depth gauge.** See **Acoustic meters**.

3.1.185. **Ultrasonic flow meter.** See **Acoustic meters**.

3.1.186. **Ultrasonic level gauge.** See **Acoustic meters**.

3.1.187. **Ultra-violet recorder.** See **Recorder**, **autographic**.

3.1.188. **Upstream total head.** In a channel, the total head measured upstream of a construction in the channel.

3.1.189. **Variable-area flow meter.** A vertical tapered tube having a float which adopts a position related to the upward flow through the tube. Because of its design the pressure drop across the meter is constant at all rates of flow.

3.1.189A. **Velocity head.** The energy that a fluid possesses due to its velocity. For a perfect fluid in steady flow it is equal to one half of the square of the velocity divided by the acceleration due to gravity. Also known as kinetic head, it is the height of a column of fluid giving a hydrostatic pressure of one half of the fluid density multiplied by the square of the flow velocity.

3.1.190. **Venturi.** A primary element (qv) in which the cross-sectional area of a pipe is reduced to a throat (qv) and then expanded to the original cross-section by gradual tapers. The differential pressure between the throat and the upstream section caused by a flowing fluid can be related to the rate of flow.

3.1.191. **Venturi flume.** See **Flume**.

3.1.192. **Venturi meter.** A flow meter in which the primary element is a venturi (qv).

3.1.193. **Vertical edgewise indicator.** See **Indicator**.

3.1.194. **Vertical strip chart recorder.** See **Recorder**, **autographic**.

3.1.195. **V-notch weir.** See **Weir**, **thin-plate**.

3.1.196. **Voltmeter.** An instrument which measures and displays electrical potential difference.

3.1.197. **Water gauge.** A unit of pressure measurement, equal to the pressure exerted by a column of water. Usually expressed as inches or millimetres of water.

3.1.198. **Water hardness meter.** An instrument which measures temporary hardness and/or permanent hardness in water.

3.1.199. **Water meter.** A positive displacement type of flow meter for measurement of total water consumption.
3.1.200. Water quality meter. A general term for an instrument which determines variables associated with the quality of water.

3.1.201. Water quality monitor. An automatic recording system used to determine the variables associated with water quality. Often operated in conjunction with a telemetry system.

3.1.202. Watt-hour meter. A meter designed to measure the electrical energy consumed in a given time. Generally calibrated in kilowatt-hours.

3.1.203. Weir. A structure mounted in a channel or other hydraulic system over which fluid flows. This controls the level of fluid upstream of the structure. The level upstream bears a known relationship to the flow over the weir and may be used for determining the rate of flow. Several types of weirs exist.

3.1.204. Weirs, broad crested. Also termed long-based weirs. A weir without contractions in which the length of the crest measured in the direction of flow is large compared with the maximum upstream head over the weir. Typical examples are: (a) a rectangular profile, in which the upstream vertical face forms a sharp rectangular corner with the plane of the crest; (b) a round-nosed weir, in which the corner between the upstream vertical face and the plane of the crest is rounded; (c) a triangular profile weir, being a special case of a long-based weir in which the construction is inclined towards the crest at a slope of 1 in 2 and then declines to invert levels at 1 in 5. If the fluid level is measured at the crest rather than upstream of the weir the structure is termed a Crump weir. (d) ogee, a weir with a curved crested profile specifically designed for rivers and spillways.

3.1.205. Weirs, compound. Weirs constructed with two or more overflow sections which are designed to come into operation at different upstream levels so that a wide range of flow rates can be measured accurately.

3.1.206. Weirs, thin-plate. Weirs installed vertically across a channel. The weir thickness relative to the width of the channel is minimal, and the weir plates should have sharp edges at the point of overflow. Types available include: (a) rectangular, in which the contractions and crest are rectilinear; (b) full width, in which there are no contractions, the crest extending across the whole width of the channel (also termed a suppressed weir); (c) fully contracted, in which the side contractions have been fully developed so that the walls of the channel have no effect; (d) partially contracted, in which the contractions are mid-way between fully suppressed and fully contracted; (e) trapezoidal, being a thin-plate weir whose contractions and crest form a trapezoid (sometimes termed a Cipolletti weir); (f) Sutro, being a main plate weir of particular section designed to linearize the upstream depth-flow relationship; (g) triangular, in which the crest is not horizontal but in the form of a V (also termed a V-notch weir).

The formula for calculating the flow through a triangular weir includes the tangent of half the included angle, hence (i) for a full V notch the angle is 90°; (ii) for a half notch the angle 53°8'; generally termed 'a 60° notch'; (iii) for a quarter notch the angle is 28°4'; termed 'a 30° V notch'.

3.1.207. Wetted perimeter. The total length of boundary between liquid in a channel and the channel itself, at a particular cross-section.

3.1.208. Wheatstone bridge. A four terminal resistance network consisting of two parallel branches of two resistances in series. An emf is applied to two opposite terminals and the other two are bridged by a detector. By adjusting one or more resistances in the network the voltage across the detector can be brought to zero (null point) and in this unique condition, specific relationships exist between the values of resistances which may be used to measure one resistance in terms of another.

3.1.209. Working standard. A measurement standard (not a reference standard) intended to verify measurement instruments of lower accuracy.

3.1.210. Zener barrier. A device consisting of resistors, zener diodes and a fuse which enables a standard instrumentation to operate safely in potentially explosive areas.

3.1.211. Zero suppression. If an instrument scale and indication does not extend to zero, the zero is said to be suppressed.
3.2. ANALYSIS

3.2.1. Absorptiometer. An instrument used to measure the degree of absorption of a particular radiation, which may originate in any of the electromagnetic frequency bands, eg infra-red, visible, ultra-violet, X-ray.

3.2.2. Absorption. A process in which the molecules or atoms of one phase inter-penetrate those of another phase, tending to complete permutation of the second substance by the first. It is distinguished from adsorption which is a surface effect.

3.2.3. Acid. Substances having a tendency to lose protons. In aqueous solution an acid gives rise to hydrogen ions, the concentration of which is expressed as pH = –log (hydrogen ion concentration). A pH smaller than 7 indicates an acidic solution. Many acids are corrosive and have a sour taste; they are neutralized by bases.

3.2.4. Acidity. The capacity to neutralize alkalinity.

3.2.5. Adsorption. The accumulation or concentration of substances at a surface or interface, as the result of molecular-scale forces acting at the surface of the material. The process can occur at an interface between any two phases such as a liquid—liquid, gas—solid, or liquid—solid interface. The material being concentrated or adsorbed is the adsorbate and the adsorbing phase is termed adsorbent. It is very likely that adsorption occurs on all surfaces, but since large objects have a relatively small area to mass ratio, the phenomenon is not very noticeable. If, however, a large particle is sub-divided many times, to the dimensions of the colloidal state, the area to mass ratio will be very large, and adsorption becomes an important factor in the behaviour of the system.

3.2.6. Aliquot. A representative sample of accurately known volume or weight.

3.2.7. Alkali. Usually a hydroxide of an alkali metal which exhibits the properties of a base, eg sodium hydroxide.

3.2.8. Alkalinity. 1. The capacity to neutralize acids. 2. In water it is usually attributable to carbonate, bicarbonate or hydroxide compounds of calcium, magnesium, sodium and potassium. Total alkalinity is determined by titration to pH 5.1 at 30 mg/l, pH 4.5 at 150 mg/l, pH 4.5 at 500 mg/l.

3.2.9. Ammonia. A pungent smelling gas which dissolves in water to give an alkaline solution. Chemical formula NH₃.

3.2.10. Ammonia nitrogen. Nitrogen in water in the form of ammonia solution or the ammonium ion.

3.2.11. Analysis. 1. Qualitative; the resolution of a substance into its components. The detection and identification of the chemical nature of substances. 2. Quantitative; the determination of the amount of each constituent or substance present in a mixture or compound.

3.2.12. Anion. A negatively charged ion (qv) which during electrolysis migrates towards the positively charged electrode (anode).

3.2.13. Atomic absorption spectrophotometry (AAS). A physical method of analysis in which the sample is volatilized, for example in a suitable flame, into the path of electromagnetic radiation emitted from a suitable source of the desired wavelength and of known intensity. Elements in the atomic state absorb radiation at their own characteristic frequencies. The decrease in intensity which occurs as a result of this absorption can be related to the concentration of the element.

3.2.14. Base. 1. A substance which reacts with an acid to form a salt and water only. 2. A substance which has the capacity to accept protons. 3. A substance which in water gives hydroxyl ions, and forms a solution of pH greater than 7.

3.2.15. Bias. The term bias denotes errors of constant sign and magnitude that are caused by an instrument and the nature of a sample but which are otherwise unaffected by time. The definition allows for the fact that the bias may depend markedly on the concentrations of the determinand and other substances in the sample.

3.2.16. Biochemical oxygen demand. The amount of oxygen consumed during biochemical oxidation of substances contained in water under aerobic conditions. It is expressed in mg oxygen per litre. The most frequently used value (BOD₅) denotes biochemical oxygen demand during five days at 20°C.
3.2.17. **Breakpoint chlorination.** A process in which chlorine is added to a contaminated water in a concentration which causes the ammoniacal nitrogen to disappear and free chlorine is detectable:

\[
3\text{Cl}_2 + 2\text{NH}_3 \rightarrow \text{N}_2 + 6\text{HCl}.
\]

3.2.18. **Buffer solution.** A solution, the hydrogen ion concentration of which is practically unchanged by dilution and by the addition of small amounts of acid or alkali. Special buffer solutions are formulated to calibrate pH meters; others to ensure that reactions take place at the correct hydrogen ion concentration.

3.2.19. **Calorific value, gross (CV gross).** The number of joules of heat derived from the complete combustion of a unit weight of combustible material.

3.2.20. **Calorific value, net (CV net).** The heat generated by complete incineration of a substance if its temperature before incineration and the temperature of its incinerated products are both referred to 20°C, and provided that the water remaining is vaporous, and the sulphur dioxide if present is gaseous. It is obtained by first determining the CV gross of a dry residue by calorimeter and deducting the evaporation energy of the water generated from hydrogen in the dry residue.

3.2.21. **Capillary suction time (CST).** The time period in seconds taken for the interface between the wet and dry areas of a standard absorbent paper exposed to a sludge under standard conditions to travel a given distance. It provides a measure of the filtrability of the sludge.

3.2.22. **Carbon dioxide, aggressive.** That portion of dissolved carbon dioxide in water which is in excess of equilibrium and which participates directly in the solution of solid calcium carbonate by forming calcium bicarbonate:

\[
\text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow 2\text{CaHCO}_3.
\]

3.2.23. **Carbon dioxide, equilibrium.** That amount of carbon dioxide in water which corresponds to an equilibrium concentration of hydrocarbonate ions and calcium ions.

3.2.24. **Carbon dioxide, free.** Carbon dioxide in excess of that present as bicarbonate. It is found by titration with standard alkali to pH 8.3, which is the pH of a pure bicarbonate solution similar to those found in natural waters. Expressed in terms of either mg of CO₂ per litre or mg of Ca CO₃ per litre.

3.2.25. **Cation.** A positively charged ion which during electrolysis migrates towards the negatively charged electrode (cathode).

3.2.26. **Chemical oxygen demand (COD).** The value characterizing the content of organic and inorganic materials in water which can be oxidized by a boiling solution of potassium dichromate and silver sulphate catalyst in strong sulphuric acid. Expressed in mg oxygen per litre of sample.

3.2.27. **Chlorine, free.** Also termed free available chlorine. The amount of chlorine available as dissolved gas, hypochlorous acid, or hypochlorite ion that is not combined with an amine or other organic compound.

3.2.28. **Chlorine, free available.** See **Chlorine, free.**

3.2.29. **Chlorine, residual.** Also termed free available residual chlorine. That portion of the total residual chlorine remaining in water at the end of a specified contact period, which will react chemically and biologically as hypochlorite ion or hypochlorous acid.

3.2.30. **Chlorine demand.** The quantity of chlorine that it is necessary to add to a water so that a trace of chlorine remains after a specific contact period at a constant temperature.

3.2.31. **Chromatography.** A method of analysis based on physical adsorption principles for separating various components from a mixture of chemical substances. In its broad interpretation, chromatography is a combination of separation, identification and quantitative measurement.

3.2.32. **Chromatography, gas.** Chromatography in which the mobile phase or carrier is a gas, which is transported through an absorbent medium, the stationary phase. The stationary phase is usually contained in a narrow bore tube which is maintained at a constant temperature.
3.2.33. **Chromatography, gas liquid (GLC).** A chromatographic method for analysing the components of a complex mixture of volatile substances. The apparatus consists of a long narrow tube packed with an inert support material of uniform particle size (eg diatomaceous earth) that has been coated with a non-volatile liquid called the stationary phase, the whole tube and its contents being maintained at a constant temperature. The sample is carried through the tube by an inert gas (eg argon) so that progress through the tube of various components of the mixture is selectively interfered with by the stationary phase, some components passing through the tube more rapidly than others. A detector measures a property of the gas leaving the column, such as its electrical conductivity, differences being recorded on a strip chart recorder which indicates peaks corresponding to the various components. The instrument is calibrated by analysing samples of known composition.

3.2.34. **Chromatography, thin layer (TLC).** Chromatography in which the conventional column is replaced by a thin layer of solid absorbent spread uniformly on an inert backing such as plate glass. A drop of the sample is applied near one edge of the plate which is dipped in a suitable solvent and this elutes the sample spot upwards. The components climb at different rates and can be identified using suitable standards.

3.2.35. **Colorimetric analysis.** A method of quantitative analysis based upon the measurement of the intensity of colour of a solution of the substance to be determined which is present as a coloured ion, coloured molecule, or a coloured derivative prepared for the purpose.

3.2.36. **Determinand.** That which is to be determined. ‘Parameter’ is often incorrectly used in this sense.

3.2.37. **Dichromate value.** See **Chemical oxygen demand.**

3.2.38. **Dissolved oxygen.** The concentration of oxygen dissolved in a liquid, usually expressed in mg/l, or as a percentage of the air saturation value (qv). It depends on the temperature and salinity of the liquid and the partial pressure of oxygen in the gas phase.

3.2.39. **Dry residue.** In sludge analysis, the substance remaining after drying the sludge at a specific temperature, to a constant weight.

3.2.40. **Electrode.** 1. A conductor by means of which a current passes into or out of a gas or liquid. 2. A metallic conductor at which there is a change from conduction by electrons to conduction by ions or other particles.

3.2.41. **Electrolyte.** 1. A substance the solution of which conducts electricity by the movement of positive and negative ions. 2. The solution itself.

3.2.42. **Enzyme.** A large group of proteins produced by living cells to catalyse reactions occurring in living organisms. Enzymes are specific in their action, and all organisms produce them. Certain enzymes are synthesized and can be used to catalyse specific chemical reactions.

3.2.43. **Enzyme electrode.** An ion selective electrode coated with a material that contains an enzyme which will react with an organic substance, producing an ion to which the electrode responds. Experimental electrodes have been constructed for amyladalin amino acids and urea, but as yet are not available commercially.

3.2.44. **Equilibrium carbon-dioxide.** See **Carbon dioxide, equilibrium.**

3.2.45. **Error** (of analytical result). The error of an analytical result in terms of units used to express the value of the determinand, given by:

\[ \text{Error} = \text{result minus true value} \]

3.2.46. **Filtrate.** Liquid removed from a solid-liquid mixture during filtration.

3.2.47. **Free carbon dioxide.** See **Carbon dioxide, free.**

3.2.48. **Free chlorine.** See **Chlorine, free.**

3.2.49. **Hardness.** The hardness of water was originally identified with its capacity for destroying soap lather. It is now customary to consider the total calcium and magnesium salts in solution as a measure of the hardness, although other polyvalent metals will destroy lather if they are present.

3.2.50. **Hardness, carbonate.** That portion of the total hardness equal to the sum of the carbonate and bicarbonate alkalinity. It is mainly due to the bicarbonates of calcium and magnesium and can be removed by boiling water, when the bi-carbonates are decomposed
to the corresponding carbonates, (which are much less soluble) carbon dioxide and water. Usually expressed as mg/l CaCO₃.

3.2.51. **Hardness, non-carbonate.** Hardness in excess of the sum of the carbonates, bicarbonates, alkalinity. It is a property of water which is due mainly to chlorides and sulphates of calcium and magnesium. Expressed as mg/l CaCO₃.

3.2.52. **Hardness, permanent.** An obsolescent term. See **Hardness, non-carbonate.**

3.2.53. **Hardness, temporary.** An obsolescent term. See **Hardness, carbonate.**

3.2.54. **Hardness, total.** The sum of non-carbonate hardness (corresponding approximately to the older 'permanent' hardness) and carbonate hardness (corresponding approximately to 'temporary hardness').

3.2.55. **Hazen number.** A number used to define the colour of water, the standard unit being the colour produced by 1 mg of platinum per litre (in the form of chloroplatini acid) in the presence of 2 mg of cobaltous chloride hexahydrate per litre.

3.2.56. **Heavy metals.** Metals that can be precipitated by hydrogen sulphide in acid solution eg lead, silver, copper, bismuth, gold.

3.2.57. **Hydrogen electrode.** An electrode formed on platinum metal coated with platinum black, immersed in an electrolyte, and saturated with hydrogen gas.

3.2.58. **Hydrogen, electrode, normal or standard.** A hydrogen electrode which is considered to have a zero potential at all temperatures, under one atmosphere of hydrogen in a solution of unit hydrogen ion activity.

3.2.59. **Hydrogen ion concentration.** Usually expressed by means of a pH value, where 
\[ \text{pH} = -\log(H^+) \], \( (H^+) \) being the hydrogen ion concentration. This is a close approximation and is satisfactory for most practical purposes, since the hydrogen ion is known to be associated with one or more solvent molecules.

3.2.60. **Infra-red radiation.** The band of electromagnetic wave-lengths lying between the extreme of the visible (about 0.75 \( \mu \)m) and the shortest microwave (about 1000 \( \mu \)m).

3.2.61. **Infra-red spectroscopy.** A method of both quantitative and qualitative analysis based on resolving the infra-red radiations originating from vibrations due to molecular bonding. When two atoms bond together the electron energy which goes into the bond surrounds both nuclei, and they are held by what is effectively an elastic force. The bond will therefore have natural vibration modes and when it is set to vibrate the nuclei will move harmonically. These natural molecular vibrations correspond in frequency to the infra-red region of the spectrum, and when radiation of resonant frequency is incident on a substance, vibration is stimulated and energy is lost in consequence from the incident radiation. The absorption bands of simple molecules are easily assigned and a large library of spectra has been built up to act as 'finger prints' for identification of an unknown substance. The depths of the absorption waves serve as a measure of the number of molecules present. With experience one can tell by cursory examination whether a substance is aromatic or aliphatic and whether it contains hydroxyl (OH), carbonyl (CO), carboxyl (COOH), or other groups. Specific features of unsaturation can be identified by ultra-violet spectroscopy. See ultra-violet spectroscopy.

3.2.62. **Interference.** A special case of bias in which the presence of constituents other than the determinand cause a systematic error of any magnitude in the results.

3.2.63. **Ion.** An atom or molecular bound group of atoms which has gained or lost one or more electrons, and which has thus a negative or positive electric charge; sometimes a free electron or other charged subatomic particle. Ions are produced in gases by the action of radiation of sufficient energy; ionic solids consist of ions bound together by their electrostatic forces and when dissolved in a polar liquid such as water, the salt dissociates into its atoms, which have an independent existence.

3.2.64. **Ion selective electrode.** A device that develops an electrical potential proportional to the logarithm of the activity of a particular ion, towards which it has been designed to exhibit a high degree of selectivity over other ions which may be present in the sample. The four main types are: (a) glass electrodes of the pH type which, by incorporating special glasses, can be made selective to H⁺, Na⁺, K⁺, Ag⁺, NH₄⁺, Li⁺, and Cs⁺; (b) electrodes with single glass crystal or pressed crystalline disk membranes, eg the lanthanum fluoride crystal used in the fluoride electrode; (c) heterogeneous electrodes in which the active constituent is dispersed in an inert binder; (d) liquid ion-exchange membrane electrodes in
which an inert hydrophobic porous disk forms the interface between the internal ion-
exchange liquid and the sample, while a third solution maintains a constant activity of the
appropriate ion within the electrode.

3.2.65. **Kjeldahl nitrogen.** The total organic nitrogen in a waste water estimated by the
Kjeldahl method, which is based on the conversion of the nitrogen to ammonium sulphate by
boiling the sample with sulphuric acid and a catalyst, and distillation of the ammonia after
the solution has been made alkaline. The distilled ammonia is determined by colorimetric
means, eg nesslerization (qv), or acid titration.

3.2.66. **Laboratory sample.** See Sample, laboratory.

3.2.67. **Limit of detection.** The concentration of the determinand for which there is a
specified confidence limit of detection, often 95 per cent. Usually this is equal to 4.6 \( \sigma \),
where \( \sigma \) is the within-batch standard deviation of the blank.

3.2.68. **Maximum permissible concentration (MPC).** The concentration of a dissolved sub-
stance in water above which the water is defined as unsuitable for a specified use or activity.

3.2.69. **Mineral matter** (sludge analysis). The non-organic constituent of the dry solids in
sewage sludge determined by heating the sludge at a temperature at which the organic
matter is burned off (usually 600°C). It is usually expressed as a percentage of the dried
solids.

3.2.70. **Molal.** A concentration in which the amount of solute is stated in moles and the
amount of solvent in kilogrammes. The unit of molality is moles of solute per kilogramme
of solvent and is designated by a small m. 1 mole of NaK1 in 1 kg of water is a 1 molal
concentration.

3.2.71. **Molar.** A concentration in which one molecular weight in grammes (one mole) of a
substance is dissolved in one litre of solution. Molarity is indicated by an italic M. Molar
quantities are proportional to the molecular weights of the substances.

3.2.72. **Monitoring.** A continuing process of sampling and/or recording of water characteristics,
environment or process state, often coupled with transmission and display of the informa-
tion, which is used for a variety of purposes, eg warning, process control, historical record.

3.2.73. **Nephelometer.** An instrument used for determining the concentration and nature of a
suspension in a liquid by the scattering of light by the suspended particles.

3.2.74. **Nesslerization.** Estimation of the concentration of ammonia in water by comparing
the colour developed from its reaction with a solution of potassium mercuric iodide in
strong potassium hydroxide solution with standard colour filters. The same visual compara-
tor may be used with other sets of filters to estimate the concentrations of many other
substances.

3.2.75. **Normal solution.** See Solution, normal.

3.2.76. **Normality.** The concentration of a substance expressed as a multiple of a normal
solution concentration.

3.2.77. **Organic carbon.** Carbon, normally associated with living matter, which may be
converted to carbon dioxide by oxidation.

3.2.78. **Organic matter.** All compounds of carbon other than those regarded as inorganic such
as carbon dioxide and carbonates. In connection with sludge analysis it is synonymous with
volatile solids except for small traces of some inorganic materials such as calcium carbonate
which lose weight at temperatures used in determining volatile solids.

3.2.79. **Orsat apparatus.** A portable apparatus used normally for determining the proportions
of carbon dioxide, oxygen and carbon monoxide in a gas.

3.2.80. **Oxidation-reduction potential (ORP or redox).** The electromotive potential (redox
potential) between any solution and a standard hydrogen electrode. A positive potential
indicates an oxidizing state, eg an aerobic environment, and a negative potential indicates
a reducing state, eg an anaerobic environment. In practice it is determined using a reference
electrode the potential of which is related to that of a standard hydrogen electrode. See
Hydrogen electrode, standard.

3.2.81. **Percentage air saturation.** The concentration of dissolved oxygen in a body of water
expressed as a percentage of its saturation value in clean water of the same ionic strength
which is in equilibrium with air at the ambient barometric pressure and the temperature
and vapour pressure of the water.
3.2.82. Permanganate oxidizability. The value characterizing the content of organic and inorganic materials in water which are oxidizable by potassium permanganate in acid, alkaline or neutral medium. The result is expressed as mg oxygen per litre.

3.2.83. Permanganate value (PV). Oxygen absorbed from acidified N/80 potassium permanganate during four hours at 27°C. The test is empirical and of somewhat restricted value.

3.2.84. Permeability. The property of a material which permits appreciable movement of liquids or gases through it.

3.2.85. pH value. A measure of the hydrogen ion activity in an aqueous solution expressed as the log base 10 of the reciprocal of the hydrogen ion activity. In practice, pH and reference electrode pairs are standardized in buffer solutions of known pH before use, to compensate for asymmetry and junction potentials. This practice has led to the practical pH scale where the pH of a solution is defined in terms of the potential between the pair of electrodes when immersed in that solution and when immersed in the standard buffer solution, by means of the following equation:

\[ \text{pH} = \text{pH}_{\text{S}} \left( 1 + \frac{(E-E_S) 2.3026 \, \text{RT/F}}{\text{F}} \right) \]

where pH is the pH of the solution to be measured, pHs is the pH of the standard buffer solution, E is the potential developed in the solution to be measured (in volts), Es is the potential developed in the standard buffer solution (in volts), F is the faraday (96.493 coulombs), R is the universal gas constant, and T is the absolute temperature (degrees Kelvin). pH 7 is neutral. A solution with a pH less than 7 is acid, and one with a pH greater than 7 is alkaline.

3.2.86. Precision. The quality of being exactly or sharply defined or stated. The precision of measurement is the degree of reproducibility among several separate measurements of the same true value under specified conditions.

3.2.87. Qualitative analysis. See Analysis, qualitative.

3.2.88. Quantitative analysis. See Analysis, quantitative.

3.2.89. Range of application. The range of concentrations to which a method of analysis can be applied without modification, and within which tests of the performance of the method have shown it to be capable of achieving the stated performance.

3.2.90. Regression. A trend or shift towards a mean. A regression curve or line is thus one that best fits a particular set of data according to some principle. See Regression analysis.

3.2.91. Repeatability error. The deviation between repeated measurements made in rapid succession at the same level of the determinand under reference environmental conditions and stated sample conditions.

3.2.92. Residual chlorine. See Chlorine, residual.

3.2.93. Reverse osmosis. The physical separation of substances from a solution by reversal of the normal osmotic process, eg high pressure, forcing water through a semi-permeable membrane to the pure water side leaving behind a more concentrated waste stream.

3.2.94. Salinity. The concentration of salts in water referred to a standard sea water. Usually expressed as mg/l of chlorides, or in parts per thousand (%/oo) sodium chloride.

3.2.95. Sample. A representative portion of a larger whole.

3.2.96. Sample, composite. A sample obtained at a specified location by adding together small samples or portions of the samples taken frequently during a given period of time proportional to the rate of flow of the fluid.

3.2.97. Sample, individual, spot or discrete. A single sample taken at a specified location at a fixed time.

3.2.98. Sample, laboratory. A sample as prepared for sending to a laboratory. Not to be confused with a sample prepared in a laboratory.

3.2.99. Sample, test. A sample which has been prepared for testing.

3.2.100. Sensitivity (of method of analysis). The relationship between the change of the analytical response and the concentration at a stated concentration of the determinand.

3.2.102. Solution, normal. A solution obtained by dissolving the gramme-equivalent weight of a substance or ion in water and making up to a total volume of 1 litre.

3.2.103. Solution, standard. A solution being an accurately known concentration of an element, an ion, or a compound. It may be formed by direct solution of a single substance, or by reaction between two or more substances in solution. The strength of these solutions is generally expressed in grammes per litre, moles per litre, or sub-multiples of these units.

3.2.104. Solution, standard matching. A solution of which the relevant characteristic is exactly known or defined (for example colour, turbidity, etc.) and is used to measure the solution under test in relation to that characteristic.

3.2.105. Solution, standard reference. A solution used for standardizing other solutions. A reference solution is prepared from a primary standard or is standardized by some other means. The strengths of these solutions are expressed in the same way as that of a standard volumetric solution. See Standard volumetric solution.

3.2.106. Solution, standard volumetric. A solution in which the concentration is defined accurately, and is used for volumetric analysis. The strength of such a solution is expressed in terms of normality or molarity, the latter being used only when this is necessary to avoid ambiguity. The strength is represented by a whole number (N, 2N, M, etc.) or by a decimal number (0.1N, 0.06N, 2.5N, 0.5M, etc.). In a few cases, the strength of the solution is given by grammes per litre.

3.2.107. Solution, test. A solution used in the determination of the properties or composition of a substance or sample. Many of the great variety of test solutions available are known by the name of the investigator who first suggested its use.

3.2.108. Specific resistance to filtration. The resistance of a cake having unit weight of dry solids per unit area to unit rate of flow of liquid having unit viscosity. The units are normally metres per kilogramme at 49 kPa.

3.2.109. Spectrographic analysis. Investigation of the chemical nature of a substance by the examination of its spectrum, using the fact that the position of emission and absorption lines and bands in the spectrum of a substance is characteristic of it. See Atomic absorption spectrophotometry, Infra-red spectroscopy, Ultra-violet spectroscopy.

3.2.110. Stability error. The deviation between repeated measurements over a stated period of time at the same level of the measurand under constant environmental and sample conditions.

3.2.111. Stable test solutions. Solutions of approximately known strengths which are constant in value over an extended period of time.


3.2.116. Standardization. 1. The process of determining the concentration of a determinand in a solution, which then becomes a standard solution. 2. The process of using a standard solution to verify that an instrument is still behaving within a particular specification.

3.2.117. Surface active agent (surfactant). A substance which has the effect of altering the interfacial tension of water.

3.2.118. Surfactant. See Surface active agent.

3.2.119. Suspended solids. Particles dispersed in a liquid which have not settled under gravity in a given environment and set of conditions.

3.2.120. Test portion. The quantity of material taken from and representative of the test sample (or, if both are the same, from the laboratory sample) on which the test is actually carried out.

3.2.121. Test solution. See Solution test.

3.2.122. Total dissolved solids (TDS). That portion of the solids in water or waste water that is soluble, measured as total solids content minus suspended solids.

3.2.123. Total solids. The sum of the solids in suspension and the dissolved solids in water.
3.2.124. Turbidity. Interference with the passage of light through a liquid caused by fine material in suspension.

3.2.125. Ultra-violet radiation. The band of electromagnetic wavelengths lying between the extremes of the visible (400 nm) and the beginning of the X-ray region (< 20 nm). See Infra-red radiation.

3.2.126. Ultra-violet spectroscopy. A method of both quantitative and qualitative analysis based on resolving the ultra-violet radiations originating from vibrations due to molecular bonding. See Infra-red spectroscopy.

3.2.127. Viscosity (for sludge). (1) Dynamic viscosity ($\eta$). The internal temperature dependent frictional resistance of a Newtonian fluid.

Unit of measurement = $\text{Pa}\ s = \frac{\text{kg}}{\text{ms}} = \frac{\text{Ns}}{\text{m}^2}$

\[ \frac{\text{resulting pressure}}{\text{velocity gradient across direction of movement}} \]

(2) Kinematic viscosity ($\nu$). Dynamic viscosity divided by density.

Unit of measurement, $\frac{\text{m}^2}{\text{s}} (= 10^4 \text{ Stokes})$

3.2.128. Volatile substance. The loss of weight of dry material which has been heated at a specified temperature, usually 600°C, for a specified period. (Note. The temperature of 600°C is in some analytical laboratories replaced by a lower temperature). Formerly known as ‘loss on ignition’.

3.2.129. Volumetric analysis. A method of analysis in which a measured volume of a sample in solution is titrated against a standard solution or solutions of known concentration which will undergo definite chemical reactions with the constituent sought. Titration is the measurement of the amount of standard solution required for reaction with the sample, or with the excess of a known addition, or with a product of an intermediate reaction.

3.2.130. Water aggressivity. Ability of water and dissolved material to break down various substances by chemical reaction.

3.2.131. Weight. The force a mass exerts on its base under mean gravity. Unit is the Newton,

\[ 1 \text{N} = 1 \frac{\text{kgm}}{\text{s}^2} \]
4. GENERAL ENGINEERING

4.1. Auxiliary facilities. The non-productive facilities which provide utilities and other services used by the process: also termed 'off-site' facilities. Include non-process equipment and other non-service facilities and buildings, messrooms, etc.

4.2. Availability. The condition of a machine or system, being ready for use and not immediately committed to other tasks.

4.3. Critical path method (CPM). A method of planning and controlling often complex projects and systems implementation; the essential activities are defined in terms of the time they require and their inter-relations, the relationships being depicted as a connected network. The critical path is then evident or can be calculated from the network data. Resources employed, including costs, can also be included in the network data with a view to optimizing the use of these resources.

4.4. Down time. The period of time during which a machine or system is idle due to breakdown or malfunction.

4.5. Dummy activities. Imaginary activities, requiring no time and no effort, that must sometimes be introduced when performing network analysis to define certain conditional requirements in the analysis.

4.6. Ergonomics. The study of human capability and psychology in relation to the working environment and equipment operated.

4.7. Feasibility study. 1. A study to determine the extent to which a plan is capable of being accomplished. 2. A study to determine the outline engineering specification, probable resource requirements, including time and cost, for developing equipment or a system to fulfil a given functional specification, the cost of the feasibility study being rarely more than 5 per cent of that of the finally developed equipment or system.

4.8. Maintenance, planned. A planned system of inspection, lubrication, adjustment, repair or replacement of plant and equipment.

4.9. Maintenance, preventive. Maintenance directed to the prevention of breakdown rather than waiting for a breakdown to occur.

4.10. Mathematical model. An equation or set of equations expressing the performance of an organization or system in terms of the relationship between the elements in that organization or system. The existence of a mathematical model enables the performance of a system to be predicted under varying conditions with a view to optimizing performance towards a given objective.

4.11. Mean time between failures (MTBF). The arithmetic mean of the periods between failures or malfunctions of a component, equipment or system.

4.12. Network analysis. A general name for the techniques employed in CPM, PERT, etc.

4.13. Operational research (OR). Also known as operations research. The application of scientific processes and methods to operational problems arising within organizations or systems to allow the more effective use of known data and to reduce the proportion of subjective judgements in making decisions. A frequent feature is the creation of a model, often a mathematical model (qv) of the operations or systems being studied.

4.14. Programme evaluation and review technique (PERT). An alternative and preferred name for CPM.

4.15. Quality control. The practice of controlling product quality on a statistical basis. The extension of inspection procedures to include statistical analysis of the results.

4.16. Reliability. The probability of a component, device or system operating within specified limits for the period and under the operating conditions (including the environment) specified.

4.17. Repair time. The time taken from the start of the repair of a machine which has broken down or malfunctioned to the time when it becomes ready to be brought back into operation.

4.18. Systems analysis. The process of methodically analysing system requirements, then designing the solutions to meet the defined requirements.

4.19. Teletotechnology. A combination of management, financial, engineering and other practices applied to physical assets in pursuit of economic life-cycle costs.
4.20. **Value engineering.** An organized effort directed at analysing the function of a manufactured product with the purpose of achieving the required function at the lowest overall cost. See Terotechnology.

4.21. **Waiting-for-repair time.** The time which elapses between notification of the stoppage of a machine or system due to a breakdown or malfunction and the start of repair or servicing.
5. ADMINISTRATION

5.1. Activity sampling. See Work study.

5.2. Benefit/cost ratio. A ratio which can be calculated for a particular project where all benefits and costs can be quantified in comparable terms and this ratio can sometimes be made the test for selecting a project from a number of alternatives.

5.3. Budget. A financial and/or quantitative statement of the policy to be pursued during a defined period for the purpose of attaining a given objective.

5.4. Budgetary control. Allocating financial limits to component parts of individual enterprises and accounting for outlays in such a way as to provide continuous comparisons between actual and forecast results so that if remedial action is necessary it may be taken at an early stage, or alternatively the objective may be reviewed.

5.5. Cost benefit analysis. A systematic comparison between the cost of carrying out a service or activity and the value of the benefits of that service or activity, with all costs and benefits (direct and indirect, financial and social) being taken into account.

5.6. Cost-consciousness. The awareness of costs during the process of decision-taking and subsequently, to ensure that costs are not unnecessarily incurred and that maximum value is obtained from those costs that are incurred.

5.7. Cost-effectiveness analysis. A method of finding (a) the cheapest means of accomplishing a defined objective, or (b) the maximum value from a given expenditure.

5.8. Costing. The techniques and processes of ascertaining the amount of expenditure (actual or notional) incurred on or attributable to particular products, processes or services (see “Terminology of Management and Financial Accountancy”, published by The Institute of Cost and Management Accountancy, 1974).


5.10. Costs, direct. A cost which it is possible to identify directly with a particular activity or product.

5.11. Costs, fixed (or period cost). A cost which tends to be unaffected by variations in volume of output but to depend mainly on the passing of time, e.g. the cost of providing facilities and organization to produce and market goods.

5.12. Costs, marginal. The amount at any given volume of output by which aggregate costs are changed if the volume of output is increased or decreased by one unit.

5.13. Costs, opportunity. The maximum amount which could be attained at any given point of time if assets or resources were to be sold, hired or put to the most valuable alternative use which would be practicable.

5.14. Costs, replacement. The cost of replacing a machine or other asset at any given point in time, either now or in the future (excluding any element attributable to improvement).

5.15. Costs, standard. A predetermined cost which is calculated from management’s standards of efficient operation and the relevant necessary expenditure.

5.16. Costs, variable. A cost which tends to vary directly with volume of output, e.g. the additional costs incurred in producing and marketing goods once the organization has been set up.

5.17. Discounted cash flow technique. The application of a suitable rate of discount to forecasts of additional outlay and income relating to a project, to take account of their incidence over the life of the project. The technique is particularly useful in comparing alternative courses of action.

5.18. Firm estimate. An estimate of the cost of a project from final drawings, specifications and site surveys; confidence limits ± 5 per cent.

5.19. Fixed costs. See Costs, fixed.

5.20. Fringe benefits. Expenses of employment over and above compensation for actual time worked.


5.22. Interfirm comparisons. The exchange of comparative information between firms with the object of helping their management to increase their firm’s efficiency.
5.23. **Inventory.** An itemized list of plant, equipment, tools and apparatus.

5.24. **Investment appraisal.** A means of assessing whether expenditure of capital on a project would show a satisfactory rate of return to an undertaking, either absolutely or when compared with expenditure on alternative projects; and of indicating the optimum time to commit expenditure.

5.25. **Job evaluation.** A method of determining the relative standing, for pay purposes, of jobs within an organization or part of an organization.

5.26. **Management audit.** The systematic assessment of standards and techniques of management.

5.27. **Management by exception.** An arrangement under which only exceptional cases are referred to management, other cases being dealt with according to precise instructions or general principles in accordance with the objectives of the undertaking.

5.28. **Management by objectives.** A technique under which targets are fixed as a basis for achieving greater effectiveness throughout the whole of an organization or part of an organization.

5.29. **Management development.** A systematic process of development of effective managers/executives at all levels to meet the requirements of an organization. This involves an analysis of the present and future management/executive requirements, assessing the existing and potential skills of managers/executives and devising the best means for their development to meet the requirements.

5.30. **Marginal cost.** See Costs, marginal.

5.31. **Method study.** See Work study, method study.

5.32. **Obsolescence.** A decrease in value or usefulness of an asset due to technological changes.

5.33. **Opportunity cost.** See Costs, opportunity.

5.34. **Organization and methods service (O and M).** A service giving advice on the structure of an organization, its management and control, and its procedures and methods.

5.35. **Output budgeting.** A system for analysing programmed expenditure by reference to particular objectives instead of under input headings such as staff, buildings, equipment, etc.

5.36. **Overheads.** Costs not directly assignable to any one process which must be allocated on some arbitrary basis.

5.37. **Replacement cost.** See Costs, replacement.

5.38. **Standard cost.** See Costs, standard.

5.39. **Time study.** See Work study, time study.

5.40. **Work measurement.** See Work study, work measurement.

5.41. **Work study.** Generic term for techniques used in the measurement of human work in all its contexts, leading to investigation of all the factors affecting efficiency and economy of the situation being reviewed, in order to effect improvement. Some of the techniques are activity sampling, method study, predetermined motion time, time study and work measurement.

5.42. **Work study, activity sampling.** A technique in which a large number of instantaneous observations are made, over a period of time, of a group of machines, processes or workers.

5.43. **Work study, method study.** A technique involving the systematic recording and critical examination of existing and proposed ways of doing work, as a means of developing and applying easier and more effective methods and reducing costs.

5.44. **Work study, predetermined motion time system (PMTS).** A technique whereby times established for basic human motions (classified according to the nature of the motion and the conditions under which it is made) are used to build up the time for a job at a defined level of performance.

5.45. **Work study, time study.** A technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analysing the data so as to obtain the time necessary for carrying out the job at a defined level of performance.

5.46. **Work study, work measurement.** A technique which is designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance.
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