Technology Training that Works

Presents

Sample chapters from the title

Best Practice in Process, Electrical & Instrumentation Drawings and Documentation

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Overview

1.1 Introduction

The objective of this course is to familiarize the participants with the various standards that apply to the production of plant drawings, diagrams and documentation. The topics contained in the course are of interest and relevance to all users of documentation whether they are designers of electrical installations, erection engineers or personnel responsible for operation and maintenance of the installations

Although many organizations have developed, over time, a range of "in-house" standards they all have a level of traceability to a set of international standards in order to facilitate clear communication of the requirements and operation of a particular plant design.

In this manual we will make direct reference to a range of commonly used standards which are either recognized internationally or are national standards with traceability to an international standard.

1.2 An overview of the contents of the manual

This manual commences with a broad overview of the role of a range of standards and their associated organizations and using these standards builds progressively a complete project documentation dossier of drawings, diagrams, lists, schedules etc. covering the Process, Instrumentation, Electrical and Electro-Pneumatic / Hydraulic needs of a plant. The manual concludes with a short section covering vendor interaction as all projects require, to a greater or lesser degree a level of documentation from equipment vendors.

It should be recognized that this dossier is by no means complete in the sense that specific projects will often require additional special documents but often these can be adapted from one of the templates contained in this manual.

1.3 What are standards and why are they necessary?

Standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure that materials, products, processes and services are fit for their purpose.

For example, the format of the credit cards, phone cards, and "smart" cards that have become commonplace is derived from an ISO International Standard. Adhering to the standard, which defines such features as an optimal thickness (0.76 mm), means that the cards can be used worldwide.

International Standards thus contribute to making life simpler, and to increasing the reliability and effectiveness of the goods and services, we use.

Standards for documentation, equipment, appliances, and devices of an installation are necessary for the following reasons.

- To ensure a uniform and consistent approach to the production of documentation ensuring that the documentation is universally understandable and usable
- Conformity of documentation throughout the plant reduces the frustration by technical staff of having to try and understand the designers approach.
- To ensure that all vendors know what is required from them to ensure that their documentation is in line with the clients.

1.3.1 So who sets the standards?

ISO – International Standards Organization

What is ISO?

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from more than 140 countries, one from each country.

ISO is a non-governmental organization established in 1947. The mission of ISO is to promote the development of standardization and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological and economic activity.

ISO's work results in international agreements, which are published as International Standards.

Many people will have noticed a seeming lack of correspondence between the official title when used in full, International Organization for Standardization, and the short form, ISO. Shouldn't the acronym be "IOS"? Yes, if it were an acronym – which it is not.

In fact, "ISO" is a word, derived from the Greek isos, meaning "equal", which is the root of the prefix "iso-" that occurs in a host of terms, such as "isometric" (of equal measure or dimensions) and "isonomy" (equality of laws, or of people before the law).

From "equal" to "standard", the line of thinking that led to the choice of "ISO" as the name of the organization is easy to follow. In addition, the name ISO is used around the world to denote the organization, thus avoiding the plethora of acronyms resulting from the translation of "International Organization for Standardization" into the different national languages of members, e.g. IOS in English, OIN in French (from Organization internationale de Normalization). Whatever the country, the short form of the Organization's name is always ISO.

How it all started

International standardization began in the electrotechnical field: the *International Electrotechnical Commission* (IEC) was created in 1906. Pioneering work in other fields was carried out by the International Federation of the National Standardizing Associations (ISA), which was set up in 1926. The emphasis within ISA was laid heavily on mechanical engineering.

ISA's activities ceased in 1942, because of the Second World War. Following a meeting in London in 1946, delegates from 25 countries decided to create a new international organization "the object of which would be to facilitate the international coordination and unification of industrial standards". The new organization, ISO, began to function officially on 23 February 1947.

The first ISO standard was published in 1951 with the title, "Standard reference temperature for industrial length measurement".

SI – System International

The creation of the decimal Metric System at the time of the French Revolution and the subsequent deposition of two standards representing the meter and the kilogram, on 22 June 1799, in the Archives de la République in Paris can be seen as the first step in the development of the present International System of Units.

IEC – International Electrotechnical Commission

Mission

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes international standards for all electrical, electronic and related technologies. These serve as a basis for national standardization and as references when drafting international tenders and contracts.

Through its member, the IEC promotes international cooperation on all questions of electrotechnical standardization and related matters, such as the assessment of conformity to standards, in the fields of electricity, electronics and related technologies.

The IEC charter embraces all electrotechnologies including electronics, magnetics and electromagnetics, electroacoustics, multimedia, telecommunication, and energy production and distribution, as well as associated general disciplines such as terminology and symbols, electromagnetic compatibility, measurement and performance, dependability, design and development, safety and the environment.

Objectives

The Commission's objectives are to:

- Meet the requirements of the global market efficiently
- Ensure primacy and maximum world-wide use of its standards and conformity assessment schemes
- Assess and improve the quality of products and services covered by its standards
- Establish the conditions for the interoperability of complex systems
- Increase the efficiency of industrial processes
- Contribute to the improvement of human health and safety
- Contribute to the protection of the environment.

Standards

IEC's international standards facilitate world trade by removing technical barriers to trade, leading to new markets and economic growth. Put simply, a component or system manufactured to IEC standards and manufactured in country A can be sold and used in countries B through to Z.

IEC's standards are vital since they also represent the core of the World Trade Organization's Agreement on Technical Barriers to Trade (TBT), whose 100-plus central government members explicitly recognize that international standards play a critical role in improving industrial efficiency and developing world trade. The number of standardization bodies which have accepted the Code of Good Practice for the Preparation, Adoption and Application of Standards presented in Annex 3 to the WTO's TBT Agreement underlines the global importance and reach of this accord.

IEC standards provide industry and users with the framework for economies of design, greater product and service quality, more inter-operability, and better production and delivery efficiency.

At the same time, IEC's standards also encourage an improved quality of life by contributing to safety, human health and the protection of the environment.

Conformity assessment

The IEC's multilateral conformity assessment schemes, based on its international standards, are truly global in concept and practice, reducing trade barriers caused by different certification criteria in various countries and helping industry to open up new markets. Removing the significant delays and costs of multiple testing and approval allows industry to be faster and cheaper to market with its products.

As technology becomes more complex, users and consumers are becoming more aware of their dependence on products whose design and construction they may not understand. In this situation, reassurance is needed that the product is reliable and will meet expectations in terms of performance, safety, durability and other criteria.

How can the industrial user and the final consumer be sure that the product they buy conforms to the criteria of an IEC standard? The IEC's conformity assessment and product certification schemes exist to provide just this reassurance, and the regulatory nature of some products now also sees recognition of the CA schemes amongst some government regulators.

On 15 September 1904, delegates to the International Electrical Congress, being held in St. Louis, USA, adopted a report that included the following words: "…steps should be taken to secure the co-operation of the technical societies of the world, by the appointment of a representative Commission to consider the question of the standardization of the nomenclature and ratings of electrical apparatus and machinery."

As a result, the IEC was officially founded in June 1906, in London, England, where its Central Office was set up.

By 1914, the IEC had formed four technical committees to deal with Nomenclature, Symbols, Rating of Electrical Machinery, and Prime Movers. The Commission had also issued a first list of terms and definitions covering electrical machinery and apparatus, a list of international letter symbols for quantities and signs for names of units, an international standard for resistance for copper, a list of definitions in connection with hydraulic turbines, and a number of definitions and recommendations relating to rotating machines and transformers.

The First World War interrupted IEC work, which resumed in 1919 and by 1923 the number of technical committees had increased to 10. IEC Council decided to create the Committee of Action "to assist in giving effect to the decisions of the Council, to second the efforts of the Central Office and to co-ordinate the work of the National Committees and of the Advisory Committees."

In 1930, the IEC established the following electrical units:

- Hertz, for the unit of frequency
- Oersted for the unit of magnetic field strength
- Gauss for the unit of magnetic flux density
- Maxwell of the unit of magnetic flux
- Gilbert for the unit of magnetomotive force
- Var for designating the unit of reactive power
- Weber for the practical unit of magnetic flux

It was decided to extend the existing series of practical units into a comprehensive system of physical units, which became the "Giorgi system", named after Giovanni Giorgi (1871-1950) - an Italian scientist and engineer. This system has been elaborated further and is now commonly known as the "Système international", or SI for short.

Between the First and the Second World Wars, a number of new international organizations came into being and the IEC recognized the need for co-operation to avoid overlapping efforts. In some cases, joint technical committees were formed, such as the International Special Committee on Radio Interference (CISPR).

In 1938 the IEC produced the first edition of the International Eletrotechnical Vocabulary (IEV). The unification of electrotechnical terminology was one of the principal tasks allocated to the IEC by the St. Louis congress. In the early days, the Nomenclature Committee was engaged in pioneer work, as no comparable international technical vocabulary had yet been published and few national electrotechnical vocabularies existed. With its 2000 terms in French, English German, Italian, Spanish and Esperanto, and its definitions in French and English, the IEV could rightly be considered as an outstanding achievement. It aroused wide interest among international technical organizations outside the electrotechnical field.

In September 1939, the IEC's activity came to a standstill because of the Second World War and did not resume for another six years.

In 1948, the IEC Central Office moved from London to Geneva, Switzerland. Subsequently, the IEC expanded its efforts in the light current field, which had constituted only a small part of the activity of the Commission before 1939. Standards covering measurements, safety requirements and the testing and specification of components for radio receivers and televisions began to appear. At the same time, work on electroacoustics started, while CISPR developed standards on permissible limits for various frequency ranges used for radio broadcasting and measurement methods for interference.

From 1948 to 1980, the number of technical committees grew from 34 to 80 and began to include such new technologies as capacitors and resistors, semiconductor devices, electrical equipment in medical practice and maritime navigation and radio communication systems and equipment.

ISA – Instrument Society of America

History of ISA – the instrumentation, systems, and automation society

Industrial instruments, which became widely used during World War II, continued to play an ever-greater role in the expansion of technology after the war. Individuals like Rimbach and others involved in industry saw a need for the sharing of information about instruments on a national basis, as well as for standards and uniformity. The Instrument Society of America addressed that need with more than 39,000 members from more than 110 countries.

Recognizing ISA’s international reach and the fact that its technical scope had grown beyond instruments, in the fall of 2000, the ISA Council of Society Delegates approved a legal name change to ISA–The Instrumentation, Systems, and Automation Society.

The founders’ mission

The object of the Society shall be to advance the arts and sciences connected with the theory, design, manufacture, and use of instruments in the various sciences and technologies.

Today's mission

The mission of ISA as the global society for instrumentation, systems, and automation is to:

- Maximize the effectiveness of ISA members and other practitioners and organizations worldwide to advance and apply the science, technology, and allied arts of instrumentation, systems, and automation in all industries and applications
- Identify and promote emerging technologies and applications
- Develop and deliver a wide variety of high-value information products and services to the global community

ASME – American Society of Mechanical Engineers

As with many other standards, the dominance of a particular institution or society, and the broad international acceptance of its publications often lead to a de facto recognition of certain publications as an international standard. As with ISA above ASME produces a wide range of standards relevant to best drawing practices and these publications (ASA's) are referenced later in this manual.

1.4 Drawing office operating standards

1.4.1 Drawing office operating manual

Introduction

In any given plant therefore the drawing office must establish what standards it is going to employ and what processes it will utilize to control the quality, workflow and ultimately the archiving of its output. As many drawing offices may use contract staff to undertake significant projects it is important that a clear and uniform set of rules be documented to cover all activities. The Drawing Office operating manual satisfies this need and a typical manual should address the following elements.

1.4.2 Drawing office organizational structure

Structure

The drawing office is a subset of the design office and as such the overall authority resides with the Resident Engineer or the Project Manager. His requirements and decisions are passed to the drawing office staff via the Chief Draughtsman and/or discipline specific Engineers.

1.4.3 Office discipline

Administration personnel involved

Time keeping and office discipline is the responsibility of the Chief Draughtsman.

Time keeping

Time books showing a log of all hours need to be maintained by the Chief Draughtsman. All staff shall submit a weekly timesheet to the Chief Draughtsman for approval before it is passed to accounts for payment and/or client billing purposes.

Workmanship

Quality and quantity of the work produced by the drawing office shall be monitored by the Chief Draughtsman.

Problem resolution

Should any contentious points arise concerning either discipline or personal problems which cannot be solved between the relevant personnel they may be brought to the attention of the Chief Draughtsman and ultimately the Resident Engineer.

1.4.4 Methods of work initiation, control and reporting

Work request

No work should commence without a work request carrying the requisite information and signatures.

The following information should be completed before commencement of work:

- Name of person requesting work - print in block capitals
- Name and signature of engineer authorizing work
- Respective cost code
- Date completed work required by ("ASAP" is not acceptable)
- Title of plant or work area
- Comprehensive work description or title
- Indicate on the work request information supplied, drawings required
- Comments – i.e. similar to equipment number 6001, contact name and extension number, refer to supplier for information, etc
- Date received by drawing office
- Chief Draughtsman signature
- Draughtsman's name to whom work is allocated

Should the work request refer to an existing structure, i.e. in the case of an extension or require a new structure based on a previous job, it is imperative that site investigations be carried out before work is commenced as modifications may have been made on site.

On completion of the job the original work request should be filed with the project documentation package and kept as a permanent record.

Program progress reports

The Chief Draughtsman is responsible for scheduling and allocating work in an endeavor to meet the Project time schedule consistent with available manpower.

1.4.5 Draughting procedures

General introduction

The function of the Design Office is to provide and communicate information to the end user in drawing form. Clear, easy to read and understandable drawings that transmit the necessary information are therefore the prime objectives.

The intent of the following section is to provide uniform information and typical details that serve as a guide and help in our work.

When making a Drawing

- Always keep in mind: Who will use the drawing and for what? What information does he need?
- Always practice functional draughting

Standards and specifications

Functional draughting is not a set of hard and fast rules. They are principles that are to be followed in making drawings. Particulars and their application in specific cases will be left to the draughtsman's judgment and good sense backed by their experience and knowledge of a given project's requirements.

Plan your drawing

A drawing must be simple yet clear and sufficient. A drawing should not just grow, it must be planned. Think through the drawing before you lay it out. Have a clear idea what has to be communicated and then decide on the best way to communicate the idea. A good clear drawing should be produced from left to right and from top to bottom and not be just a random distribution of details and views fitted in wherever there happens to be space for them.

Avoid artistry

A drawing is not a picture; it is a diagrammatic representation of the object. Any unnecessary line is a waste of time: Eliminate unnecessary elaboration that adds nothing to the message. Shading, etc. falls into this category with few exceptions.

Repetition of typical details

Once a typical detail has been identified -stop. If ten off are required -draw the one detail only and indicate by a note or instruction that there are ten off required. If this typical detail is required on other drawings for the project then all that is needed is a reference to the original key drawing with the typical detail - do not redraw the detail.

It is important to establish the existence of an obvious pattern. Once sufficient draughting is done to establish this pattern clearly, stop delineating and give a note or instruction.

Eliminate unnecessary views

Always question the necessity of a projected view. A description, a note or a reference may be all that is required. Guard against re-drawing an entire item in another projection just for the sake of showing a minor divergent detail, or a secondary view which does not show anything but a diameter or a thickness.

Drawing sheets

Pretty much all of us live in a metric world. All drawings should be scaled to standard metric size sheets (in CAD software) or prepared on standard metric plastic drawing sheets.

All sheets should use pre-configured templates with title blocks, borders, etc. (for CAD software) or pre-printed equivalents when using plastic drawing sheets.

Scales

Where possible a constant set of scales shall be used on one set of drawings. This can help considerably in checking out obstructions between disciplines by a simple overlay. In addition, the eye becomes accustomed to viewing the drawing in perspective.

Avoid using "odd" scales, e.g. 1:25, 1:30, 1:175, etc. as in future someone else may work on these drawings. Try to use only common scales e.g. 1:200, 1:100' 1:50, 1:20, 1:10, 1:5.

Drawing implements

For hard drawings, plastic leads or ink may be used. For CAD based drawings layering should be used with all detail in black.

Lettering

Lettering sizes and styles for different sheets sizes should be defined.

Titles of drawings

In general the drawing title will be presented in a three-sequence format after the initial box-designating client name:

- Facility of Plant Area
- General Description of Work
- Details or Specifics (as required), e.g.

1.4.6 General information on drawings

Cross-reference and information traceability

It is of utmost importance that the information shown on a drawing be cross-referenced such that the source is fully traceable and other project drawings that are directly affected by this information are identified. It is therefore critical that each drawing used as a source of information in the preparation of your current drawing be noted as a reference drawing in the current drawing reference block provided.

Key plans

There are three main cases where the use of a key plan is necessary:

- Where a layout drawing is part of a larger area consisting of a number of drawings then a key plan is required to show this area covered in each drawing
    - Shaded area represents are covered on that drawing
- Where a plan has been produced on one drawing and some or all of the sections on other drawings
    - Section Lines or Arrows are to be used i.e. A-A and 8-8 show where section has been taken through on other drawing
- Location purposes also require a key plan

First angle / Third angle projections

Projection is a means to represent a three dimensional attribute of an object on one or more planes. A company standard convention should be defined such that all projection drawings are either 1^{st} Angle (European) or 3^{rd} Angle (American). The projection type must always be shown on the drawing.

Information systems

The location and utilizing of existing information is critical in the production of drawings. *Do not re-invent the wheel.*

Catalogued reference system

A comprehensive catalogued reference system should be maintained in the Drawing Office Filing Section. This system references and correlates all drawings to projects, types of plant, structures, buildings and related manufacturer's items. This system should be available to all personnel.

The reference system may consist of:

- Catalogued index
- Microfile System

Manufacturer's information

Manufacturers provide a vast source of catalogued information which is readily available on request. A good library is an invaluable resource in ensuring that the draughtsmen utilize readily available materials rather than custom manufactured items in so far as possible. Maintaining this library and keeping it up to date with a formalized system of review is an inherent part of the overall operation of a drawing office.

Alternative source of information

If having exhausted the Drawing Registers, catalogues, etc, the draughtsman still lacks information ASK. There is often available (to all draughtsmen) a senior person with specialized knowledge and many years experience and this should be utilized to the full.

Information - responsibility and accuracy

The Engineer is responsible for the aesthetic, schematic and detailed design of any plant, equipment or structure. He will be involved in the conceptual layout of any given scheme to ensure suitability for duty, safety of operation and code compliance. He must also sign the Approval Drawing.

The Chief Draughtsman and Draughtsman are responsible for the accurate representation of all information on the drawings.

Drawing distribution procedures

A formalized system of drawing approvals must be implemented in any drawing office to define the stage / status of a drawing – the following gives some suggestions as to how this process can be accommodated.

1.4.7 Issued for approval

Approval drawings are required mainly for layouts but may be used for any drawing where specific items are required to be drawn to the Engineer's attention. An approval drawing need not be complete or fully dimensioned, but must clearly define the concept.

The approval drawing is a scheme, which requires approval from the Engineer. These drawings are not to be issued for Tender, Construction or to any Consultant or Contractor to use as final drawings.

After approval of a drawing with all appropriate signatures the drawings need not be re-issued for final approval unless specifically requested on the approval form.

To summarize

- Approval drawings are for internal use only, i.e. between Client/Design Department
- No construction may be carried out using an approval drawing
- Where approval of any drawing is required, it must be issued to the responsible Engineer or Manager
- If a second or third approval is required, the drawing must state this.
- Drawing numbers refer to a single drawing or document. Two or more drawings cannot have the same number
- A duplicate drawing can be issued and stamped accordingly
- Where approval has been sought, the final drawing must indicate this.
- An approval drawing which has been approved need not be re-submitted

1.4.8 Issued for final approval

On completion of final drawings and prior to issue, a print shall be made and this shall be handed over to the Project Engineer for his signature and to record that final drawings have been issued to his approval, all previous comments having been acted on to his satisfaction. This shall not be used for further modifications.

1.4.9 Issued for information only

There are a number of situations where a drawing may be issued for information only, i.e. these drawings may be worked to for manufacture or construction.

- Drawings may be issued to a Civil Contractor for planning his construction program
- Drawings may be issued to a supplier to assist in determining type of merchandise best suited to our requirements
- Drawings may be issued to a Quantity Surveyor for preparation of Bill of Quantities
- Drawings may be issued inter-departmental to expedite work. In each of the above cases the Drawings must be clearly stamped: *for information only not to be worked to*

1.4.10 Issued for tender

- Drawings shall be as complete as possible before issuing for tender purposes. The more: information given at this stage the more accurate the quote and the less likely future claim for extras
- Where possible send out detail drawings at tender stage
- Whenever possible have drawings checked before going out on tender
- Tender closing date must be realistic.
- An extension to the tender closing date may be given at the discretion of the Resident Engineer on request by one or more of the Tenderers. However, should this occur tenderers must be notified of the new date.
- Manufacture/Fabrication time allowed on Tender should tie in with program requirements but again be realistic towards the Supplier.
- Tender documents shall carry a reference to all drawings, specifications etc., which form part of the Tender.

1.4.11 Issued for manufacture or construction

- Any variations between drawings at tender stage and construction issue shall be highlighted by way of a revision on the drawing.
- In conjunction with issuing the drawing for construction to the fabricator issues shall also be made to client, i.e. Plant etc., and to a Quantity Surveyor should he be involved.

1.4.12 As built

- Represents the final revision to all drawings reflecting actual changes made during the construction and commissioning of the plant.
- Will form part of the Plant Operating and Maintenance documentation and must be archived on completion of the project.

Checking procedures

Checking procedures fall directly under the control of the Chief Draughtsman.

The Checking activity is the "last line of defense" in the system to ensure that a drawing represents as closely as possible the functional requirements of the job. As such, the checker needs to critically analyze and question any proposal put forward.

The Checker has the right and may challenge, without prejudice, any idea, concept or formulation that has been committed to paper.

The Checker shall not subscribe to any suggestion until the Checker is totally convinced of its usefulness and fitness for purpose.

No drawing shall be issued for manufacture unless it is authorized by a Checker.

1.4.13 Analysis

The checking procedure entails a methodical step-by-step study of all phases of the design of a given item in relation to the function it performs. The philosophy underlying this approach is not concerned with appraisal of any given part per se. Rather the appraisal focuses on the function, which the part, or the larger assembly containing the part, performs. This approach is designed to lead the analyst away from a traditional perspective which views a part as having certain accepted characteristics and configurations. Indeed, it encourages the analyst to adopt a broader point of view and to consider whether the part will perform the required function as efficiently and as inexpensively as possible.

1.4.14 The checklist

It is useful to develop a checklist to systemize the checking activity. The following is a general checklist, which should be supplemented by more specific items from the checkers.

Determine the function of the item then establish:

- Can the item be eliminated?
- If the item is not standard can a standard item be used?
- If it is a standard item, does it completely satisfy the application or is it a misfit?
- Does the item have greater capacity than required?
- Can the mass be reduced?
- Is there an off-the-shelf item that could be substituted?
- Are closer tolerances specified than are necessary? (h) Is unnecessary fine finishes specified?
- Are unnecessarily fine finishes specified? (j) Is "Commercial quality" specified?
- Can the item be easily and cheaply transported? (I) Can cost of packaging be reduced?
- Are suppliers being asked for suggestions to reduce cost?
- A very important question is "What does it cost to perform the function done by this part?" or "Is the importance of the function to be performed commensurate with the cost of performing it?"

1.4.15 Dimensional accuracy

This is of crucial importance. Dimensions must be checked on a local and overall basis. Particular attention must be given to mating parts, e.g. base plates, foundations, etc.

The orientation of each element must be checked in relation to the total unit. In this respect, an orientation diagram must be included on the drawing showing the relevant position of the item in question.

1.4.16 Checking procedures

- All drawings produced need to be checked before issue for tender
- Except under special circumstances, drawings should be checked in a different department than the section producing them.

A suggested color code for checking

- *Red* – Incorrect
- *Yellow* – Correct
- *Green* – To be used by draughtsman when correcting errors. Green through red indicating alteration has been done
- Should there be revisions to a drawing once it has been signed off as checked then it should be returned for a further check
- Where there is a point of contention between Checker and the originating Draughtsman, the Chief Draughtsman should be consulted

1.4.17 Printing and filing

Printing and filing activities need to be defined in a drawing office to ensure the highest level of efficiency together with the best utilization of available printing equipment.

Printing of all drawings

Printing requirements normally fall into three categories:

- Printing for developing of working drawings
- Printing for issuing internally
- Printing for issuing externally

- All Prints_should be officially requested. This may take the form of an Issue Slip, or a Print Request Slip.
- Where a job is deemed to be urgent then the Chief Draughtsman must prioritize.
- All other printing shall be done on a "First come First served" basis

Registering of drawings

- All drawings must be registered in the Master Drawing Register.
- Vendor's drawings on arrival in Drawing Office shall be registered with all the relevant information, i.e. request for Drawing Office Number to be given to drawing, registering in Drawing Register, filing and returning of copies to interested parties

Filing of all drawings

- All completed drawings shall be filed in the appropriate place in the Filing Section – this may be a dedicated location on a server hard disk or a physical location for hard copies.
- A Draughtsman should only have in his possession the drawing relevant to the job he is currently working on. All other drawings in his possession should be in the form of prints or microfilm prints and marked accordingly as copies.

Records of all expenses on office supplies

It is the responsibility of the Chief Draughtsman to keep accurate records of all stationery ordered.

Issuing and dispatching of drawings

All drawings issued through the Drawing Office / Printing Section must be formally requested. This may be done by way of an official issue slip or drawings being for tender or construction. All drawings issued should be accompanied by a document transmittal form which should be signed and returned and filed by the originator for record purposes.

Binding of documents

Where required the parties responsible for printing the documents may be called upon to make up a package of documents required for tender purposes. Again, explicit instructions shall be given as to the number required and the content therein.

1.5 General drawing standards

1.5.1 Introduction

Although we acknowledge that a large number of mature organizations have adapted a range of standards to suit their particular needs it is appropriate in this manual to provide recommendations with direct traceability to an international set of rules. The following recommendations are therefore taken from **AS 1100.101-1992 Technical Drawing – General Principles** – the Australian Standard for Technical Drawing.
This standard is in agreement with the following International Standards.

ISO 128	Technical Drawings – General Principles of Presentation
ISO 129	Technical Drawings – Dimensioning
ISO 406	Technical Drawings – Tolerancing of linear and angular dimensions
ISO 1101	Technical Drawings – Geometrical Tolerancing
ISO 1660	Technical Drawings – Profile Dimensioning
ISO 3040	Technical Drawings – Cone Dimensioning
ISO 3098/1	Technical Drawings – Lettering
ISO 5455	Technical Drawings – Scales
ISO 5459	Technical Drawings – Datum Systems for Geometric Tolerancing
ISO 6410	Technical Drawings - Representation of Threaded Parts

1.5.2 Size of drawing sheets

Preferred sizes

The preferred size of drawing sheets is taken from the ISO-A series which is listed in the table below.

Designation	Trimmed size (mm)	Width of border (mm)
A0	841 × 1189	20
A1	594 × 841	20
A2	420 × 594	15
A3	297 × 420	15
A4	210 × 297	15

Non-preferred sizes and roll drawings

Under certain circumstances the use of other drawing sheet sizes may be necessary and the ISO-B series sheets may be used. Roll drawings when required should have standard widths of either 860mm or 610mm.

1.5.3 Thickness of format lines

Recommended line thicknesses in mm for format lines are per the table below.

Feature	A0 Sheet	A1 Sheet	A2, 3, 4 Sheet
Border Lines	1.4 mm	1.0 mm	0.7 mm
Title Block Lines	1.0 mm	0.7 mm	0.5 mm
Grid Lines	0.7 mm	0.5 mm	0.35 mm
Fold Lines	0.25 mm	0.25 mm	0.25 mm
Other Format Lines	0.35 mm	0.25 mm	0.18 mm

1.5.4 Thickness of drawing lines

The thickness of drawing lines is covered in detail in the standards and is based on line group types which may be 1.0, 0.7 & 0.5 mm (line group 1.0 mm typically used on A0 sheet sizes) through to 0.35, 0.25 & 0.18 mm (line group 0.35 mm which may be more appropriate for A4 sheets). The standard specifically states that the minimum line thickness on a drawing after reproduction (including reduction) should not be less than 0.18 mm.

1.5.5 Text types and character heights

The following text types are provided for in the drawing standards.

- Upright Gothic
- Sloping Gothic
- ISO 3098/1 Type B Upright
- ISO 3098/1 Type B Sloping
- Microfont

The height of the characters should be one of the following (in mm) with minimum character line thickness not less than 10% of the height

- 2.5 mm
- 3.5 mm
- 5 mm
- 7 mm
- 10 mm
- 14 mm
- 20 mm

The height of the characters should not be less than 1.7 mm on a reduced drawing reproduction.

1.5.6 Ratio of text size to corresponding line thickness

The ration of line thickness to text size is generally 1:10 and one of the following sets of standard text sizes and corresponding line thickness' is often used. Note that although Set 2 does not strictly meet the Australian Drawing Standard it is often referenced in other standards – the attached tables reference to the South Africa standard (SABS 0111 1990).

SET 1	
Text Size	Line Thickness
1.8 mm	0.18 mm
2.5 mm	0.25 mm
3.5 mm	0.35 mm
5 mm	0.5 mm
7 mm	0.7 mm
10 mm	1.0 mm

SET 2	
Text Size	Line Thickness
2.0 mm	0.2 mm
3.0 mm	0.3 mm
5.0 mm	0.5 mm
7.0 mm	0.7 mm
10.0 mm	1.0 mm
14.0 mm	1.4 mm

1.5.7 Title block

Title block layouts are normally laid out as standard templates with unique logos pertaining to the individual company. The standards cover a variety of designs with dimensions for different sheet sizes but specific layout is not dictated. As a general rule however the title block should be located in the bottom right hand corner of the drawing sheet or when this restricts the drawing layout the top right hand corner may be used.

As a minimum however the Title block contains the following:-

- Name of firm, organization or department
- Title or name of drawing
- Drawing number
- Signatures or initials and dates
- Additional information such as scale, method of projection, native sheet size etc.
- Provision to show revision level and drawing status.

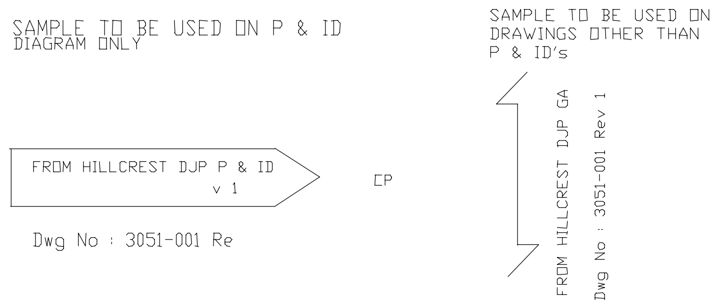
Other information of relevance may include:

- A space may be added to the top or added to the left hand side of the company title block, in which space the Contractor's details and title block may be added
- A further space may be added in the same area for the Contractor's drawing number
- The Contractor shall indicate the persons responsible for producing the drawing, the title, scale, project name, date, revision etc. in the spaces provided for in the company title block

1.5.8 Reference drawings

- Where applicable, all reference drawings shall be noted in an appropriate place, on all drawings
- Smaller series drawings (A4 and A3) may bear reference drawing numbers as a note, in an appropriate position, on the drawing

- Where a drawing is of sufficient complexity and size that warrants being split over several pages, continuation lines shall be conveyed by means of either of the under mentioned symbols. Note that the direction of the arrow shall indicate the direction of information flow.



1.5.9 Recommended sheet sizes versus drawing types

As stated previously many companies have established in-house standards regarding a variety of drawing areas not covered by ISO standards. A typical recommendation of drawing sheet size versus drawing type is as per below. Bear in mind the reduction of drawing size when reproducing large drawings must not allow the line thicknesses or character heights to fall below the values stated in the standards for legibility. Reductions of more than 2 drawing sizes will in nearly all cases make portion of a drawing illegible.

Documentation type	***Drawing size***
Process Drawings	
Piping & Instrumentation Diagrams	A1
Process Flow Diagrams	A1
Metering & Instrumentation	
Instrument Schedules	A4
Instrument Data Sheets	A4
Instrument Hookup Diagrams	A4
Loop Drawings	A4
Panel Wiring Diagrams	A1/A4
Cable Schedules	A1/A4
Cable Block Diagrams	A1
Cable Interconnection Diagrams	A1
Software Documentation	
Plant I/O Schedules	A4
Flow Charts	A4
Software Listings	A4
Electrical Documentation	
Single Line Diagrams	A1/A4
Electrical Schematic & Wiring Diagrams	A1
Cable Schedules	A1/A4
Cable Block Diagrams	A1
Cable Interconnection Diagrams	A1

2

Symbols and numbering

2.1 Overview

The use of a consistent set of symbols to identify major plant components, instruments and electrical equipment is fundamental to the purpose of clearly communicating the functionality of a particular plant diagram. Additionally each item needs to have some form of unique identification in the physical plant and a numbering system likewise needs to employ a standard methodology that is easily understood.

The purpose of this section of the manual is to give the reader an overview of some typical standards which are recognized globally such that the adoption of these would provide the foundation for generating drawings, diagrams, lists and schedules which can be readily understood by parties outside the immediate company.

It should be highlighted at this stage that the examples contained in this manual are no substitute for a drawing office having a full set of standards as the examples contained herein represent only a portion of the detail covered in full in the referenced standards.

2.2 Reference to standards

The following standards have been used in compiling this topic and represent either standards which are directly traceable to an ISO set or are considered de facto international standards by virtue of their use globally and their acknowledged expertise in a specific area.

Process drawings and diagrams

- American Society of Mechanical Engineers (ASME)
    - ASA Y32.11 Graphical Symbols for Process Flow Diagrams
    - ASA Z32.2.3 Graphical Symbols for Pipe Fittings, Valves & Piping

Instrumentation drawings and diagrams

- Instrument Society of America (ISA) (now known as The Instrumentation Systems and Automation Society)
  - ISA–S5.1–1984(R1992) Instrumentation Symbols and Identification
  - ISA-S5.3-1983 Graphic Symbols for DCS/Shared Displays
  - ISA-S5.4-1989 Instrument Loop Diagrams
  - ISA-S5.5-1985 Graphic Symbols for Process Displays

Electrical drawings and diagrams

- International Electrotechnical Commission (IEC)
  - IEC Publication 27 Letter Symbols to be used in Electrical Technology
  - IEC Publication 50 International Electrotechnical Vocabulary
  - IEC Publication 617 Graphical Symbols for Diagrams

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2.3 Process drawings and diagrams

2.3.1 Plant equipment numbering

Plant area numbering

Plant area numbering is a useful tool in large plants with complex processes in that it readily enables all personal to identify equipment with a particular section of plant. Plant Area numbering schemes normally use either a 3 digit or 4 digit numeric system in the form XXX where a plant areas may be 100, 200, 300 etc and identify discrete plant sections (e.g. Furnace Area, Waste Heat Boiler Area, Converter Area etc). Plant Area numbers are then used as the preliminary number in identifying all physical plant equipment and instrumentation tags.

Plant equipment numbering

All physical plant equipment must be given an equipment number. The equipment number will normally take the form of either 1, 2 or 3 alpha characters followed by either 3 or 4 numeric characters. The alpha characters may be site specific but are normally tied to a specific company standard and identify the functional component (e.g. P or PMP for pump, V for vessel etc). The numeric characters are unique for each device of a particular type – i.e. P100 and P101 may identify 2 pumps. When used in combination with a Plant Area number the full equipment number may appear as XXXP100 and XXXP101 (e.g. 100P100 and 100P101).

Line numbering

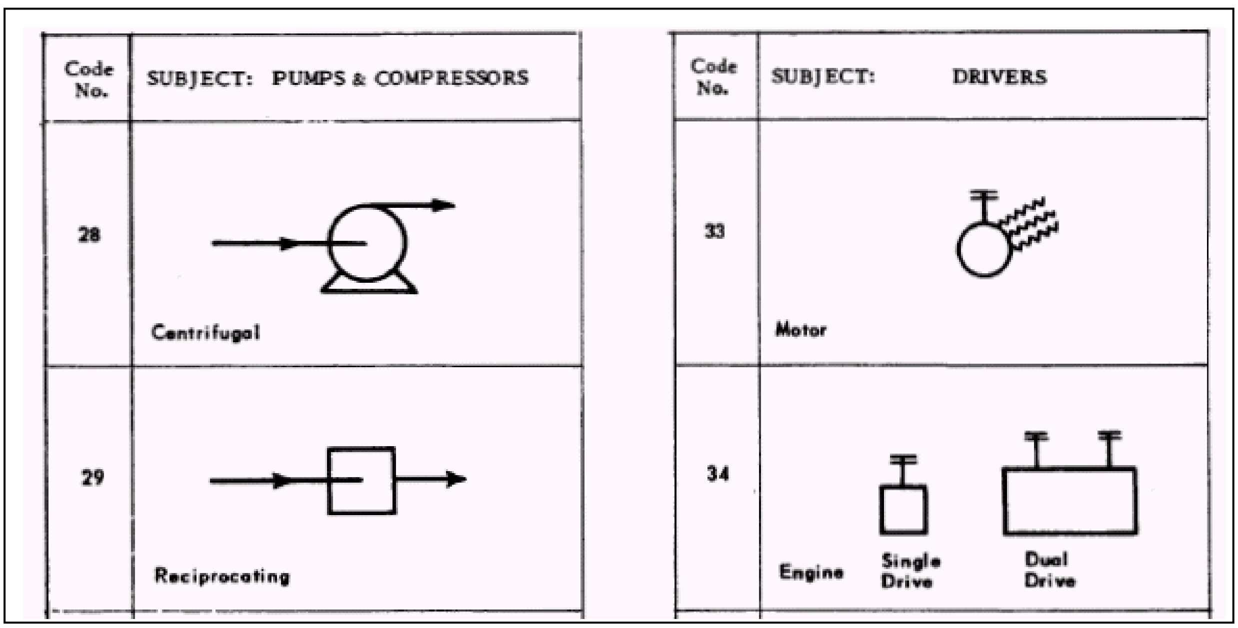
All process lines are similarly given line numbers normally in the form of a series of alpha and numeric characters which identify the following line elements:-

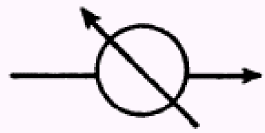
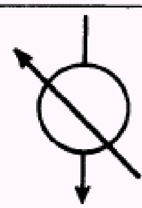
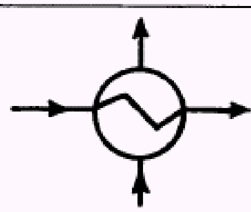
- Plant Area Number (e.g. 100)
- Service (e.g. LP for low pressure steam)
- Sequence Number(a unique number e.g. 001)
- Pipe Size (Nominal) (e.g. 100 for 100 mm NB)
- Line Material (e.g. CS for carbon steel)

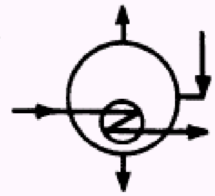
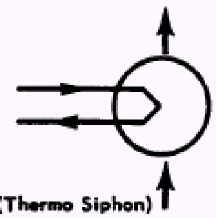
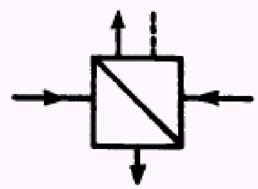
The resulting line number would appear as 100-LP-001-100-CS. The sequence number changes each time there is a break in the integrity of the pipe – either a flanged joint or any other form of change in the pipe.

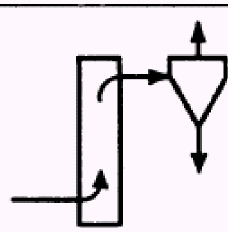
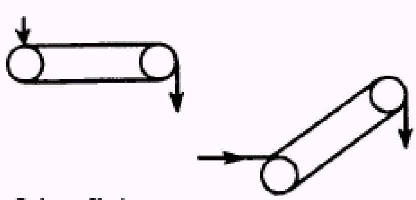
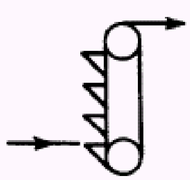
2.3.2 Plant equipment symbols

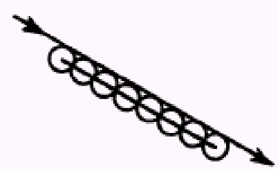
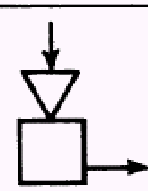
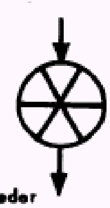
Plant equipment symbols are used in conjunction with plant equipment numbers to identify discrete items of plant and show their interconnection to the rest of the process. Symbols shown in the table below represent some established ASME standards. Note that ISA also produces a wide variety of symbols for hand valves as well as control valves. Many software vendors provide symbol libraries for popular CAD software which contain literally thousands of symbols.



Code No.	SUBJECT: HEAT TRANSFER
19	 Water Cooled Exchanger
20	 Water Cooled Condenser
21	 Shell & Tube Exchanger

Code No.	SUBJECT: HEAT TRANSFER (Cont'd)
24	 Reboiler (Kettle Type)
25	 Reboiler (Thermo Siphon)
26	 Superheater or Reheater

Code No.	SUBJECT: MATERIAL HANDLING EQUIPMENT
47	 Air Lift
48	 Belt or Shaker
49	 Bucket or Flight Conveyor

Code No.	SUBJECT: MATERIAL HANDLING EQUIPMENT (Cont'd)
51	 Roller Conveyor
52	 Feeder & Hopper
53	 Rotary Feeder

2.4 Instrumentation drawings and diagrams

2.4.1 Instrument numbering (tagging)

Instrument Tag Nos.

As with Equipment numbers all instruments (including virtual instruments that exist in a DCS, PLC or other shared system) are given unique identifiers called tag numbers. The ISA tagging system is virtually universally adopted in terms of the basic construction of a tag number. The ISA system comprises a group of alpha characters which describe both the variable being measured (or controlled) together with the broad characteristics of the instrument itself. The first alpha character in the tag always identifies the physical variable with which the instrument is associated (e.g. Pressure, Temperature, Flow etc). Subsequent alpha characters identify the function of the instrument and may be comprise more than one additionally character. Hence FIC would refer to a Flow Indicating Controller, PAHL would refer to an alarm device on pressure with both High and Low alarm settings. Once the basic alpha tag characters are established a group of numeric characters are added to identify the loop number. These may be 3 or 4 or more numerals but all devices interconnected on the same loop must have the same loop number – the individual instruments are therefore differentiated by their alpha character functionality. As with the equipment numbering system large plants employing an Area numbering scheme may add the plant area number in front of the tag to create the full tag number. As an example tag number 100PT001 and 100PIC001 are respectively a pressure transmitter and a pressure indicating controller in plant area 100 on loop number 001. The table below lists the ISA alpha character system.

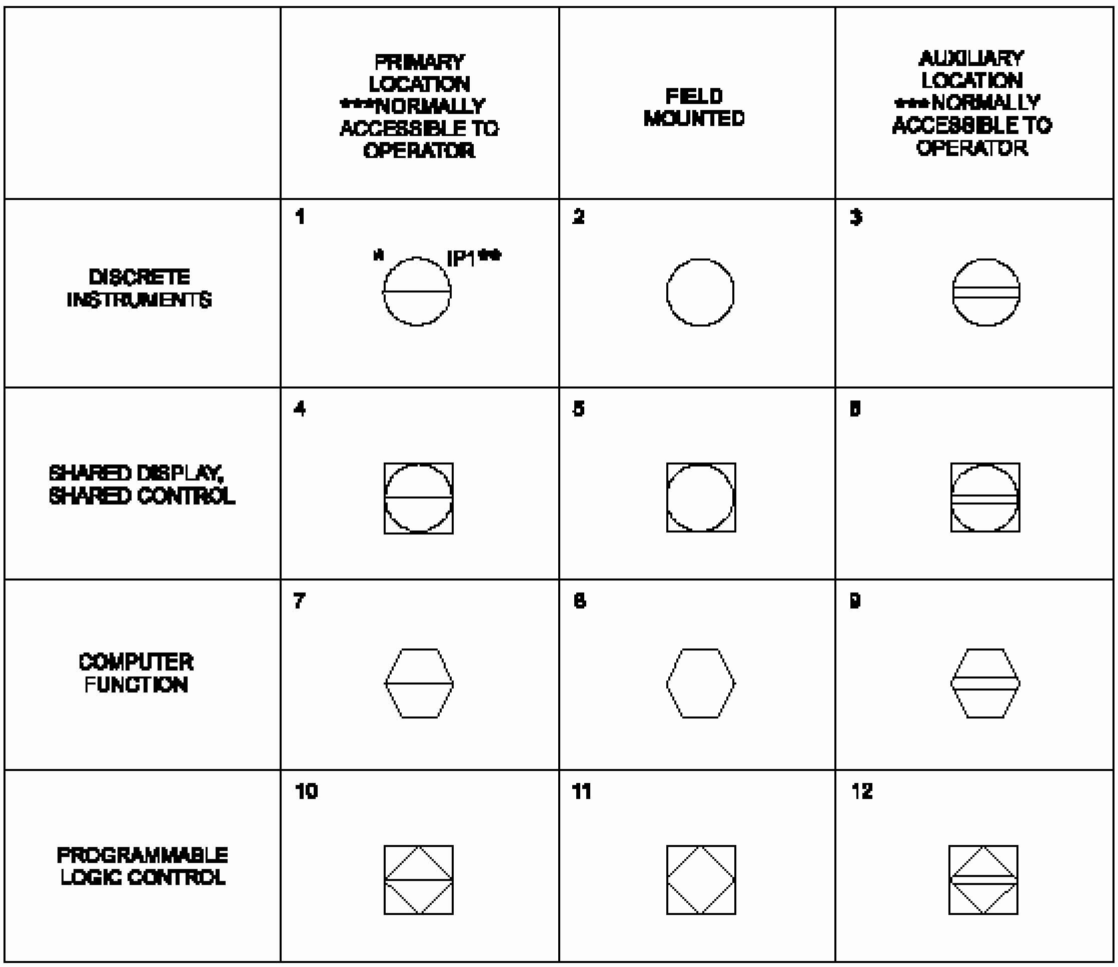
	FIRST-LETTER (4)		SUCCEEDING-LETTERS (3)		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	Analysis (5,19)		Alarm		
B	Burner, Combustion		User's Choice (1)	User's Choice (1)	User's Choice (1)
C	User's Choice (1)			Control (13)	
D	User's Choice (1)	Differential (4)			
E	Voltage		Sensor (Primary Element)		
F	Flow Rate	Ratio (Fraction) (4)			
G	User's Choice (1)		Glass, Viewing Device (9)		
H	Hand				High (7, 15, 16)
I	Current (Electrical)		Indicate (10)		
J	Power	Scan (7)			
K	Time, Time Schedule	Time Rate of Change (4, 21)		Control Station (22)	
L	Level		Light (11)		Low (7, 15, 16)
M	User's Choice (1)	Momentary (4)			Middle, Intermediate (7,15)
N	User's Choice (1)		User's Choice (1)	User's Choice (1)	User's Choice (1)
O	User's Choice (1)		Orifice, Restriction		
P	Pressure, Vacuum		Point (Test) Connection		
Q	Quantity	Integrate, Totalize (4)			
R	Radiation		Record (17)		
S	Speed, Frequency	Safety (8)		Switch (13)	
T	Temperature			Transmit (18)	
U	Multivariable (6)		Multifunction (12)	Multifunction (12)	Multifunction (12)
V	Vibration, Mechanical Analysis (19)			Valve, Damper, Louver (13)	
W	Weight, Force		Well		
X	Unclassified (2)	X Axis	Unclassified (2)	Unclassified (2)	Unclassified (2)
Y	Event, State or Presence (20)	Y Axis		Relay, Compute, Convert (13, 14, 18)	
Z	Position, Dimension	Z Axis		Driver, Actuator, Unclassified Final Control Element	

First-Letters	Initiating or Measured Vaiable	Controllers				Readout Devices		Switches and Alarm Devices*			Transmitters			Solenoids, Relays, Computing Devices	Primary Element	Test Point	Well or Probe	Viewing Device, Glass	Safety Device	Final Element
		Recording	Indicating	Blind	Self-Actuated Control Valves	Recording	Indicating	High**	Low	Comb	Recording	Indicating	Blind							
A	Analysis	ARC	AIC	AC		AR	AI	ASH	ASL	ASHL	ART	AIT	AT	AY	AE	AP	AW			AV
B	Burner/Combustion	BRC	BIC	BC		BR	BI	BSH	BSL	BSHL	BRT	BIT	BT	BY	BE		BW	BG		BZ
C	User's Choice																			
D	User's Choice																			
E	Voltage	ERC	EIC	EC		ER	EI	ESH	ESL	ESHL	ERT	EIT	ET	EY	EE					EZ
F	Flow Rate	FRC	FIC	FC	FCV, FICV	FR	FI	FSH	FSL	FSHL	FRT	FIT	FT	FY	FE	FP		FG		FV
FQ	Flow Quantity	FQRC	FQIC			FQR	FQI	FQSH	FQSL			FQIT	FQT	FQY	FQE					FQV
FF	Flow Ratio	FFRC	FFIC	FFC		FFR	FFI	FFSH	FFSL						FE					FFV
G	User's Choice																			
H	Hand		HIC	HC						HS										HV
I	Current	IRC	IIC			IR	II	ISH	ISL	ISHL	IRT	IIT	IT	IY	IE					IZ
J	Power	JRC	JIC			JR	JI	JSH	JSL	JSHL	JRT	JIT	JT	JY	JE					JV
K	Time	KRC	KIC	KC	KCV	KR	KI	KSH	KSL	KSHL	KRT	KIT	KT	KY	KE					KV
L	Level	LRC	LIC	LC	LCV	LR	LI	LSH	LSL	LSHL	LRT	LIT	LT	LY	LE		LW	LG		LV
M	User's Choice																			
N	User's Choice																			
O	User's Choice																			
P	Pressure/ Vacuum	PRC	PIC	PC	PCV	PR	PI	PSH	PSL	PSHL	PRT	PIT	PT	PY	PE	PP			PSV, PSE	PV
PD	Pressure, Differential	PDRC	PDIC	PDC	PDCV	PDR	PDI	PDSH	PDSL		PDRT	PDIT	PDT	PDY	PE	PP				PDV
Q	Quantity	QRC	QIC			QR	QI	QSH	QSL	QSHL	QRT	QIT	QT	QY	QE					QZ
R	Radiation	RRC	RIC	RC		RR	RI	RSH	RSL	RSHL	RRT	RIT	RT	RY	RE		RW			RZ
S	Speed/Frequency	SRC	SIC	SC	SCV	SR	SI	SSH	SSL	SSHL	SRT	SIT	ST	SY	SE					SV
T	Temperature	TRC	TIC	TC	TCV	TR	TI	TSH	TSL	TSHL	TRT	TIT	TT	TY	TE	TP	TW		TSE	TV
TD	Temperature, Differential	TDRC	TDIC	TDC	TDCV	TDR	TDI	TDSH	TDSL		TDRT	TDIT	TDT	TDY	TE	TP	TW			TDV
U	Multivariable					UR	UI							UY						UV
V	Vibration/Machinery Analysis					VR	VI	VSH	VSL	VSHL	VRT	VIT	VT	VY	VE					VZ
W	Weight/Force	WRC	WIC	WC	WCV	WR	WI	WSH	WSL	WSHL	WRT	WIT	WT	WY	WE					WZ
WD	Weight/Force, Differential	WDRC	WDIC	WDC	WDCV	WDR	WDI	WDSH	WDSL		WDRT	WDIT	WDT	WDY	WE					WDZ
X	Unclassified																			
Y	Event/State/Presence		YIC	YC		YR	YI	YSH	YSL				YT	YY	YE					YZ
Z	Position/Dimension	ZRC	ZIC	ZC	ZCV	ZR	ZI	ZSH	ZSL	ZSHL	ZRT	ZIT	ZT	ZY	ZE					ZV
ZD	Gauging/Deviation	ZDRC	ZDIC	ZDC	ZDCV	ZDR	ZDI	ZDSH	ZDSL		ZDRT	ZDIT	ZDT	ZDY	ZDE					ZDV

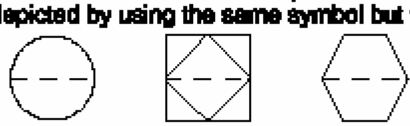
2.4.2 Instrument symbols

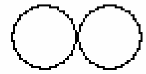
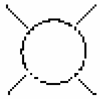
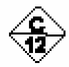
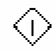
Bubbles

The ISA standard employs a simple system to identify instruments on process drawings by using "bubbles" – the terminology originating from the fact that the original symbol set used circles exclusively. The symbol set has now been expanded to account for the emergence of shared systems such as DCSs, PLCs and host software systems which all have multiple levels of functionality within one box. The system endeavors to identify the location of the instrument function (field, control room, auxiliary panel etc) and when used in conjunction with the instrument tag gives the reader of a diagram a clearer understanding of the overall control loop and strategy. The ISA bubble symbol set is shown in the attached table.



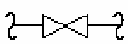
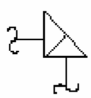
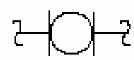
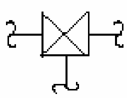
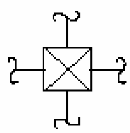
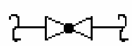
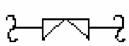
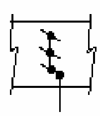
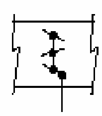
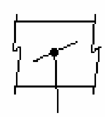
*** Normally inaccessible or behind-the-panel devices or functions may be depicted by using the same symbol but with dashed horizontal bars, i.e.

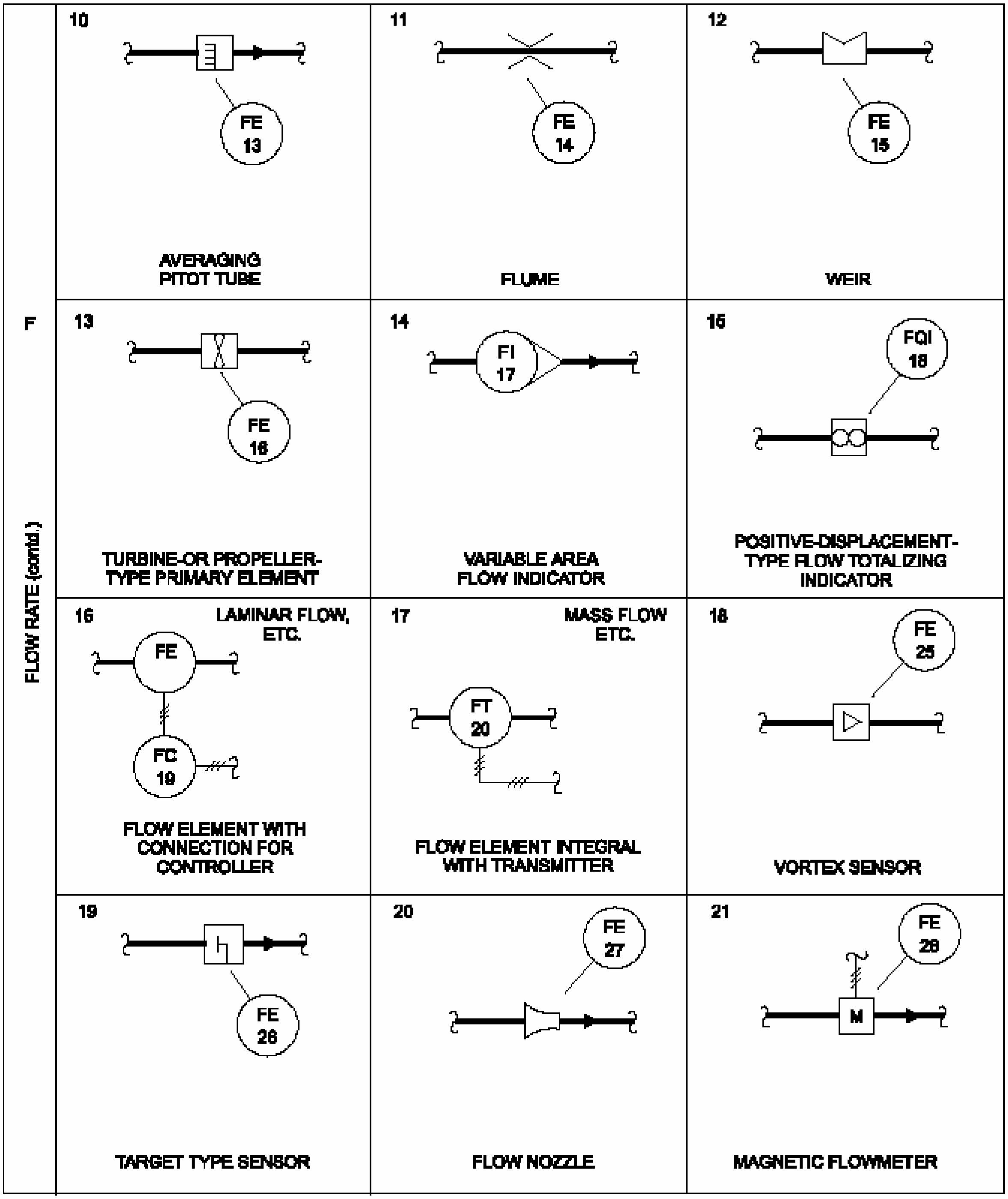


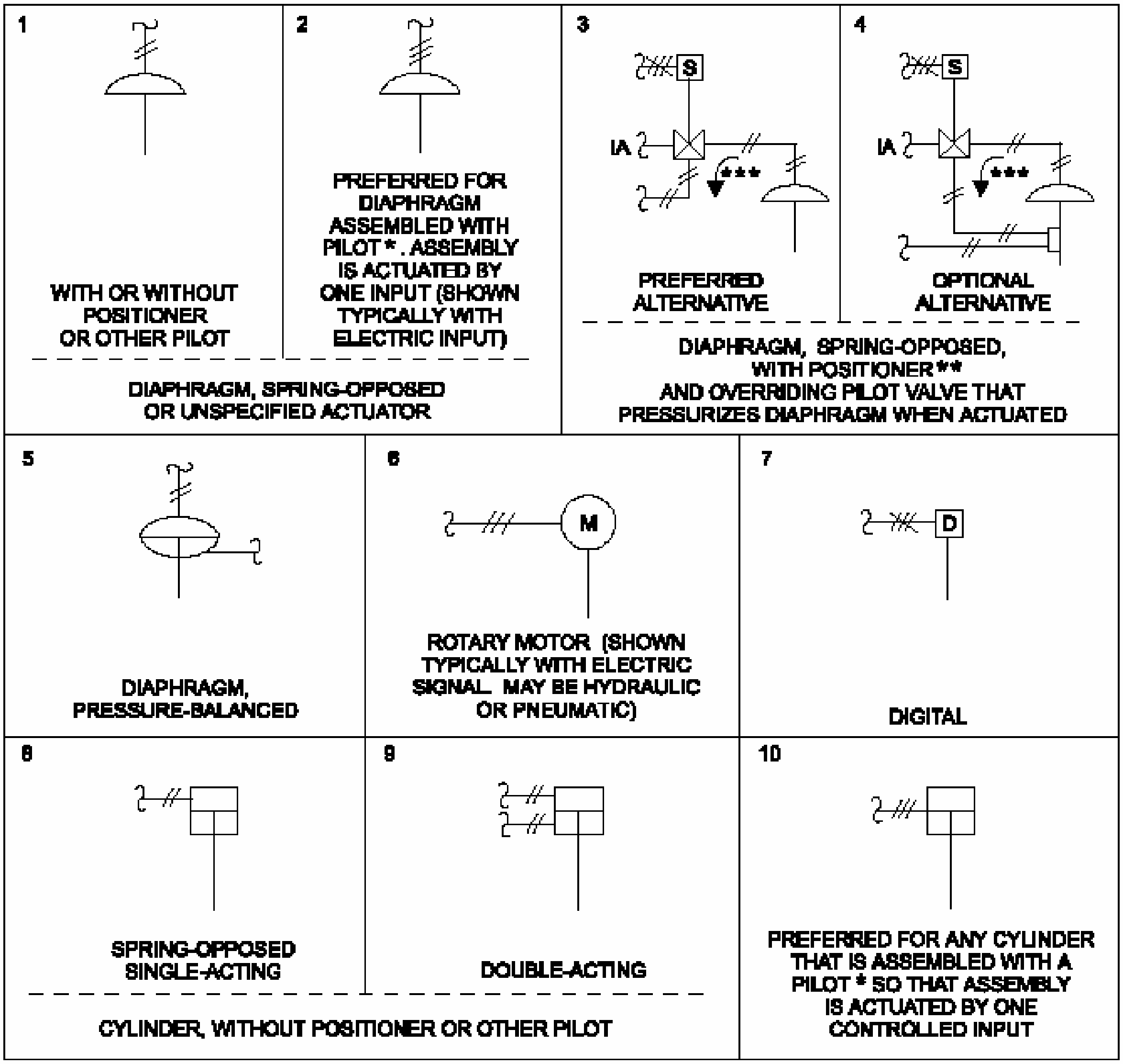
13	14  STE 2584-23 INSTRUMENT WITH LONG TAG NUMBER	15  INSTRUMENTS SHARING COMMON HOUSING *
16  PILOT LIGHT	17  C 12 PANEL MOUNTED PATCHBOARD POINT 12	18  P ** PURGE OR FLUSHING DEVICE
19  R ** RESET FOR LATCH-TYPE ACTUATOR	20  DIAPHRAGM SEAL	21  I ** *** UNDEFINED INTERLOCK LOGIC

Primary and final elements

The ISA standard recognizes that many primary and final elements cannot be fully described by a bubble and tag number alone and therefore caters to the use of a wide variety of symbols to show the technology associated with a primary or final element. An example of these symbols is shown in the tables below.

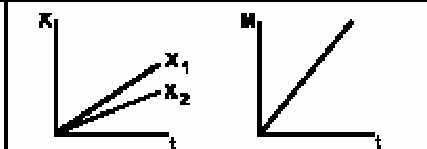
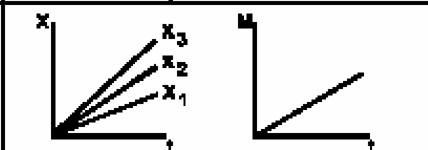
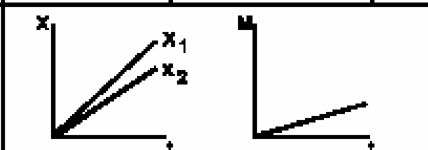
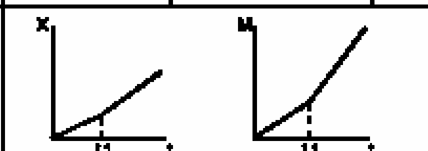
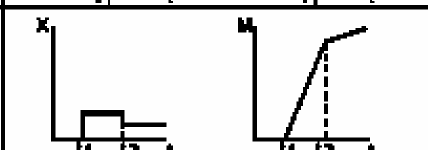
1  GENERAL SYMBOL	2  ANGLE	3  BUTTERFLY	4  ROTARY VALVE
5  THREE-WAY	6  FOUR-WAY	7  GLOBE	8
9  DIAPHRAGM	10 	11 	12 
	DAMPER OR LOUVER		


F
FLOW RATE (contd.)
10
FE 13
AVERAGING PITOT TUBE
11
FE 14
FLUME
12
FE 15
WEIR
13
FE 16
TURBINE-OR PROPELLER-TYPE PRIMARY ELEMENT
14
FI 17
VARIABLE AREA FLOW INDICATOR
15
FQI 18
POSITIVE-DISPLACEMENT-TYPE FLOW TOTALIZING INDICATOR
16
LAMINAR FLOW, ETC.
FE
FC 19
FLOW ELEMENT WITH CONNECTION FOR CONTROLLER
17
MASS FLOW ETC.
FT 20
FLOW ELEMENT INTEGRAL WITH TRANSMITTER
18
FE 25
VORTEX SENSOR
19
FE 26
TARGET TYPE SENSOR
20
FE 27
FLOW NOZZLE
21
FE 28
M
MAGNETIC FLOWMETER



Extended functionality

The ISA standard further recognizes that certain instruments may have a complex or unique functionality that cannot be full described by a tag number and bubble and to this end it allows for the inclusion of a small box/boxes outside the bubble with a symbol to identify the specific detail of the instrument. A representative table of ISA functionality legends appears below.

NO	FUNCTION	SYMBOL	MATH EQUATION	GRAPHIC REPRESENTATION	DEFINITION
1	SUMMING	Σ	$M = X_1 + X_2 + ... + X_n$		THE OUTPUT EQUALS THE ALGEBRAIC SUM OF THE INPUTS. (THE INPUTS MAY BE LABELED WITH POSITIVE OR NEGATIVE SIGNS).
2	AVERAGING	$\Sigma/_n$	$M = \frac{X_1 + X_2 + ... + X_n}{n}$		THE OUTPUT EQUALS THE ALGEBRAIC SUM OF THE INPUTS DIVIDED BY THE NUMBER OF INPUTS.
3	DIFFERENCE	Δ	$M = X_1 - X_2$		THE OUTPUT EQUALS THE ALGEBRAIC DIFFERENCE OF THE TWO INPUTS.
4	PROPORTIONAL	K 1:1 2:1	$M = KX$		THE OUTPUT IS DIRECTLY PROPORTIONAL TO THE INPUT. IN THE CASE OF A VOLUME BOOSTER, "K" MAY BE REPLACED BY 1:1 FOR INTEGER GAINS, 2:1, 3:1, ETC., MAY BE SUBSTITUTED FOR K.
5	INTEGRAL	$\int$	$M = \frac{1}{T_I} \int X dt$		THE OUTPUT VARIES IN ACCORDANCE WITH BOTH MAGNITUDE AND DURATION OF THE INPUT. THE OUTPUT IS PROPORTIONAL TO THE TIME INTEGRAL OF THE INPUT.
6	DERIVATIVE	$^d/_{dt}$	$M = T_D \frac{dX}{dt}$		THE OUTPUT IS PROPORTIONAL TO THE RATE OF CHANGE (DERIVATIVE) OF THE INPUT.

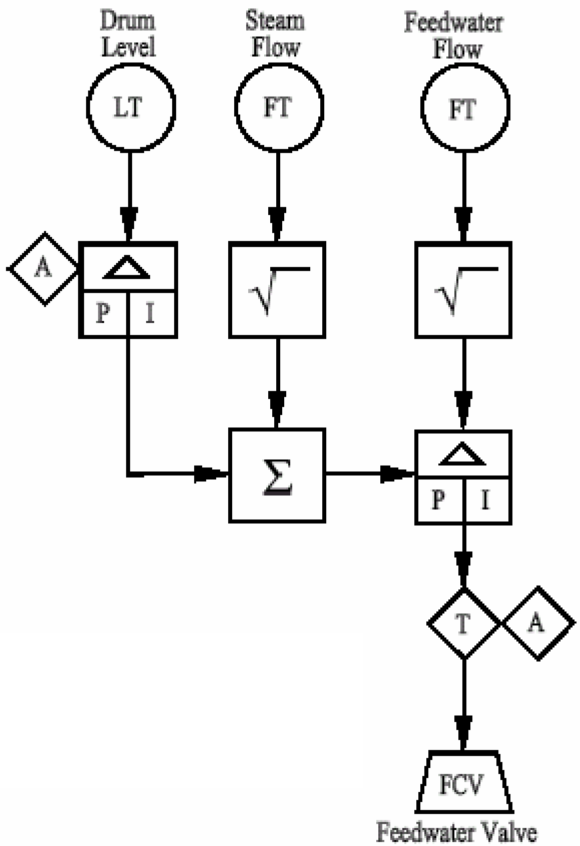
The SAMA system

The Scientific Apparatus and Manufacturers Association further expands on the ISA extended functionality system by using a range of blocks linked together to describe the functionality within a control loop. Although seldom employed these days it provides a useful tool for identifying control and measurement functions within complex loops. A table of SAMA functions and an example of the scheme are shown below.

FUNCTION	SIGNAL PROCESSING SYMBOL
Summing	Σ or $+$
Averaging	Σ / n
Difference	Δ or $-$
Proportional	K or P
Integral	$\int$ or I
Derivative	d/dt or D
Multiplying	x
Dividing	$\div$
Root Extraction	$\sqrt[n]{}$
Exponential	x^n
Non-Linear Function	f(x)
Tri-State Signal (Raise, Hold, Lower)	[illegible]
Integrate or Totalize	Q
High Selecting	>
Low Selecting	<
High Limiting	[illegible]
Low Limiting	[illegible]
Reverse Proportional	-K or -P
Velocity Limiting	V [illegible]
Bias	$\pm$
Time Function	f(t)
Variable Signal Generator	A
Transfer	T
Signal Monitor	H/, H/L, /L

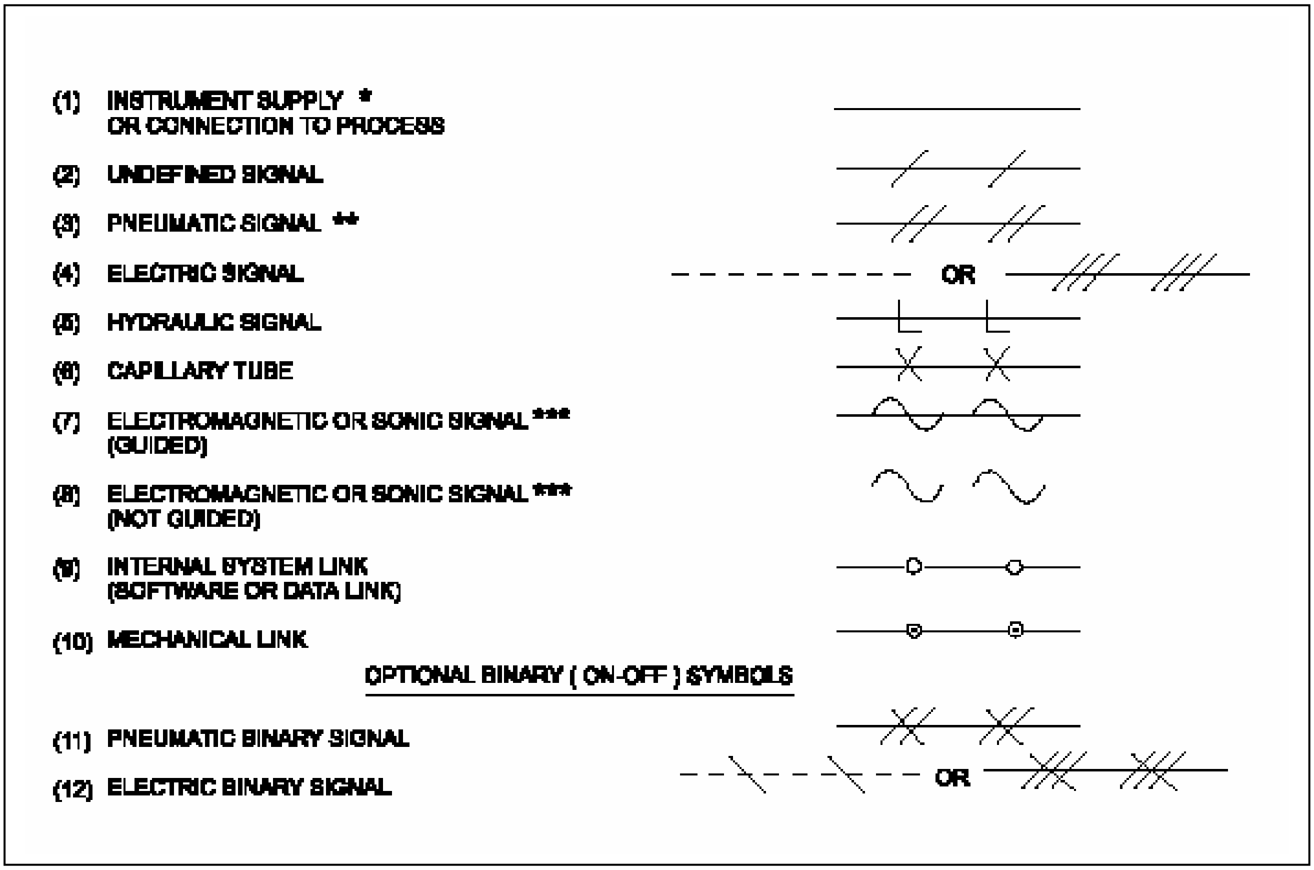
FUNCTION		SIGNAL PROCESSING SYMBOL
Logical Signal Generator		B
Logical AND		AND
Logical OR		OR
Qualified Logical OR n = an integer	> n	GTn
	< n	LTn
	= n	EQn
Logical NOT		NOT
Set Memory		S, SO
Reset Memory		R, RO
Pulse Duration		PD
Pulse Duration of the Lesser Time		LT
Time Delay on Initiation		DI or GT
Time Delay on Termination		DT
Input/ Output Signal Converter Examples: D/A I/P	Analog	A
	Digital	D
	Voltage	E
	Frequency	F
	Hydraulic	H
	Current	I
	Electromagnetic or Sonic	O
	Pneumatic	P
	Resistance	R

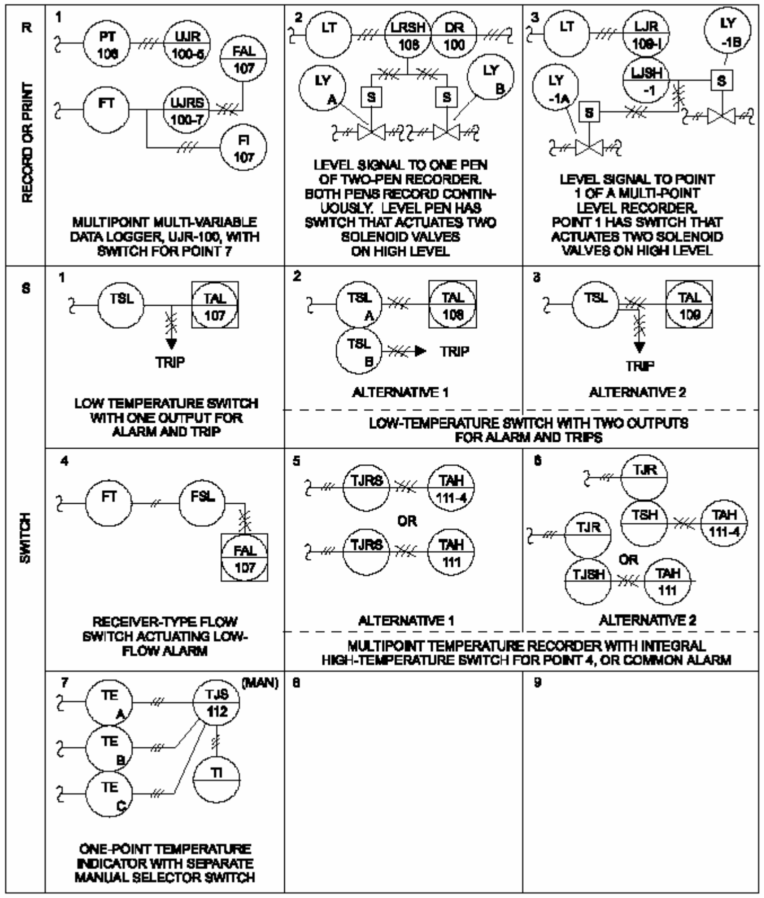
Example of a SAMA Scheme for describing the control strategy of a 3-element boiler drum level control system.



2.4.3 Instrument interconnections

The ISA standard also provides for the interconnection of bubbles to show, on process drawings, the media by which they communicate – be it pneumatic, electrical, non-contact etc. The table below lists how the bubbles are interconnected.


(1) INSTRUMENT SUPPLY *
OR CONNECTION TO PROCESS
(2) UNDEFINED SIGNAL
(3) PNEUMATIC SIGNAL **
(4) ELECTRIC SIGNAL
OR
(5) HYDRAULIC SIGNAL
(6) CAPILLARY TUBE
(7) ELECTROMAGNETIC OR SONIC SIGNAL ***
(GUIDED)
(8) ELECTROMAGNETIC OR SONIC SIGNAL ***
(NOT GUIDED)
(9) INTERNAL SYSTEM LINK
(SOFTWARE OR DATA LINK)
(10) MECHANICAL LINK
OPTIONAL BINARY (ON-OFF) SYMBOLS
(11) PNEUMATIC BINARY SIGNAL
(12) ELECTRIC BINARY SIGNAL
OR



2.5 Electrical drawings and diagrams

2.5.1 Electrical equipment numbering

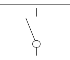
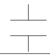
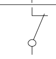
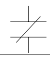
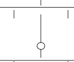
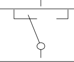
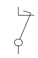
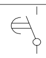
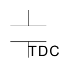
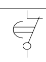
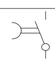
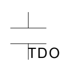
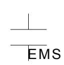
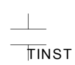
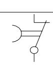
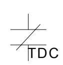
Component numbering

Components of an electrical circuit are numbered by means of a single alpha character combined with a sequential digit each time a component of a new type is used. The standards for the alpha character may vary from company to company and it is normal to draw a legend sheet to explain the use on a particular set of drawings. The attached table broadly coincides with the recommendations of the IEC Publication 27 standard for letter designations.

Letter Code	Type	Examples
A	Assemblies, subassemblies	Amplifier with transistors, magnetic amp, laser
B	Transducers, from mechanical to electrical and vice versa.	Thermo electric sensor, transducer, loudspeaker
C	Capacitors	
D	Delay / storage devices	Bi-stable, mono-stable, register
E	Miscellaneous	Lighting and heating devices
F	Protective devices	Fuse, arrestor
G	Generators, supplies	Battery, supply device
H	Signaling devices	Optical and acoustic indicators
J		
K	Relays, Contactors	
L	Inductors	Induction coil, line trap
M	Motors	
N	Amplifier, regulator	
P	Measuring / Test equipment	Indicating, recording devices
Q	Mechanical switching devices	Circuit breaker/ isolator
R	Resistors	Potentiometer, rheostat, shunt,
S	Switches, selectors	Pushbutton, limit, selector
T	Transformers	Voltage, current transformer
U	Modulators, changers	
V	Tubes, semiconductors	Diode, transistor,
W	Transmission paths, waveguides, aerials	Jumper wire, cable, busbar, dipole
X	Terminals, plugs, sockets	Socket, test-jack
Y	Electrically operated mechanical devices	Brake, clutch
Z	Terminations, hybrid transformers, filters, equalizers	

2.5.2 Single line symbols

IEC Publication 617 provides an extensive range of symbols which are used in electrical circuits. These are normally employed in both single line and electrical schematics but differ from those symbols employed in ladder logic schematics. Typical examples of the IEC symbol set are shown below.

SYMBOL	CADD	DESCRIPTION	I.E.C.
	C62	MAKE CONTACT (NORMALLY OPEN) - GENERAL SYMBOL	07-02-02
	C62A	CONTACT - NORMALLY OPEN	
	C63	BREAK CONTACT (NORMALLY CLOSED) - GENERAL SYMBOL	07-02-03
	C63A	CONTACT - NORMALLY CLOSED	
	C64	TWO WAY CONTACT WITH CENTRE - OFF POSITION	07-02-05
	C65	CHANGE OVER CONTACT	07-02-04
	C66	MAKE CONTACT (OF A MULTIPLE CONTACT ASSEMBLY) WHICH IS EARLY TO OPERATE RELATIVE TO THE OTHER CONTACTS OF THE ASSEMBLY.	07-04-01
	C67	MAKE CONTACT (OF A MULTIPLE CONTACT ASSEMBLY) WHICH IS LATE TO OPERATE RELATIVE TO THE OTHER CONTACTS OF THE ASSEMBLY.	07-04-03
	C68	TIMED CLOSE INSTANT OPEN	07-05-02
	C68A	CONTACT NORMALLY OPEN,TIME DELAY CLOSING, INSTANT OPEN.	
	C69	TIMED OPEN INSTANT CLOSE	07-05-03
	C69A	CONTACT NORMALLY CLOSED,TIME DELAY OPENING, INSTANT CLOSE.	
	C70	INSTANT CLOSED TIMED OPEN	07-05-01
	C70A	CONTACT NORMALLY OPEN INSTANT,CLOSE TIME DELAY OPENING.	
	C71	EMERGENCY STOP SWITCH (CONVEYOR TYPE)	
	C72	TIMER CONTACT NORMALLY OPEN,INSTANT CLOSE & OPENING.	
	C73	INSTANT OPEN TIMED CLOSE	07-05-05
	C73A	CONTACT NORMALLY CLOSED INSTANT,OPEN TIME DELAY CLOSING.	

2.5.3 Wire numbering system

Although there is no set standard for wire numbering of electrical circuits the generally accepted rules are to use a numeric system with 3 (or more) digits in which the number increments each time there is a break in the circuit (i.e. terminal, fuse etc).

The reader should be aware that there are individual country standards (e.g. AS3000 – Australian Wiring Rules) that govern the use of certain letters (e.g. L, A, N, E) in wire numbering systems involving potentially lethal voltages.