

CHAPTER 3

OVERVIEW THE DESIGN OF SUBSTATION PROJECT

In this chapter, the description of technical document for Substation will be discussed firstly. Then the general design process in XYZ company will be discussed next.

3.1 Description of Technical Document for Substation

3.1.1 General Project Documents

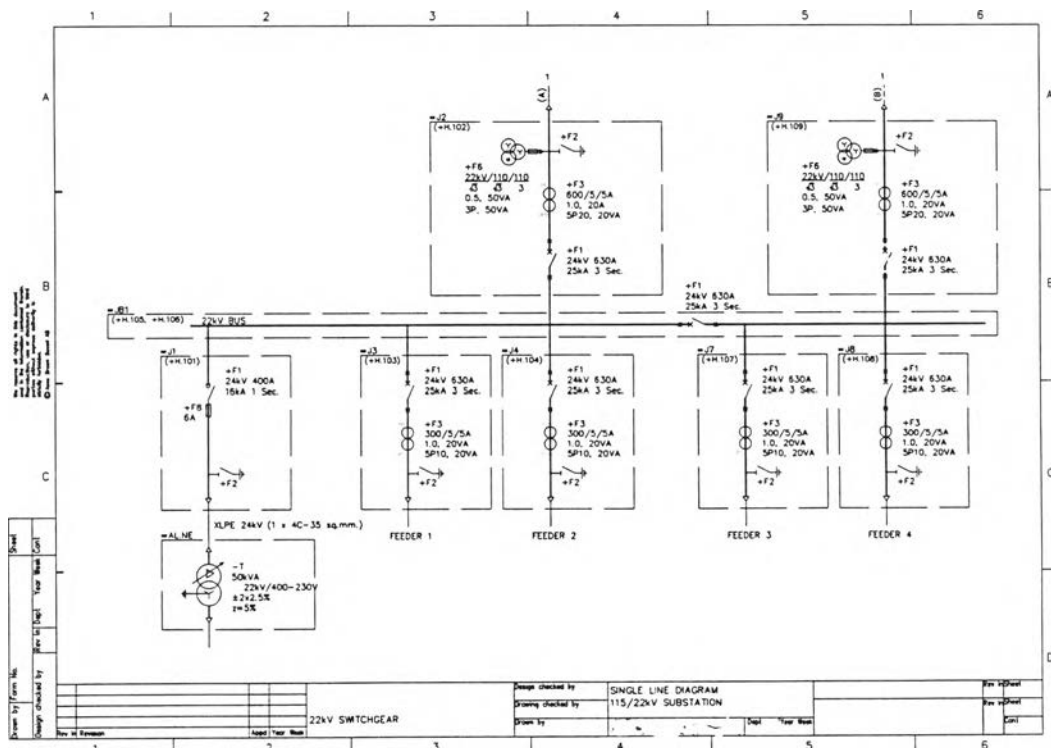
(1) Scope of Supply

The scope of supply is a very important document which contains a specification of all the equipment and material to be supplied and all work to be done according to the specific contract.

(2) Single Line Diagram

The single line diagram is made for a switchgear or for a whole substation to show the electrical configuration. The main circuits are shown in single line representation. The system is divided into functional units indicated by higher level item designations in order to show the structure of the equipment and the documentation of the delivery.

Figure 1 Single line diagram



The overview diagram mainly contains:

- Symbols with item designations and legend of symbols
- General electrical data and designations of all High Volt apparatus and busbars
- CT and VT data such as ratio, class, burden and location of cores
- Border of delivery.

(3) Site Plan

The Site Plan is an overview document showing location of buildings, roads and switchyard arrangements related to coordinates.

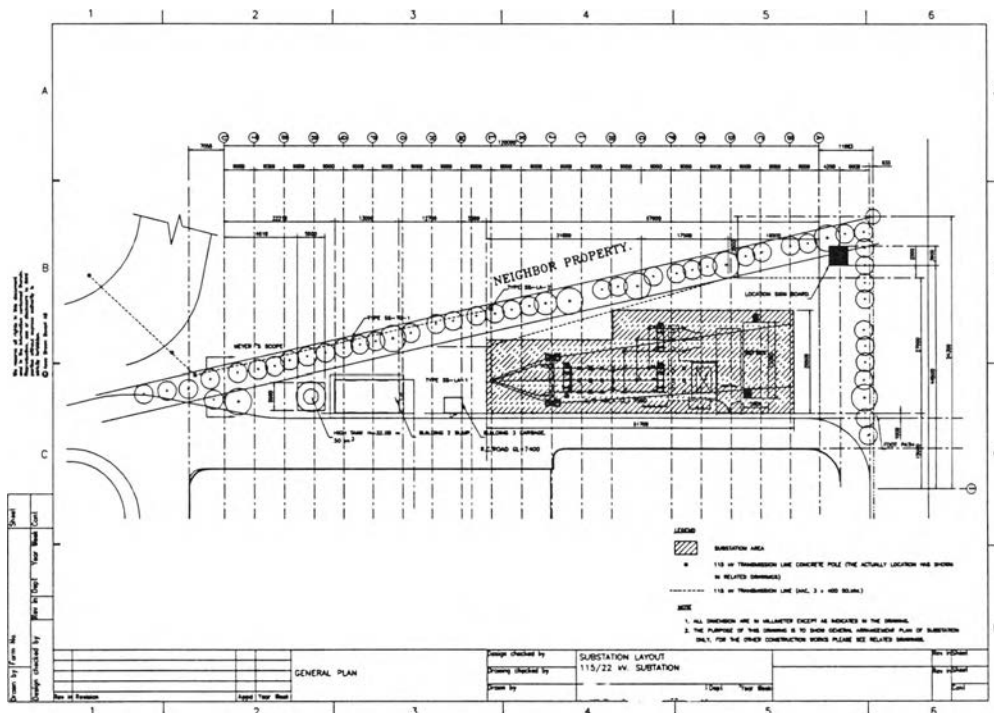
(4) Project Time Schedule

The project time schedule covering the complete project period. Important steps of design, manufacturing, testing, delivery, etc., are shown for all equipment included in the project.

(5) Operation and Maintenance Manual (OMM)

The OMM is a set of files including descriptions of the supplied equipment and instructions of how to erect, test and use the equipment.

Figure 2 Site layout plan drawing



3.1.2 The Primary Circuit Design

Air Insulated Switchgears

(1) Switchyard Data

The switchyard Data sheet gives all applicable electrical and mechanical data as well as related standards for the switchyard. All calculations related to the switchyard will be based on the data given in this document.

Example of typical switchyard data is as below:

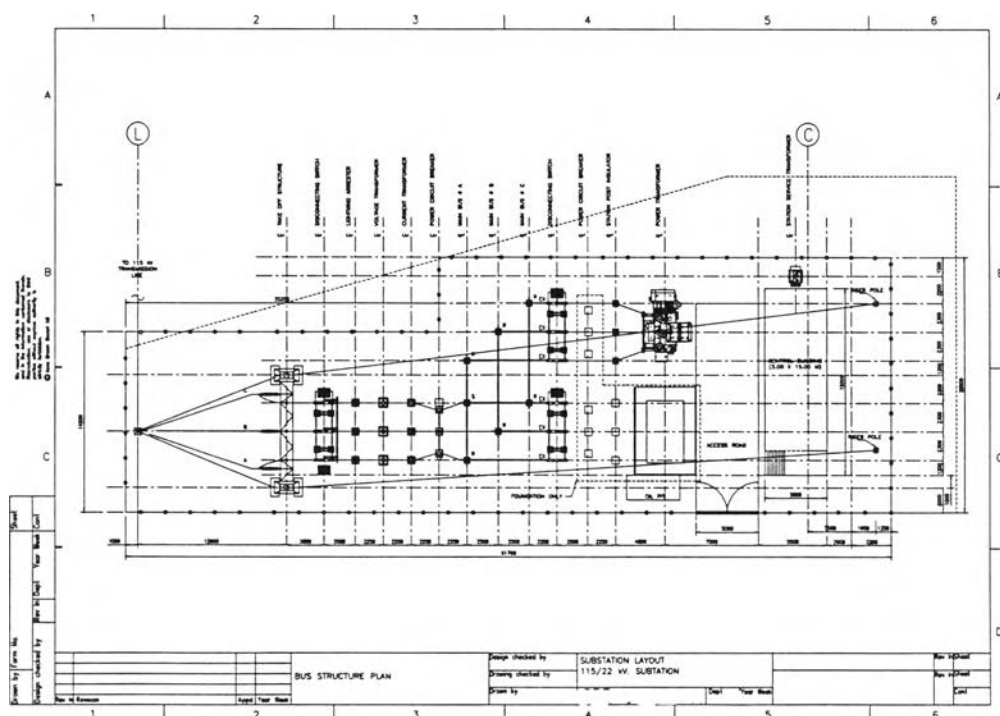
- Rated electrical values
- Maximum ambient and conductor temperatures
- Section area of conductors
- Maximum tension of incoming lines
- Environmental data

(2) Switchyard Layout and Switchyard Section Drawing

The switchyard layout drawing shows the switchyard in a top view and gives the main dimensions of the switchyard. The layout is built up by section drawings for each bay.

The switchyard section drawing shows the different bays from both top and side view. All apparatuses, transformers and other equipment, etc. are shown with their dimensions.

Figure 3 Switchyard Layout drawing



(3) Parts List of High Voltage Equipment

The parts list specify all HV equipment. The equipment is identified by item designations with references to the switchyard section drawing and relevant dimension drawings.

The parts list may also be a summary of HV equipment including type definition, main data and number of units of each type.

(4) Steel Structure Design Principles

The steel structure design principles give the principle on which the steel structure design and calculations are based.

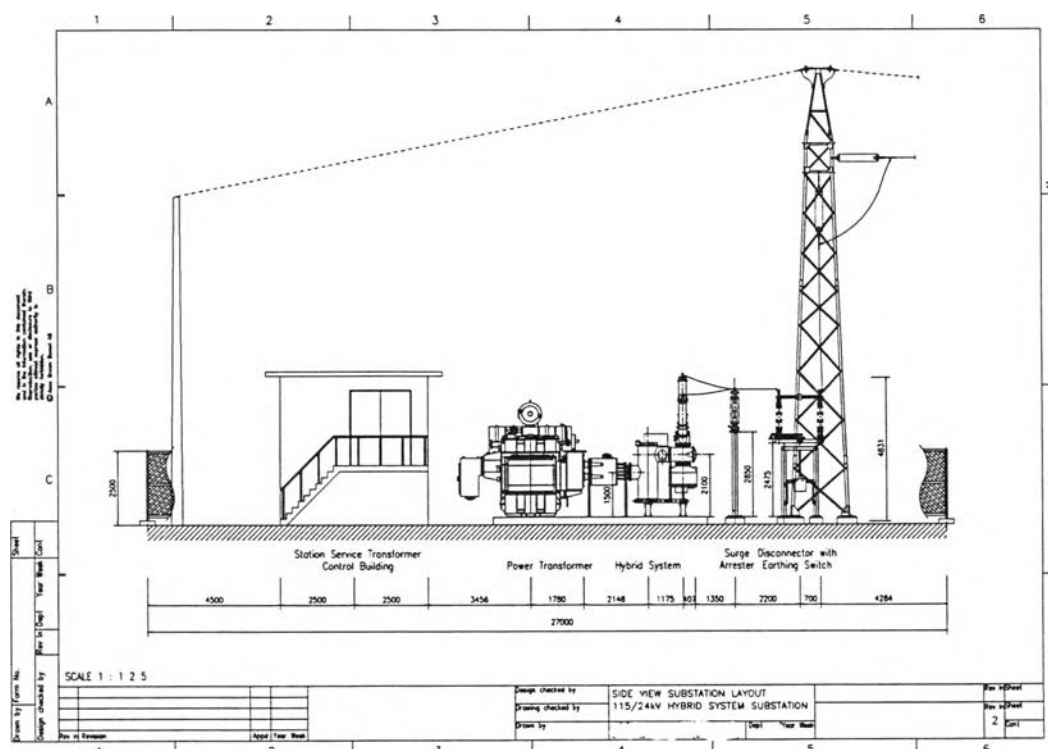
Typical information is below;

- Load combinations
- References to relevant standards
- Summary of conductor forces

(5) Foundation Plan and Duct Plan

The foundation and duct plan shows the locations of foundations and cable ducts. The drawing is the direct result of the switchyard layout, and is prepared after the final verification of the switchyard design. The purpose of the document is to bring the necessary information to the civil design. The drawing is also used for all cable length calculations of switchyard cables.

Figure 4 Switchyard section drawing



(6) Foundation Loadings

The document includes view, section figures and a table of loadings. The foundation loading table shows the reaction forces, from the structure, acting on the top of different foundations. The figures show the foundation top geometry with quantity and location of foundation bolts.

This drawing serves as information for civil design and is the direct result of the foundation load calculation

(7) Sag & Tension Chart

The sag and tension chart gives the sag and pulls for different temperatures, presented in a table form, for all spans included in the switchyard. The maximum force, which serves as an input to the steel calculation, is also presented.

The sag & tension chart is the result of the sag and tension calculation.

(8) Dimension Prints of Switchyard Material

Dimension prints of relevant switchyard material give the necessary dimensions for the detailed design. Reference is made to the list of material.

Typical materials are below;

- Insulators
- Connection clamps
- Earthing material
- Conductors

(9) Assembly Drawings for Steel Structures

The assembly drawings show the steel structure design for the different support and gantries. References are made to a material list which is usable at time of erection. The assembly drawings and lists of material are the direct result of the steel design calculation, which on the other hand is based on the steel structure design principles.

(10) Earthing Plan and Earthing Drawings

The earthing plan shows the extent and arrangement of the earthing grid. Earthing drawings show the details around the earthing installation, e.g. location and dimensions of earthing terminals, references to list of material and general installation instructions.

(11) List of Switchyard Material

All switchyard material is listed. Lists may be specified for different groups of switchyard material as earthing, conductors, clamps, etc. References are made both to dimension prints and section drawings.

The lists are intended to be used for erection but may be useful also for maintenance and reconstruction.

High Voltage Apparatus

(1) Technical Data Sheet

The main technical data for each apparatus will be given in the technical data sheet such as below:

- Rated voltage and rated current
- Rated breaking capacity and short circuit withstand voltage
- Insulation strength
- Breaking and closing times
- Type of operating mechanism
- Standards
- Test records and other reference documents

(2) Dimension Drawing

The dimension drawing gives all necessary dimensions of the apparatus including details and information of below:

- Operating mechanism including cable inlets
- Supporting structure
- Terminals including maximum terminal loads
- Static loads and dynamic loads at operation and earth fault.

(3) Rating Plate Drawing

The rating plate drawing shows the layout of the rating plate including the technical data which will be included. Information about size and material of the plate is also included.

The rating plate drawing is often used for final acceptance of specified data.

(4) Magnetisation Curve Print of Current Transformer

The current transformer magnetisation curves include detailed technical data for each core together with the graphical representation of the magnetisation curve.

This drawing is often used for verification of specified classification and factory test results.

(5) Functional Description

Operation instruction and description of functionality of the supplied units. The document may also include apparatus list, spare parts list and sketches or pictures showing the construction of product. The Functional description is an important part of the Operation and Maintenance Manual.

Gas Insulated Switchgears

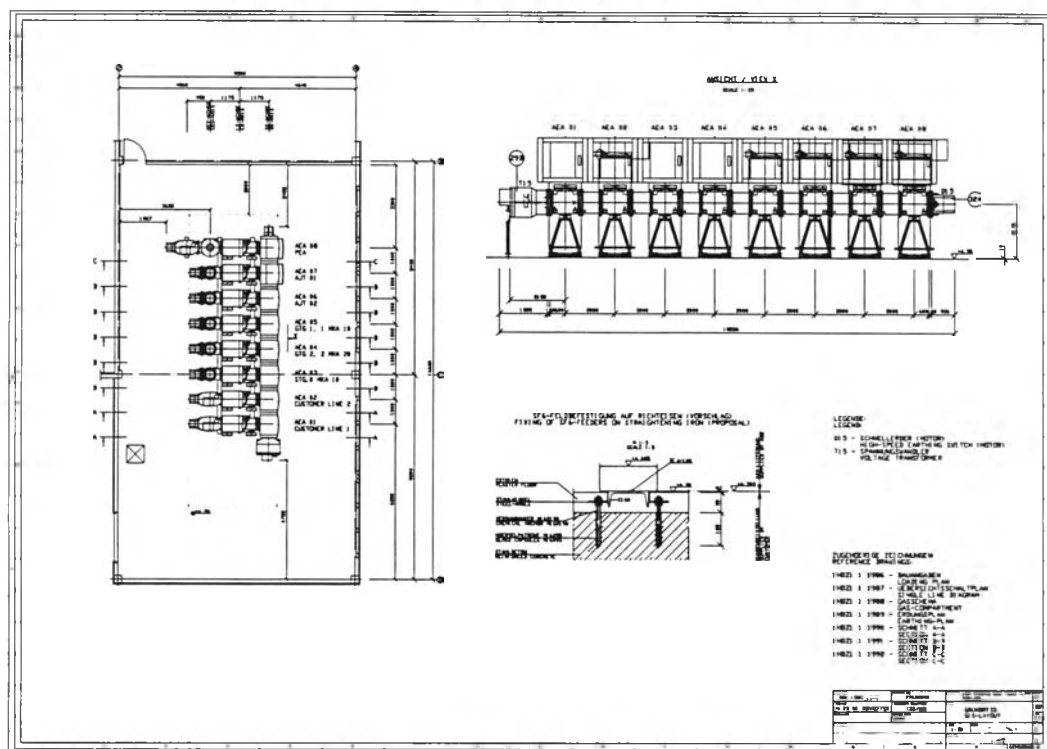
(1) Layout Drawing

The layout drawing shows the complete switchgear in both plan and sections. Main dimensions are given and the location of the switchgear inside the switchgear room is also indicated. Feeder names, apparatuses as well as phase arrangement are shown and identified.

(2) Earthing Plan

The earthing plan shows the earthing connection points of the switchgear together with details of the earthing installation. Included will also be details of cable end earthing and earth connection of the local control panel.

Figure 5 GIS layout drawing



(3) Instruction for Civil Design

The document provides information for civil design are as below;

- Loadings at different locations of the floor
- Details of the fixing to the floor
- Height and capacity of possible crane
- Requirements of floor

(4) Gas Schematic Diagram

The gas schematic drawing shows in single line representation each gas room of the switchgear including the location and type of gas density guards.

Information of filling pressure/density and response value for the density guards are also included in the diagram.

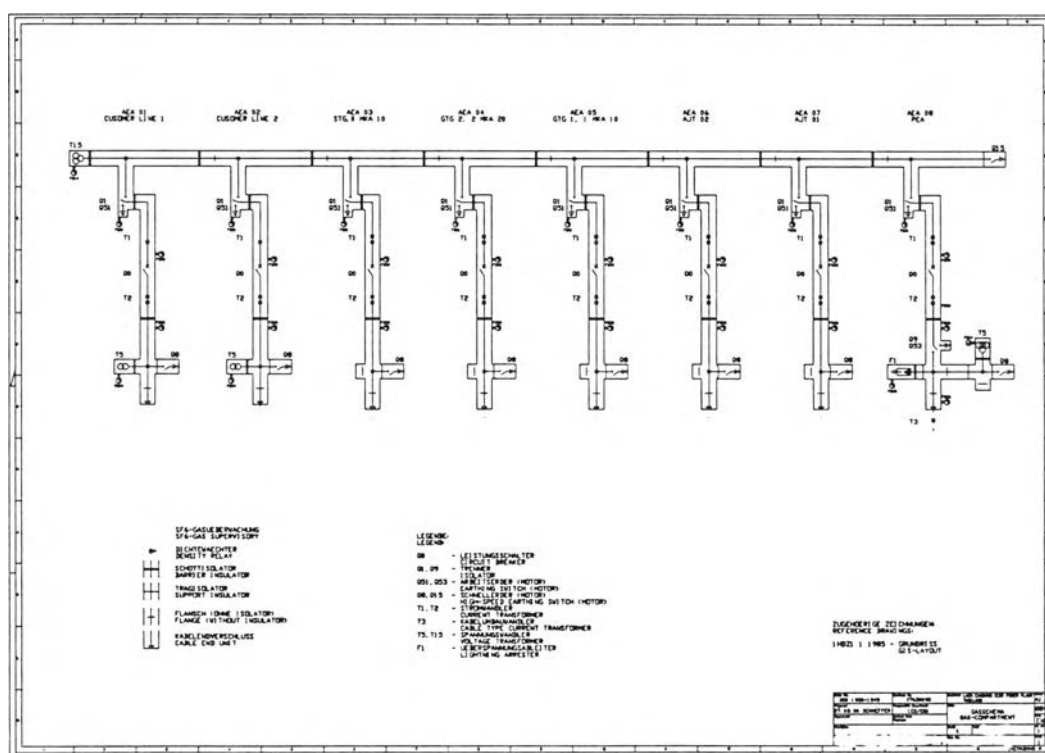
(5) Magnetisation Curve Print of Current Transformer

The current transformer magnetisation curves include detailed technical data for each core together with the magnetisation curve.

(6) Functional Description

Operation instruction and description of functionality. The document may also include spare parts list and sketches or pictures showing the HV apparatus and operating mechanism. The Functional description is an important part of the Operation and Maintenance Manual.

Figure 6 GIS gas Schematic Diagram



Power Transformers and Reactors

(1) Outline Drawing and Detail Dimension Drawings

The outline drawing shows the assembled transformer including radiators, bushings, conservator and cable boxes in both top and side views. Main dimensions and position numbers for included parts are indicated in the drawing. Jacking point, tolerances for SF₆ connections and lifting view are also shown in the drawing.

The dimension drawing are the detailed drawings of the main components of the transformer/reactor. e.g. bushings, cable boxes, radiators, control cabinets, valves, Buchholz relays, temperature indicators, etc.

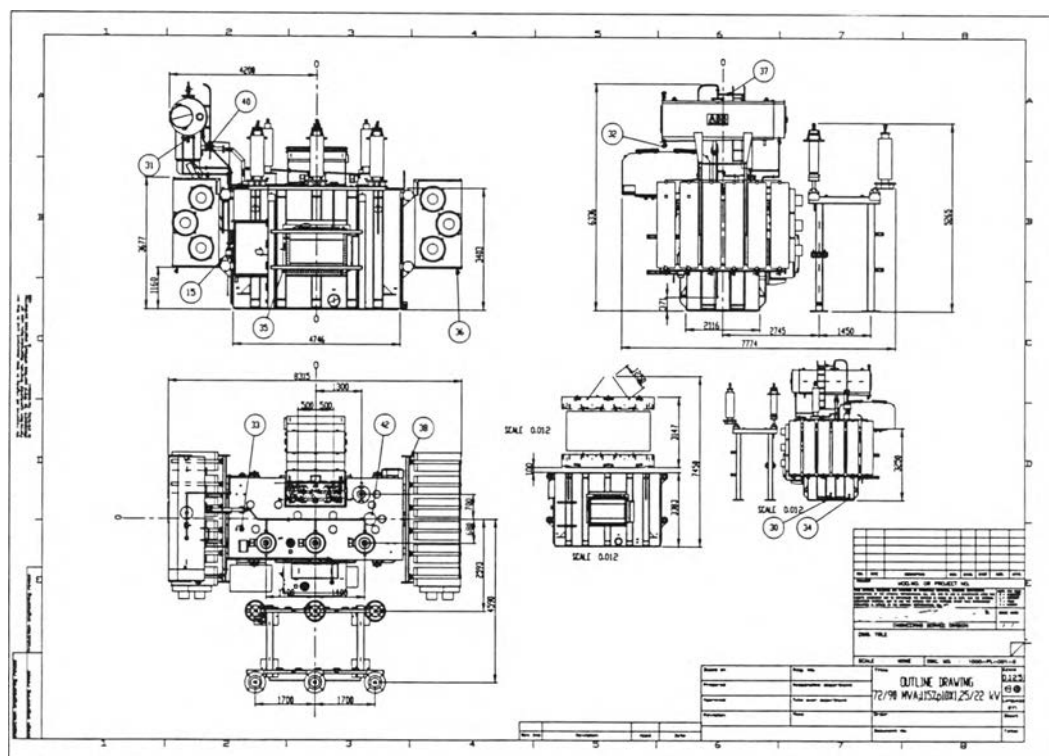
(2) List of Components

The list of components is a specification of all components included with position numbers for reference to the outline drawing.

(3) Rating Plate Drawings

The rating plate drawing shows the layout of the rating plate including the technical data which will be included. Information about size and material of the plate is included.

Figure 7 Transformer Outline Drawing



(4) Painting Information

The painting information gives a detailed description of the corrosion protection and painting of a transformer or reactor.

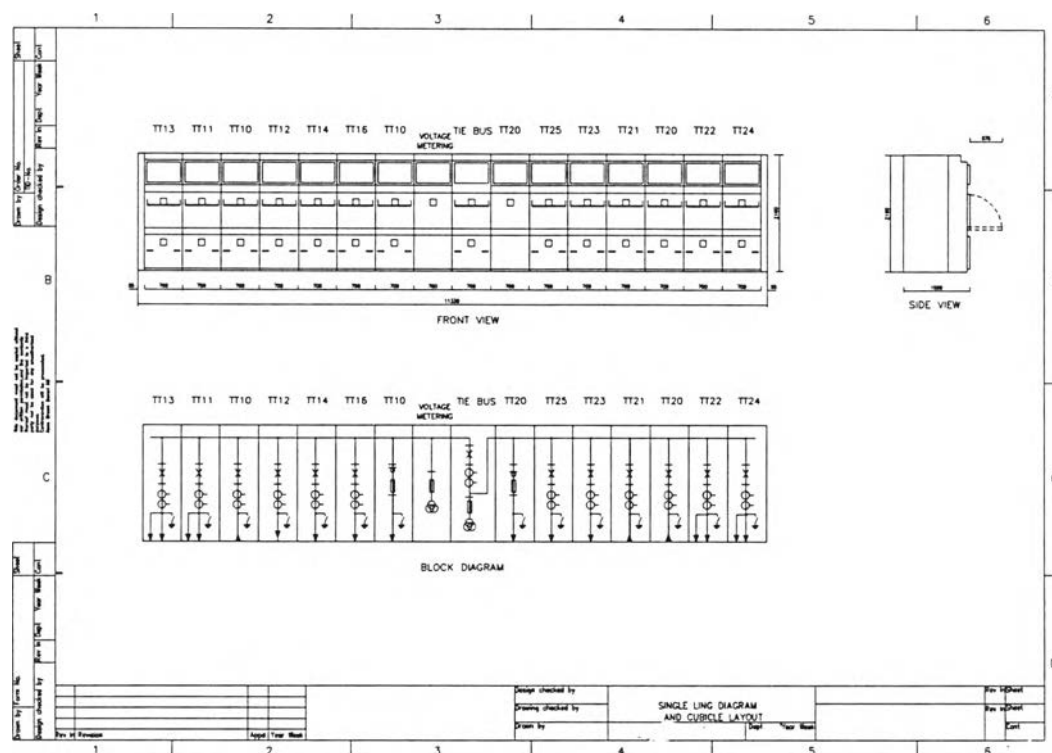
Medium Voltage Switchgear

(1) Technical Data Sheet

The main technical data for the switchgear will be given in the technical data sheet such as below;

- Rated voltage and current
- Rated breaking capacity and short circuit withstand voltage
- Insulation strength
- Breaking and closing times
- Type of operating mechanism
- Standards
- Test records and reference documents.

Figure 8 Single line and dimension Drawing



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(2) Installation Drawing

The installation drawing includes the following;

- Front layout of the complete switchgear
- Foundation plan including requirements for floor openings
- Overview diagram of Medium Voltage circuits including busbar arrangement.

(3) Dimension Drawings

The dimension drawings are the detailed drawings of the main components of the switchgear, e.g. typical bays, circuit breakers, etc.

Cables and Cable Work**(1) Technical Data HV Power Cables and LV Power and Control Cables**

Technical data of cables is normally described in two documents;

- Technical Data HV Power Cables and
- Technical Data LV Power and Control Cables.

These documents include cable data as;

- Type / designation
- Conductor size
- Material in conductor (HV cable)
- Number of cores
- Type of insulation
- Type of screen (control cable)

(2) Information for Civil Design

The information for civil design is mainly made for indoor equipment, but data for outdoor cable trenches will also be included. The information includes drawings of cable arrangements in cable ducts and cable basement as well as necessary dimension and erection drawings. Cross references are made to switchyard layout, foundation plan, etc.

(3) Cable Laying Drawing Power Cables and Erection Drawing Cable Ladders

The cable laying drawing of power cables shows installation and connection of cables with consideration to the calculations made. Cross references, in form of item numbers, to list of material and other drawings are also given.

The erection drawing of cable ladders shows the installation of cable ladders both outdoor and indoor. Cross reference is made to list of material and switchyard layout.

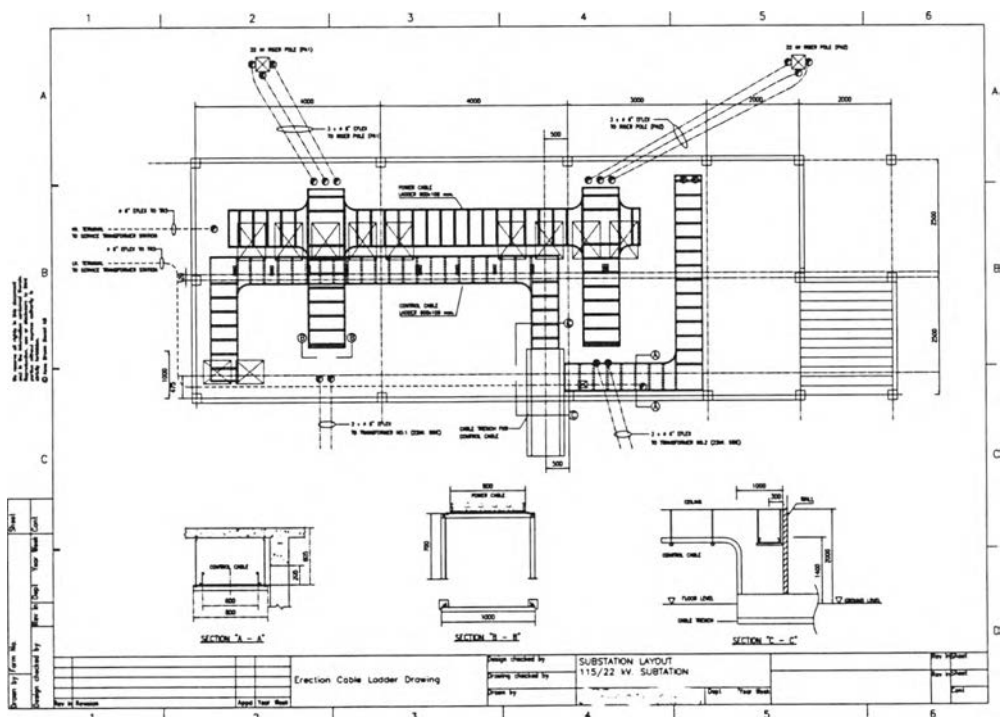
Above drawing types, intended for erection purpose, may be divided into different drawings depending on the extent of plant and buildings.

(4) List of Material, Cables

List of material is made for the relevant group of material, such as HV cables, indoor earthing equipment, cable ladders, LV power and control cables, etc. Listed for all material are:

- Type and data
- Quantity
- Reference to purchase order
- Reference to erection drawings.

Figure 9 Erection Drawing Cable Ladders



3.1.3 Secondary Circuit Design

(1) Block Diagram

The block diagrams show the principles for protection and supervision of the HV equipment in a typical switchgear bay. All circuits are shown in single line representation. The diagram may be divided into diagrams for protection and diagram for measuring and metering. Data is normally shown in separate list documents called "Surveys".

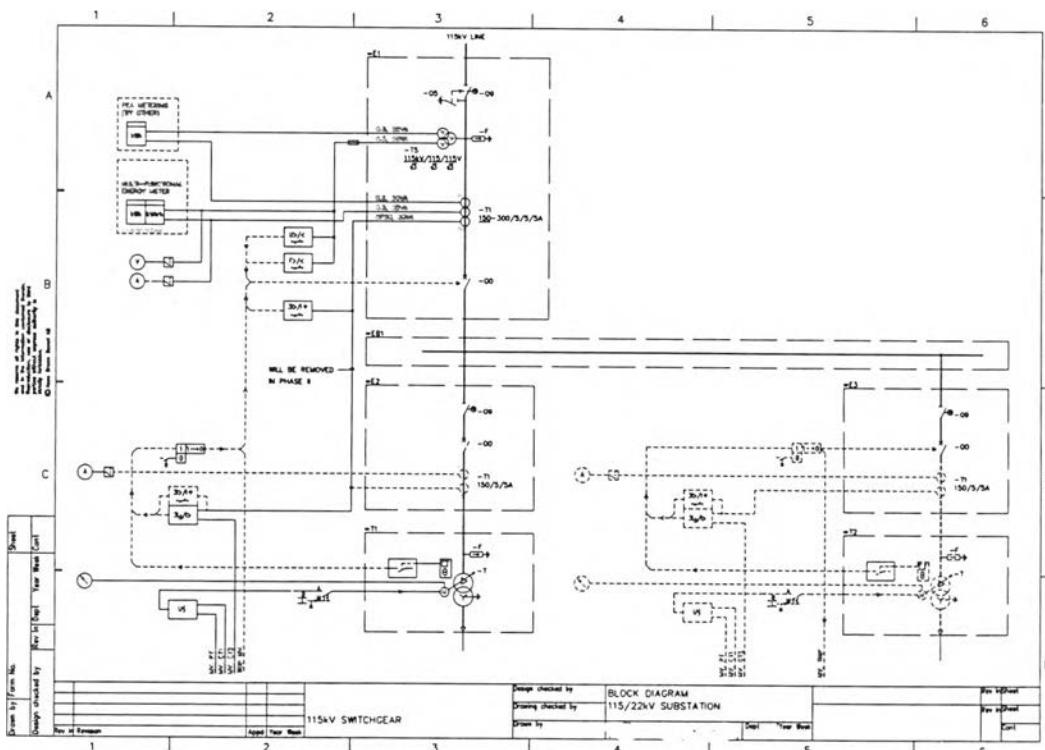
The block diagram includes main circuits, measuring circuits and trip circuits in typical feeders. The arrangement of measuring circuits indicates:

- Connection to core
- Type of measuring equipment or protective relay
- Connection order of units (CT circuit)
- Type of fuse/MCB (VT circuit)

Trip and auto reclose circuits are indicated by signal connection lines and operating units.

The survey includes general data of CT/VT's, protective relays and metering equipment. In a second step the survey can be extended with settings of protective relays and other measuring units.

Figure 10 Block diagram



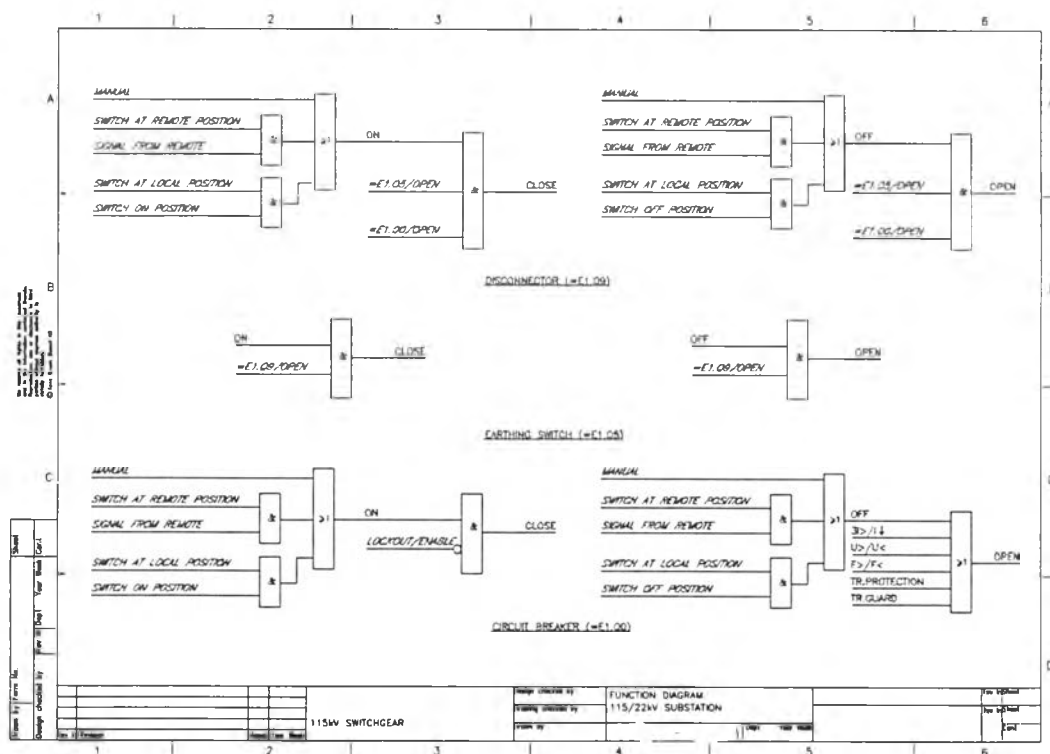
(2) Function Diagram

The function diagram show the principles of a general function in the substation. The function is represented in "block diagram" or "logic diagram" form.

Typical functions shown by Function diagrams are:

- Synchronizing and interlocking systems
- Interlocking system
- Alarm system
- Tap changer control and voltage regulating systems
- LVAC power supply system
- Battery and DC-distribution systems.

Figure 11 Function diagram



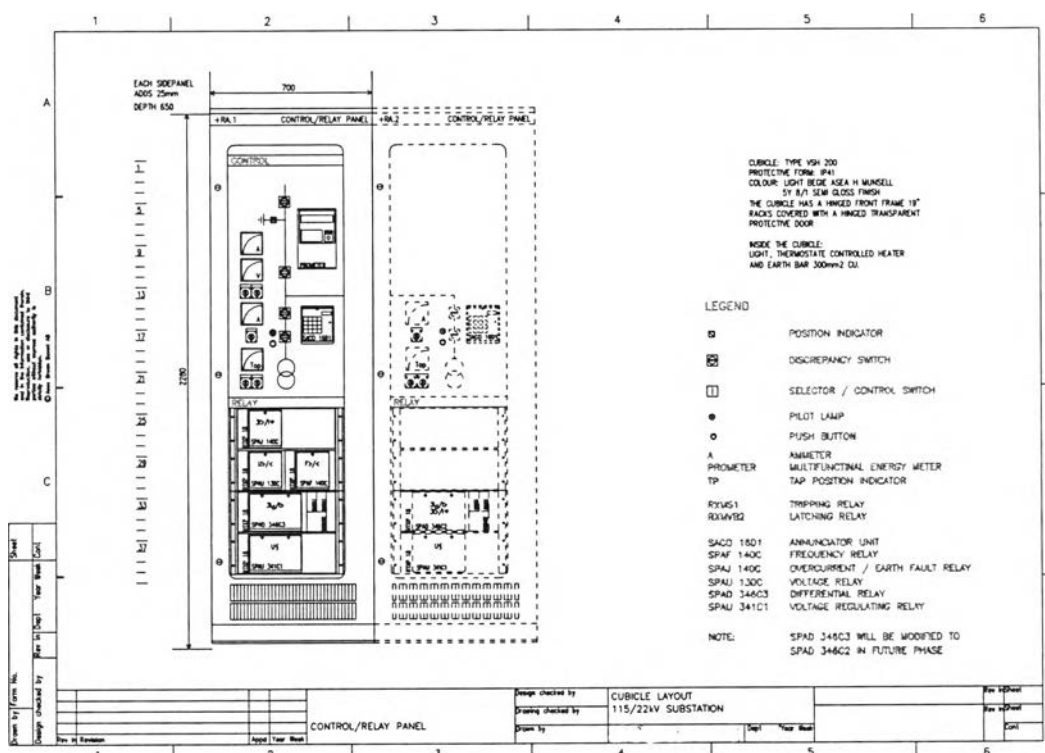
(3) Panel Front View

The panel front layout drawing shows the front of the complete panel board in order to indicate the position of apparatus and the arrangements and dimensions of the panel. More detailed drawings of panels may be used for manufacturing. These drawings should include true measures of apparatus and locations, etc. Manufacturing of panels and boxes can also be made according to standardized product design using product defined drawings.

The panel front view mainly contains:

- Position of apparatus and labels at the front panel
- Item designation of cubicles and bays
- Front and top view with sizes of the panel board.

Figure 12 Panel Front View



(4) Circuit diagram

The plant circuit diagram shows the electrical function of all equipment and all interconnections / signals in a function oriented way. The diagram is an aid for maintenance and fault finding in the substation.

If a product is represented by a simplified picture in the plant circuit diagram, reference should be made to an equipment circuit diagram. The equipment circuit diagram show the function and internal connection of a single product.

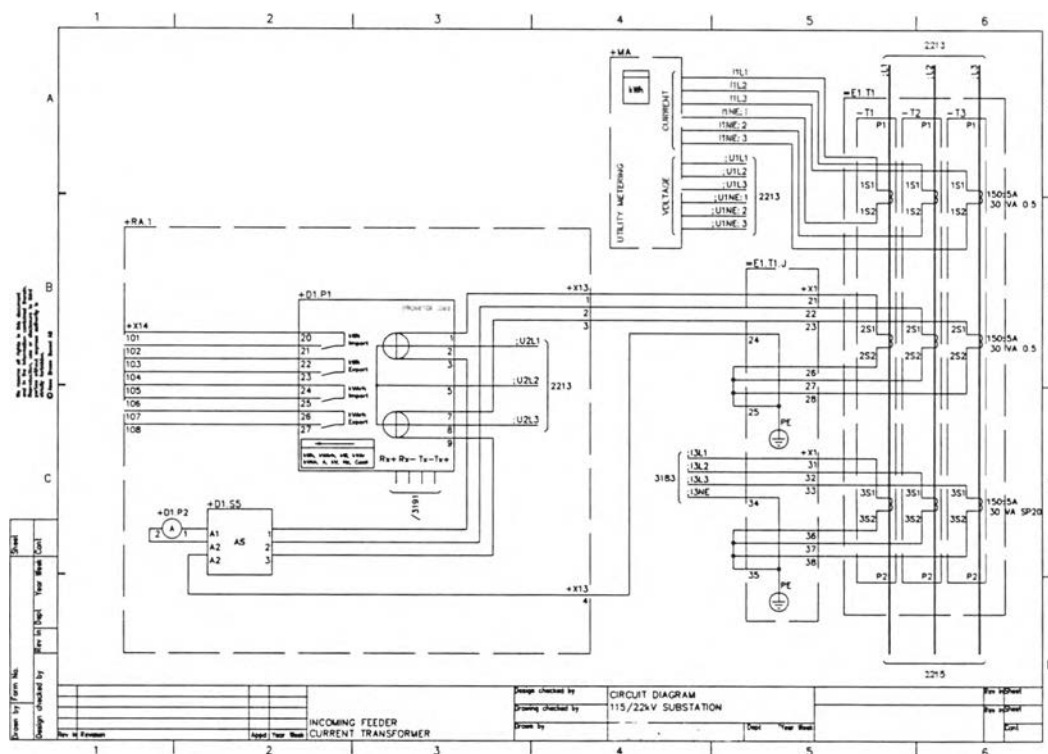
Functions of the delivered equipment and their relationship to other equipment are explained by :

- Symbols and item designations according to standards
- Identification of circuits and interconnections between units
- Reference of circuits between sheets and to other circuit diagrams
- Explanation of circuits / functions and identification of interface points.

The Plant circuit diagram is mostly represented by a set of diagrams, one per each bay in the HV switchgear. A common list of contents and a set of diagrams for the general functions in the substation will be included. References of connections between the diagrams are included in each diagram.

The circuit diagram is a basic document for all connections of cables and wires as well as configuration of signal / alarms in the substation.

Figure 13 Circuit diagram



(5) List of Apparatus

The list of apparatus gives an overview of all electrical apparatus used in a unit. It can also be used for ordering of spare part

The list of apparatus mainly contains:

- Item designation, location and other references of apparatus
- Description and technical data
- Manufacture identity and ordering number

(6) List of Cables / Cable Connection Schedule

The list of cables and cable connection schedule are needed for ordering and erection of cables and accessories. The documents are also intended for fault-finding in the substation.

List of cables mainly contains:

- Type of cable with number of cores and cross section, etc.
- Cable designation (number)
- Connection of equipment (From-to)

Cable connection schedule mainly contains:

- Identification of core (number, color, designation, etc.)
- Item designation of connection points of cores in a list.

(7) List of Signals / List of Alarms

The list of signals or alarms is used for approval of the content and text of alarms, inputs to recorders or interface to supervisory. It is also an information for design of alarm system and connections in circuit diagram.

Signal lists contain:

- Typical signals per feeder and general signals in the substation
- Signal names or alarm text
- Type and designation of signal (e.g. measuring, event, alarm, etc.)

(8) List of Typical Labels / List of Labels

The list of typical labels is intended to survey the labels and texts which will be used on the equipment. Based on the typical list, a complete list of labels is produced for each assembly. These lists also includes instructions for manufacturing and mounting of all labels.

The list of labels contains:

- Type and size of labels
- Text on labels
- Location of labels

(9) Technical Data Sheet and Outline Drawing (of purchased equipment)

Important equipment is normally described in technical data sheets, including rated main technical data for the unit, and the outline drawing shows the assembled unit. References may also be made to standards, test records and other reference documents.

3.2 The General Design Process of Substation Project

As discussed in the previous chapter about the general substation. The design work for substation can be mainly divided into two type of design function as the primary circuit design (mechanical design) and secondary circuit design (Control and relay protection design).

3.2.1 Primary circuit design

The primary circuit design means the design activities for Switchyard & Substation Layout such as single line diagram, indoor and outdoor layout, grounding system, steel structure, cable routing ,lighting system ,identification sign and all necessities design to complete the works according to the specification and scope of works.

The primary circuit design can be divided into two main groups as the outdoor and indoor switchyard design.

I. Outdoor Switchyard Design

The outdoor substation is called "Conventional substation", or "Air insulated Switchgear (AIS) " which their components such circuit breaker, current transformer, disconnecting switch and etc. will be installed in open area. This type of substation use more area in order to keep the clearance between their equipment for safety purpose. So the main task of outdoor switchyard design is to layout the equipment according to the safety clearance based on the standard, prepare the installation drawing for erection of all equipment, estimate hardware and their accessories and etc.

The procedure and estimated time schedule of process design of Outdoor Switchyard Design are as below;

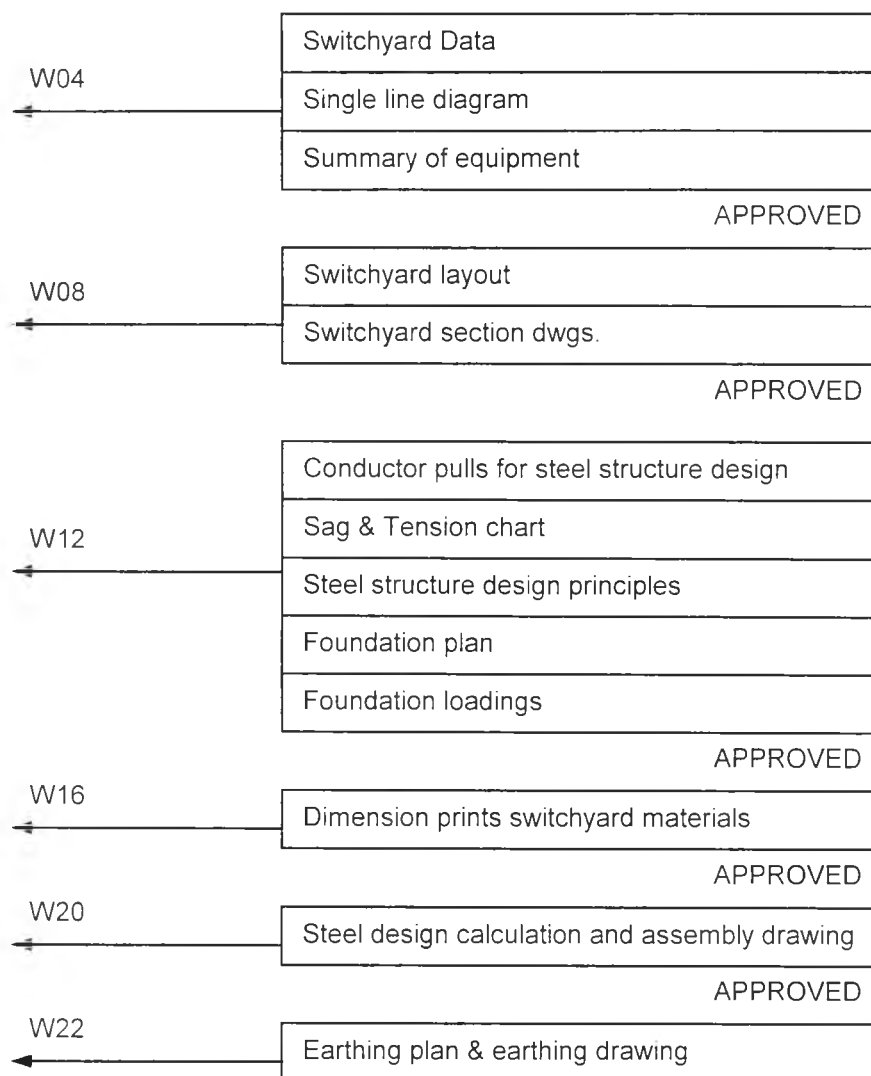


Figure 3.14 Design process sequence for a practical and logical method of working (Outdoor switchyard design)

II. Indoor Switchyard Design

The indoor substation is called "Gas insulated switchgear (GIS)" which their components such as circuit breaker, current transformer, disconnecting switch and etc. will be installed in gas compartments and mounted together as the same equipment . So this type of substation use less

area than the conventional type and normally installed in building. The main task of indoor switchyard design is to layout this equipment with necessaries tools such as overhead crane, grounding system and etc. into the building. This includes other equipment such relay and control boards, battery and battery charger, power and control cable ladders and etc.

The procedure and estimated time schedule of process design of indoor Switchyard Design are as below;

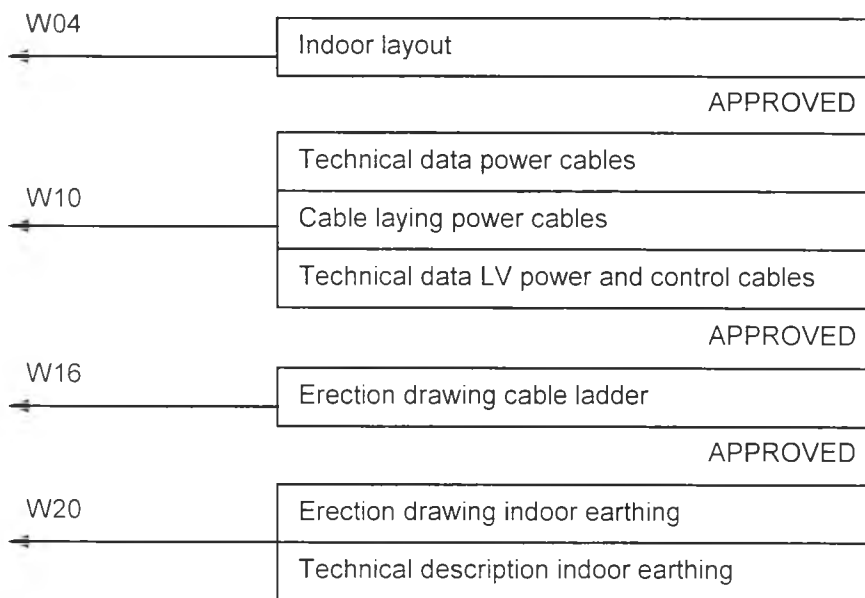


Figure 3.15 Design process sequence for a practical and logical method of working (Indoor switchyard design)

3.2.2 Secondary circuit design

The secondary circuit design means the design activities for Control and Relay protection such as system diagram, blocks diagram, function diagram, Panel front layout and all necessaries design to complete the works according to the specification and scope of works.

The main task of secondary circuit design is to design the control and protection system for correcting the operation process and protecting the system when abnormal condition occurred during operation period.

The procedure and estimated time schedule of process design of Secondary Design are as below:

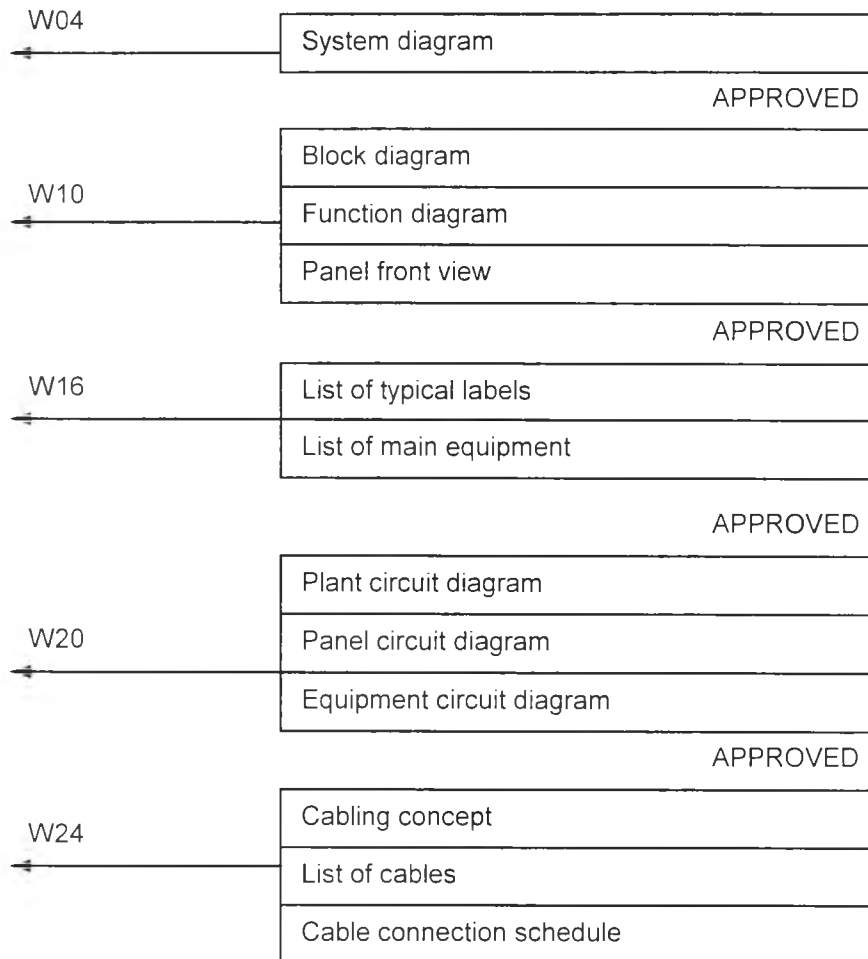


Figure 3.16 Design process sequence for a practical and logical method of working (Secondary circuit design)