Central Arizona Project

CAWCD Design & Submittal Guidelines Manual

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Acronyms and Abbreviations

CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CO	Contracting Officer
DC	Design Consultant

1.0 GENERAL

1.1 Background

The Central Arizona Project (CAP), owned and constructed by the United States Bureau of Reclamation, is a 336-mile long system of aqueducts, tunnels, pumping plants, and pipelines that carry water across Arizona. Designed to bring 1.5 million acre-feet of Colorado River water per year to Pima, Pinal and Maricopa Counties. CAP is the largest single renewable water resource in the state.

In 1971, the Central Arizona Water Conservation District (CAWCD) was created to not only provide a means for Arizona to repay the federal government for the reimbursable costs of construction, but to also assume the responsibility for the care, operation, maintenance and management of the system.

Engineering Services Department exists to support the operation, maintenance, repair, and replacement of CAP's infrastructure and physical assets and consists of internal professional, administrative, and technical staff members. Engineering Services is also responsible for managing all external engineering design consults, their various scopes of work, and deliverables, and ensures that CAP benefits from the expertise and capacity that private consultants provide. In order to more effectively meet the needs of CAP, Engineering uses professional services contracts to partner with consultants for capital project development, engineering studies, and technical assessments. This manual will help to ensure that communication, expectations, and work process between internal staff and external consultants align together to effectively support the mission of the Central Arizona Project.

1.2 Purpose

This Design Guidelines Manual is intended to prescribe standard procedures and instructions to complete the required design, drawings, specifications, project preliminary report, design analysis, cost estimates and related support tasks to capital improvements and modifications. This manual is written for the purpose of assisting external design consultants with a consistent logical approach to performing design and developing design related documents. The manual describes the process to develop fully detailed 100% complete design drawings and fully edited specifications for use in a variety of construction contract delivery methods.

1.3 CAWCD Expectations

The Design Consultant (DC) is expected to provide project specific execution criteria in conformance with the published 'Scope of Professional Engineering Design Services' (Scope of Work) developed for individual projects.

The DC is expected to furnish sufficient technical, supervisory and administrative personnel to ensure satisfactory completion of the work specified in the Scope of Work including meeting the agreed upon milestone dates and progress schedule.

1.3.1 Design Consultant Actions Prior to notice to proceed:

1. The DC will submit a proposal detailing anticipated costs to complete the work described in Scope of Work.

2. The DC will typically submit a project design schedule including significant milestones such as review submittals and deliverable dates. The schedule provided will demonstrate project completion within the time specified in Scope of Work. Typical CAP review of submittals is two (2) weeks.

1.3.2 Design Consultant Actions during Design Execution (Notice to Proceed issued)

1. Update progress schedule. An updated progress schedule will be submitted on a monthly basis unless otherwise defined in Scope of Work.

2. The DC will use those individuals designated in their proposal. Any changes to personnel will require immediate CAP notification in writing.

3. During the course of design execution, the DC will maintain a 'Key Decision/Needs' list and submit the list to CAP at a predetermined frequency until all open issues are resolved. The list will also be included in each formal submittal. The list will be an itemized list of design data required by the DC to advance the design. This list will be maintained on a continuous basis with completed action items identified and new items added as required. Items in the list will include a sequence number, description, name of individual or agency responsible for completion and remarks.

4. Site investigations must be sufficiently thorough to ensure that design details are compatible with project site. Necessary visits to the project site to obtain accurate 'as-built' information and coordinate the design with the existing facility, validating 'as-built' conditions on the existing drawings provided by CAWCD is the responsibility of the DC.

1.4 Applicable Publications

1.4.1 Adopted Codes

CAP has adopted the following Codes:

Code Titles*
NEC (NFPA 70)
N.E.S.C. - National Electrical Safety Code (IEEE C2-2012)
IFC (International Fire Code)
IPC (International Plumbing Code)
IMC (International Mechanical Code)
IBC (International Building Code)

NFPA 101 Life Safety Code

ANSI/ASME B31.1 Power Piping

ANSI/ASME B31.3 Process Piping

AWS D1.1 - Structural Welding Code - Steel

*CAP will provide adopted edition (year) during the design kickoff meeting

1.4.2 CADD Standards

The DC drawings shall conform to the CADD Standards Manual (latest release). The latest release of CADD Standards Manual will be made available during the design kickoff meeting.

Some key points in the CADD Standards Manual:

- No drawings or drawing numbers to be created by DC, contact CAP for missing/need drawings
- No additional layers to be created by DC, contact CAP for missing info
- No models to be created by DC, contact CAP for missing info
- Create Construction notes in paper-space
- CAP to provide existing design sheets with a X (new design) and a D (demo) sheet
- CAP Arial is the only font acceptable
- CAP colors is a print protocol, DC is not to change colors per layer

Submit all Drawings as Vault.zip file and a single combined PDF file.

1.4.3 Surveying Standards

Consultation with CAP's Lands and Survey division will be required to identify survey standards and expectations. Lands and Survey will provide project by project support and/or requirements as needed.

1.5 Submittal Requirements

The following sections describe general requirements for submittals listed in the Scope of Work. These submittals may include all or part of the following:

- Design Report
- Drawings
- Specifications.

Each subsequent design submission will not be accepted unless all items from previous design review have been fully addressed.

The term 'fully addressed' in this context means that each review comment or directive on drawings or specifications has been individually recognized and demonstrably attended to. This is typically done by means of a CAP standard comment tracking spreadsheet and should be readily recognizable in the documents affected.

Additional requirements are located in discipline specific chapters of this manual.

1.5.1 Preliminary Design (30%)

This submittal represents approximately 30% of the design effort and will contain enough detail to show how CAP's functional and technical requirements will be met. Additionally the level of detail will indicate the DC's approach to the solution of technical problems, show compliance with design criteria and provide a valid estimate of cost. The Preliminary Design could, depending on scope of work, consist of:

1. Design Analysis:
    a. Design narrative and calculations for all disciplines
    b. Any required permitting memorandums
2. Specification Table of Contents – select CAP standard specifications from specifications checklist. Preliminarily identify what new or custom specifications will be required for this design.
3. Preliminary Drawings
4. Preliminary Bidding Schedule
5. Preliminary Cost Estimate
6. Any component of a system that is proposed to be provided on a proprietary, single-source, or sole-sourced basis, to be reviewed by CAP. DC will provide all required justification and documentation
7. Value engineering suggestions, with recommendations including life cycle costs to determine approaches of best value

1.5.2 Interim Design (60%)

This submittal, if required, could consist of:

1. Design Analysis developed to approximately 60% complete
2. Approximately 60% complete drawings, including cover sheet with index of drawings for all disciplines.
3. Detailed cost estimate developed to approximately 60%
4. Complete and edited specifications for applicable sections along with an updated table of contents
5. Annotated review comments on Comment Tracking Spreadsheet from previous submittal
6. Completed permit applications (as applicable)
7. Value engineering suggestions
8. Proposed Phasing Plan and anticipated Project Construction Schedule

1.5.3 Final Design (100% Un-reviewed)

This submittal represents a 100% complete design with the exception of the incorporation of any review comments resulting from the review of the submittal. This may require additional review time for management review. The Final Design could consist of:

1. Design Analysis with all items 100% complete. It will include all backup material previously submitted and revised, as necessary, all design calculations, and all explanatory material giving the design rationale for any design decisions which would not be obvious to an engineer reviewing the Final drawings and specifications
2. 100% complete (unsealed) drawings. Specific for each discipline, as applicable; an updated list of the drawings, general notes, abbreviations, legends, key notes, key plans, column lines, north arrow, and coordinated backgrounds.
3. Specifications. Final edited specifications.
4. Bid schedule and an explanation of Bid Items.
5. Detailed 100% complete cost estimate

6. Annotated review comments on Comment Tracking Spreadsheet from previous submittal
7. The final design submittal stage, the DC will make a plan-in-hand site inspection to ensure that the final design accurately reflects existing conditions.

1.5.4 Ready-To-Advertise (Reviewed 100%)

This submittal represents the complete design (Design Analysis, Drawings and Specifications) including annotated review comments from previous submittal. Drawings and Specifications shall be sealed by a professional engineer.

1.6 Design Report

The Design Report may include the following major sections, and all sections specified in the Scope of Work shall be included in each identified submittal to be considered fully addressed. A bookmarked combined pdf of the required information in the Design Report shall be included with each submittal. Potential Sections are:

- Design Analysis
- Design Calculations
- Studies
- Comment Tracking Sheet
- Cost Estimate
- Sole-Source Narrative
- Key Decision List
- Schedule
- Quality Management
- Storm Water Management

1.6.1 Design Analysis

The design analysis is a written explanation of the projects design and is expanded and revised for each submission. The design analysis will contain a summary of the criteria for design and design calculations (written or computer generated), assumptions and design sketches or diagrams to illustrate preliminary designs.

1.6.2 Design Calculations

The design calculations are separate attachments relative to the discipline of work, may include calculations and reports done by third parties.

1.6.3 Studies

The design studies are separate attachments relative to the discipline of work, may include reports done by third parties.

1.6.4 Comment Tracking

A document of all questions made by the design team, and all comments made by CAP during reviews with updated annotations by DC of answers implemented in the project for each submission. Comment Tracking document with each submittal in a format that is editable by both CAP and DC.

1.6.5 Cost Estimate

To provide guidance to those professionals preparing cost estimates whom have contracted with CAP.
Unless otherwise specified in design-contract documents, the DC must design the project so that construction costs will not exceed the funding limitations. The DC should take all reasonable means to accomplish this requirement. If construction costs are expected to exceed allowable funding the DC shall propose alternatives (Value-Engineering) to be presented to CAP for approval. Cost Estimates will be calculated (choose 1 or 2 – not both):

1. In accordance with AACE by a Certified Cost Professional (CCP). Estimates should follow AACE Cost Estimate Classification System for expected accuracy range methodology and end usage. When providing an estimate for each phase of work, expected accuracy is shown below.

AACE Class of Estimate	Accuracy Range		Submittal Phase
	Low	High	
Class 4	-15% to -30%	+20% to +50%	**Preliminary / 30%**
Class 3	-10% to -20%	+10% to +30%	**Interim / 60%**
Class 2	- 5% to -15%	+ 5% to +20%	**Final (Un-reviewed)/ 100%**

2. As an Engineer's Estimate in each Submittal Phase with +/- 20% accuracy.

CAP utilizes the pre-defined specification sections established by the Construction Specification Institutes (CSI). When formatting the cost estimate it is important to organize cost based upon this organizational method, by Division and Section number.
Direct costs are those costs which can be attributed to a single task of construction work, labor, material and equipment, or subcontracted costs. It is important to account for CAP requirements for a designated safety representative and an onsite full-time superintendent in direct cost.
Indirect costs are those costs which cannot be attributed to a single task of construction work. These costs include overhead, profit, and bond. Indirect costs are also referred to as distributed costs therefore, use 20% of Direct Cost to account for indirect cost.
Contingencies are an integral part of the total estimated costs of a project and cover costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties concerning project scope. Contingencies should be listed separately, and magnitude (or percentage of direct cost) be listed.
Allowable contingencies for each cost estimate submittal are shown below:

Estimate Submittal	Contingency	
	Site and Design	Construction
Preliminary	10%	20%
Interim	7%	15%
Final Design	5%	10%
Ready-to-advertise	0%	10%

1.6.6 Sole-Source Narrative

A narrative of sole-source equipment requirements, with progression of ideas, costs, and implementation in the project with subsequent submittals. If the proposed system is to be provided on a proprietary, single-source or sole-source basis, review the requirements with the Owner and submit the required justification and documentation.

1.6.7 Key Decision List

A list of key decisions made by the design team with progression of decisions implementation in the project with subsequent submittals.

1.6.8 Schedule

A Gantt chart including a Description, Early Start, Early Finish, Predecessors, and Logic path clearly identified including all Milestone dates listed in the Scope of Work in the contract.

1.6.9 Quality Management

A Quality Control Plan (QCP) is required for all projects. The DC is responsible for developing and implementing the QCP and performing a Quality Assurance (QA) review on their products prior to submission. The QCP will be prepared as follows:

1. Within 10 calendar days after NTP the DC will submit for approval the firm's QCP. The QCP will maintain a quality-control program which will assure that all services, designs, drawings and specifications required are performed in a manner that meets professional engineering quality standards. As a minimum, the QCP will mandate that all submittal documents be reviewed by competent reviewers. Errors and deficiencies in the design documents shall be corrected prior to submittal. The QCP will include the names and contact information for each senior design engineer responsible for review.
2. The QCP will be implemented by the assigned person with the DC's organization who has the responsibility of being present during the times work is in progress. This person will have verifiable engineering design experience and is a registered professional engineer. The QCP will identify the name of the individual to fulfill this role and an alternative person assigned to the position.
3. If required by SOW or requested, The DC will submit with each submission a letter certifying that the quality control check has been performed, name of the participants and provide a copy of all comments and marked drawings generated by its own QC check/review. Failure to do so may be cause to reject the submittal.
4. When required in the Scope of Work, the DC will hold a formal QC check/review prior to submittal. The DC will notify the CAP at least three (3) calendar days prior to holding this formal QC check/review so that CAP personnel may participate.

1.6.10 Storm Water Management

A narrative of the **Stormwater** impacts, including methods of erosion and sediment control. DC to provide SWPPP (Storm Water Pollution Prevention Plan) as needed.

1.7 Drawings

Drawings required at each design will be complete and thoroughly checked by following the DC's approved QCP and verified for conformance with CAP CADD standards and criteria. Comments on CADD conformance will be provided and require addressing by DC. Generally, and sometimes required by Scope of Work, prior to first submittal an onsite consultation with CAP Drawing Services and DC occur with representative drawings from the proposed submittal

for a pre-submittal review. This process has been found effective at resolving DC CADD submittal issues early in the project lifecycle.
Submit Drawings as Vault.zip file (see CADD Standards) and a single PDF combined file.

1.8 Specifications

CAP is developing its own standard specifications to be used for projects. In general, the format follows the standard CSI format, but in addition to construction specifications, CAP also utilizes a series of “Material Specifications” for products and materials that are frequently utilized. During the design kickoff meeting, CAP will deliver the available standard specifications to the DC. Any other specifications required for the project will be created by the DC and follow the format and numbering of CSI specifications. It is the intent of CAP that the specifications be modified for each specific project.

2.0 Architectural

This section includes descriptions of additional requirements to various phases of design beyond those described in Section 1.5. The Scope of Work documents will identify the project specific design requirements.

2.1 Architectural Preliminary Design Requirements (30%)

2.1.1 Preliminary Design Drawings

Drawings to include, as applicable:

1. Life safety plans for each level of the building clearly delineating exiting, egress, fire separation and enclosure requirements, fire ratings of building structural elements and other building construction required to be fire rated including floor and roof construction, occupancy type, and area and number of occupants in each habitable or occupiable room. Indicate the maximum travel distance and path of travel for each primary and/or incidental occupancy shown. Show all applicable or planned areas of refuge, smoke compartments, horizontal exits, vertical exits, exit passageways, exit loads and capacities, and units of egress. Show any temporary means of egress and protection to be utilized during the construction activities.
2. Location Plan showing the project location at a minimum scale of 1" = 100'.
3. Floor Plans (1/8" = 1' scale minimum, unless otherwise approved) – shall include all required spaces, doors, windows, stairs, square footage, planned occupancies, elevators, exits, and major items of fixed equipment, and illustrating reasonable compatibility with routings of mechanical and electrical services. Provide overall dimensions and dimensions of major components.
4. Roof plan(s) indicating the approximate location of all equipment and accessories. Show roof drainage system and roof slopes.
5. Rendering or 3D model of building depicting overall look (if required)

2.2 Architectural Interim Design Requirements (60%)

2.2.1 Interim Design Drawings

Drawings to include, as applicable:

1. Updated and developed drawings provided at 30% submission.
2. Physical samples of fabric, flooring, wall coverings and color pallet
3. Floor plan(s) indicating the following: dimensions, structural grid system, building cores, stairs, elevators, internal partitions, doors, windows, floor slab and level elevations, built-in furniture items, partition types, door and room numbers, toilet fixtures, keyed detail areas, sections, and elevations.
4. Roof plan(s) indicating locations of all mechanical equipment, hatches, skylights, keyed details, slope, and drainage areas.
5. Building sections (1/8" scale minimum) shall include major cuts in all required directions for all structures with basic vertical dimensions.
6. Building elevations indicating all materials, features and dimensions at 1/8" scale minimum.
7. Large scale plans (1/4" scale minimum) of key areas such as lobbies, toilet facilities, public spaces, casework, elevators (including cab finishes, hoistway dimensions and door openings) and stairs.
8. Interior elevations of key areas such as lobbies, and toilet facilities.

9. Reflected ceiling plans indicating ceiling type, soffit, height, mechanical, electrical and fire protection components, exit signs, emergency lighting, and access panels, coordinated with all disciplines.
10. Door and room finish schedules.
11. Elevations of all windows, doors and frames, and curtain wall/ribbon window assemblies at 1/4" scale minimum.
12. Large scale details (3/4" scale minimum) of exterior wall sections, windows, door jambs, sills and heads, casework, roofing work, typical partition types, seismic bracing (as applicable), stairs, and railings.
13. Identify all rated floor and wall assemblies, indicating UL system or other acceptable rating information. Coordinate and detail the wall framing for all mechanical opening protectives, (fire damper and smoke dampers). Address continuity of fire rated construction around membrane penetrations greater than 16 sq. in. such as fire hose cabinets, electrical panels, valve boxes, etc.

3.0 Civil - Site Design

This section includes descriptions of additional requirements to various phases of design beyond those described in Section 1.5. The Scope of Work documents will identify the project specific design requirements.

3.1 Civil Preliminary Design Requirements (30%)

3.1.1 Drawings

Drawings include a site plan with utility information and a preliminary alignment. These drawings should show enough detail to allow the design team to evaluate the proposed solution.

a. Preliminary details that are vital to the design phase success
b. Site Plan(s) (1" = 40' scale minimum) - shall include location of building or buildings in relation to the immediate area around it, property lines if applicable, major dimensions, all existing and/or proposed utility lines, existing and proposed grades, grade elevations, site improvements, lighting, walks, all accessible routes and entrances, roads and parking, and locations of stormwater runoff and retention areas.
c. Location of major site features including site lighting, exterior stairs, sidewalks, retaining walls, and other features as applicable for work to be performed.
d. Existing grade contours and topographical survey data, surface drainage, existing paving and other features where applicable

3.1.2 Design Report

a. Analysis narrative to describe goals and proposed solution.
b. site scope of work and proposed construction staging/storage areas required
c. General description of the site including its past and current uses, geotechnical features, site features, and current surface drainage patterns as applicable to the work to be performed.
d. Estimated quantity for rock cuts, earth cuts, and earth fills where applicable.
e. Description for various paving systems where applicable.

f. Existing and anticipated loads on utilities including documentation of all utility analyses performed where applicable.
g. Stormwater impacts, including methods of erosion and sediment control
h. Studies: geotechnical, hydrological, hydraulic etc. as needed
i. Required permits identified.
j. Environmental considerations.
k. CAP land requirements identified.

3. 2 Civil Interim Design Requirements (60%)

3.2.1 Drawings

a. Updated and developed drawings provided at 30% submission with all comments submitted from CAP addressed.
b. Preliminary major details for utilities, site work, and paving, as applicable, including:
    i. utility inverts and design slopes
    ii. typical paving details
    iii. sections and major details for typical site features such as retaining walls, exterior stairs/ramps, pervious paving, underground retention or treatment systems, and other site amenities
    iv. erosion control and sediment control plan, as required
    v. areas of contaminated soil identified for removal

3.2.2 Design Report

a. All reports (geotechnical, drainage, etc) completed and available as backup for design decisions.
b. All permit applications completed and ready for submittal.

3.3 Final Design (100% Un-reviewed)

3.3.1 Drawings

a. Updated and developed drawings provided at 60% submission with all comments addressed
b. Updated and developed plan sheets and details

4.0 Civil - Structural Design

This section identifies criteria, requirements and guidance for structural design in addition to the requirements of Section 1.5. This section includes structural and geotechnical design elements.

4.2 Preliminary Design Requirements (30%)

4.2.1 Preliminary Design Analysis - Structural

1. Written design narrative to include, as applicable:
    a. Description of the basic structural systems to be used on the project (foundations, substructure, superstructure, lateral force resisting system, etc.).

2. Structural Loading Information (include criteria and reference source). Loading will include the following, as applicable:
    a. Floor and roof live load
    b. Wind loading. Include basic wind speed, wind importance factor, wind exposure and applicable internal coefficient and component and cladding design pressure
    c. Machinery and equipment loads
    d. Seismic loading.
    e. List all load combinations that will be used.
3. Structure Performance Design Criteria to include, as applicable:
    a. Maximum allowable drift criteria
    b. Maximum allowable floor live load deflection
    c. Maximum allowable roof deflection
4. Geotechnical Design Criteria (Geotechnical Report). Reports, when required, will include the following, as applicable:
    a. General site plan
    b. Test boring location plan showing the as-drilled location of test borings.
    c. Subsurface exploration logs.
    d. Description of the site location, topography and overall condition
    e. Summary of historic and relevant existing subsurface data at the site.
    f. Summary of the subsurface investigation and laboratory testing services performed specifically for the project.
    g. A description of the subsurface conditions, including the depth to groundwater and bedrock and a discussion on evidence of contamination or historic fills identified in the test borings.
    h. Seismic site classification.
    i. The results of laboratory tests performed, as applicable.
    j. Description of foundation analyses performed and summary of foundation design recommendations. Provide recommendations for foundation type, relevant design criteria and allowable capacities required by the structural engineer.
    k. Expected total and differential settlement for the foundation systems analyzed.
    l. Parameters required for the design of retaining walls, including seismic lateral earth pressures where required.
    m. Floor slab design recommendations.
    n. Recommendations for waterproofing, damp proofing, footing and floor slab underdrains, if required.
    o. Construction considerations, including recommendations for groundwater control, excavation support, subgrade preparation and backfill materials.
    p. Geotechnical considerations related to development of site features, including pavement, utilities, site grading (slopes) and drainage.
    q. Recommendations for monitoring and protection of adjacent structures during construction.
5. Define the following parameters:
    a. Active Earth Pressure / Equivalent Uniform
    b. Passive Earth Pressure (as applicable)
    c. Surcharge Coefficient
    d. At-Rest Earth Pressure (as applicable)
    e. Unit Weight of Soil(s)
    f. Soil Classification (Basis of seismic design)
    g. Maximum Allowable Bearing Capacity
    h. Uplift Capacity
    i. Lateral Resistance

j. Subgrade modulus

6. Material Information, as applicable to include:
    a. Concrete
        i. Provide basic material properties for concrete to be used in each of the following structural elements. Include compressive strength, entrained air content, maximum aggregate size, allowable w/c, unit weight or aggregate type, and anticipated admixtures.
        ii. Identify potential for substitution of fly ash or other suitable replacement for cement.
        iii. Identify concrete mixtures to be used for footings, foundations walls, slab on grade, elevated slabs, superstructure columns and beams, roof slabs.
        iv. Rebar – bar and welded wire fabric requirements.
        v. Provide the ASTM material designation for rebar to be used. Indicate the anticipated uses and locations for special rebar types (epoxy coated, galvanized, high strength, etc).
    b. Masonry
        i. Provide information and ASTM International (ASTM) designations for typical masonry units to be used on the project including bricks, Concrete Masonry Units (CMU), terra cotta, Glass Fiber Reinforced Concrete (GFRC) units, autoclaved aluminum aerated concrete units, and stone.
        ii. Provide information on the various types of mortar to be used on the project.
        iii. Provide information on lintel materials, flashing materials and installation, ties and anchors.
        iv. Provide information on masonry tolerances to be used on the project.
    c. Steel
        i. Provide the ASTM material designation for the steel to be used for each of the following items: steel columns, steel beams, base plates, built-up beams or girders, steel truss chord members, lateral bracing system; Itemize by American Institute of Steel Construction (AISC) shape as applicable (W, HP, S, C, L, plate, steel pipe, round, square and rectangular HSS), including material types and sizes.
        ii. Type of anticipated structural steel connections.
        iii. Provide the diameter, ASTM material designation, and finish for the typical bolt assembly to be used on the project, including nuts, washers, and bolts.
        iv. Provide a list of the locations where slip-critical bolts are anticipated.
        v. Provide the test method to be used to verify the bolt tension in the slip critical connections.
        vi. Provide the anticipated type of moment connection to be used on the project.
        vii. Provide basic information on the welding materials and processes that will be used on the project.
        viii. Provide information on the type of base plate / anchor rod assembly. Include material type and sizes.
        ix. Provide basic information regarding priming/painting of steel members including materials, locations, slip coefficients, etc.
        x. Steel Deck - provide basic information on the anticipated steel decking to be used, including profile and depth, ASTM material designation, span condition, finishes and coatings, and method of attachment. Indicate if shoring will be required. Also indicate any deflection criteria.

d. Wood and Engineered Wood Products
    i. Indicate grade and species for all anticipated wood framing products.
    ii. Indicate engineering design requirements for engineered wood products.
    iii. Indicate typical spacing for framing members.
    iv. Indicate special treatment requirements (pressure treated, fire resistive).
    v. Indicate requirements for wood sheet goods (oriented strand board (OSB), plywood), thicknesses, and locations for use (roof deck, floor deck, exterior sheathing).

4.2.3 Preliminary Drawings

Drawings to include, as applicable:

1. Provide preliminary drawing of foundation system including walls, footing, and pile locations.
2. Provide preliminary drawings for the typical steel frame layout including column, beam and girder locations: Indicate lateral bracing system on the layout.

4.3 Interim Design Requirements (60%)

4.3.1 Interim Drawings

Drawings to include, as applicable:

1. Updated and developed drawings provided at 30% submission with all comments from CAP addressed.
2. All structural systems need to be defined to the extent that the reviewer can fully understand the intent and can check the design.
3. The structural load paths for the structure are completed and designed for all loads including gravity and lateral loads; soils and groundwater loads; wind and seismic loads; equipment and live loads.
4. Foundation system is fully defined including:
    a. Wall and slab-on-grade thickness are determined.
    b. Brick shelf locations are determined.
    c. Slab-on-grade construction is shown.
    d. Footing steps and elevator pits are located.
    e. Waterproofing and waterstop systems are defined and shown on the drawings.
    f. Insulation materials are shown on the drawings.
    g. Footing schedule is completed and shown on the drawings.
    h. Typical footing details have been shown.
    i. Typical pier details have been shown.
    j. Grade beams and tie beams have been sized and shown on the drawings.
5. All building expansion joints are shown. Foundation wall and slab-on-grade construction and control joints are shown.
6. Fire rated assemblies are determined and listed systems are shown on the drawings.
7. Concrete superstructure is defined; all beams, columns, piers and elevated slabs are located and sizes/thickness have been determined.
8. Structural steel superstructure is defined including:
    a. All columns and beams have been shown.
    b. Column sizes and orientation are shown.
    c. Beam sizes are shown.
    d. Lateral bracing system is indicated.

e. Design end reactions, connection moments and axial loads have been designated directly on the drawings in accordance with the AISC Code of Standard Practice.
f. Column schedule is completed.
g. Base plates and anchor bolts are determined and shown on the drawings.
h. Steel beam camber is determined and shown on the drawings.
i. Shear stud type and length has been determined.
j. Approximate locations and support for major mechanical equipment are shown. Identify and label equipment and machinery weights over 1000 pounds.

9. Elevated slab-on-deck has been defined including:
    a. Slab thickness and typical reinforcing is shown.
    b. Steel decking configuration, gauge, and orientation are indicated.
    c. Changes in top-of-slab elevation are indicated.
10. Masonry systems defined including:
    a. Indicate typical masonry reinforcing and spacing requirements for both load bearing and non-load bearing walls and partitions.
    b. Indicate masonry seismic anchorage and lateral support requirements.
    c. Indicate masonry bond beam requirements.
11. Wood framing systems defined including:
    a. Non typical wood framing member locations are called out (double joists, multiple wall studs or posts, etc.)
    b. Provide nailing and fastener schedule.
12. Provide typical section for the project:
    a. Floor - Typical cross sections; Spandrel sections: Parallel and perpendicular to facade
    b. Roof - Typical cross sections; Spandrel sections: Parallel and perpendicular to façade
    c. Wall - Foundation wall(s); Retaining wall(s); Load Bearing wall(s)
13. Provide standard detail sheet(s) modified to suit the project.

4.4 Final Design Requirements (100% Un-reviewed)

4.4.1 Final Design Drawings

Drawings to include, as applicable:

1. Updated and developed drawings provided at 60% submission with all CAP comments addressed.
2. Concrete Foundation/Framing Drawings
    a. Provide typical details for concrete footings, beams, columns, slabs, and walls as required for the project; do not include details that do not apply to the scope of work.
    b. Provide completed concrete column, beam, pilaster, and footing schedules.
    c. Indicate information for concrete slab construction including:
        i. Slab joint pattern for concrete slabs-on-grade.
        ii. Slab thickness and top of slab elevations.
        iii. Slab reinforcing including sizes, spacing, placement, and clearances.
        iv. Typical slab construction details including construction and control joint details, typical details at slab-column isolation joints, slab-wall joint details, waterstop and waterproofing details, and slab insulation details.
        v. Indicate all changes in slab elevations including depressions and pits, sump pits at the bottom of all elevator pits.

vi. Indicate all sloped slab locations with both beginning and ending slope elevations.

d. Indicate information for all continuous and isolated footings including:
   i. Indicate footing sizes and locations.
   ii. Top of footing elevations.
   iii. Step footing locations and the top of footing elevations at each step.
   iv. Waterproofing and waterstop details and requirements.
   v. Footing reinforcing sizes, spacing, and clearances.
   vi. Required keyways and dowels.
e. Indicate information for foundation walls including:
   i. Elevation at top of wall.
   ii. Elevation at top of brick shelf or other supports.
   iii. Elevation at beam pockets and changes in wall heights.
   iv. Wall thickness and location to column lines.
   v. Wall reinforcing size, direction, spacing, and clearances.
   vi. Integral pier or pilaster size, location, reinforcing, and elevation.
   vii. Waterproofing, waterstop, and insulation details.
   viii. Wall penetrations including size, locations, and additional reinforcing.
   ix. Locations and details for embedded items such as connection plates or anchors.
f. Steel Framing Drawings
   i. Indicate all steel framing member sizes. Include all shear stud and camber information for floor framing members.
   ii. Indicate all connection design loads including vertical reactions and design moments for moment connections.
   iii. Indicate column orientation on framing plans.
   iv. Indicate all locations requiring the installation of slip-critical bolts.
   v. Indicate all bridging and bracing member sizes, locations, and connections.
   vi. Indicate metal decking sizes, span criteria, and direction.
   vii. Provide all relevant typical details. Do not include details that do not apply to the project.
   viii. Provide a complete column schedule including member sizes, splice locations and types, base plate sizes and orientation, column loads and heights.
   ix. Provide anchor bolt sizes, hardware, and pattern.
   x. Provide all non-typical or non-standard connection details.
   xi. Indicate all dunnage and support steel members. Provide sizes and details.
   xii. Indicate all lintels (loose and attached) and support angles.

5.0 Fire Protection and Fire Alarm System Design

This chapter identifies criteria, requirements, and guidance for design of Mechanical Fire Protection (FP) systems and the design of Fire Alarm (FA) in addition to the requirements of Section 1.5. Fire Alarm systems include fire alarms, fire and smoke detection, annunciation, and associated auxiliary systems. The information found below is not all inclusive and may or may not be required for individual projects.

5.1 Preliminary Design Requirements (30%)

5.1.1 Preliminary Drawings

1. All existing CAP drawings that are affected by this project shall be identified by this phase of the design. Include final drawing list as provided by CAP and all associated new drawings in this submittal for initial review.
2. Architectural Specific (FP) - Life safety plans for each level of the building:
    a. Show fire ratings of building structural elements and location and rating of fire walls, barriers, doors and dampers. Specify occupancy type and area and number of occupants in each habitable or occupiable room. Indicate maximum travel distance and path of travel for each primary/incidental occupancy shown. Show all applicable or planned areas of refuge, smoke compartments, horizontal exits, vertical exits, exit passageways, exit loads and capacities, and units of egress. Show any temporary means of egress and protection to be utilized during construction activities.
3. FP floor and layout plans for each level, showing building layout, and fire areas, FP plans shall show:
    a. Major pieces of equipment, and existing services located and sized.
    b. Location of HVAC ducts with cfm ratings for intake and exhaust ducts for each HVAC unit.
4. FP Drawings:
    a. Shall show size, and location of water mains, and location of risers, hydrants, sprinkler system lead-ins, and sectional valves.
    b. Sprinkler standpipe/piping layout.
    c. Location of areas to be sprinklered, include features of construction and HVAC that could present obstructions of which the sprinkler contractor must be aware.
5. FAS Drawings:
    a. Preliminary fire alarm riser diagram.
    b. Floor plans showing:
        i. Electrical, telecommunications rooms and closets.
        ii. Major equipment such as fire alarm control panels, sub-panels, transponders, etc.
        iii. Show FAS areas of coverage and location drawings.
    c. A site plan showing (as applicable) the location of central campus fire alarm monitoring stations, connection points, routing of services to the building (new and existing).

5.2.1 Preliminary Design Analysis

Written design narrative to include, as applicable:

1. Description of the FP and FA system design intent.
    a. Include general description of the major FP and FA systems that will be a part of the work. Describe new FP and FA system major components, and reasons for selection and inclusion as a component of the system.
    b. Identify and describe any special system requirements, such as:
        i. Modifications to existing fire pump(s) and/or storage tank(s) or installation of new fire pump(s) and/or storage tank(s)
        ii. Wet pipe sprinkler systems

iii. Carbon dioxide or dry agent systems
iv. Pre-action sprinkler systems
v. Switchyard suppression systems

c. Determine if there are any required modifications to existing FA systems or new installations of FA systems.

2. Describe all code required FP, FA and fire/smoke detection systems and equipment.
3. Evaluation and Calculations:
    a. Life Safety analysis with applicable codes of record, IBC construction type, and NFPA 101 occupancy type.
    b. Determine if approval by the authority having jurisdiction is needed in order to proceed with elements of the conceptual design, and present information for CAWD AHJ for approval.
    c. Determine if modifications are required in order to comply w/ current NFPA, IFC, and IBC Codes.
    d. Determine FP system design criteria and appropriate safety factor(s) used.
    e. Determine equipment / system redundancy requirements.
    f. Identify any special hazards or environmental concerns associated with the existing and/or new systems.
    g. Verify that existing systems, when utilized, have sufficient capacity to support new work. List existing major equipment or systems related to the work that will be reused or salvaged.
    h. For Mechanical FP System(s):
        i. Determine fire suppression system conceptual design.
        ii. For water sprinkler systems:
            1. Obtain Fire Flow Test data from site.
            2. Prepare fire sprinkler system hydraulic calculations for the most hydraulically demanding area to insure that flow and pressure requirements can be met with current water supply.
    i. For FA System(s):
        i. Provide fire alarm schematic design narratives describing the fire alarm systems to be incorporated into the design
        ii. Describe all code required fire alarm and fire/smoke detection systems and equipment.
        iii. Provide a general description of the overall fire alarm system and interfaces including:
            1. Type of system, i.e. zoned, addressable, etc.
            2. Type of initiation and/or detection devices to be used and locations (including but not limited to manual pull stations, fire protection system devices, and smoke, heat, and CO detection).
            3. Type of notification appliances and locations.
            4. Control panel, transponder, sub-panel, and remote annunciator panel locations.
            5. Information concerning items such as tie-ins to existing fire alarm or building management system.
            6. Local fire department notification, supervising station, central station, central campus monitoring system connections.
            7. Fan shutdown and damper operation.

8. Elevator recall and power shunt trip (where sprinklered).
9. Information concerning power supply and system grounding).

iv. Provide a brief description of systems and interfaces to be addressed in the FA system. Description(s) should include the following (if applicable):
1. Manual FA Systems.
2. Fire/smoke detection systems.
3. Emergency one and two-way voice communication systems.

v. Existing Conditions (where applicable): A description of the existing fire alarm system that will be utilized to provide service for the project. Information on existing fire alarm equipment including approval by the authority having jurisdiction of the existing equipment/system and verification of spare capacity shall be included.

j. Electrical Specific Items:
i. Determine approximate electrical demand for new FP and FA system equipment.
1. Determine any modifications to existing or installations of new electrical service and distribution to accommodate new equipment.
2. Emergency or standby power requirements.
3. Fire alarm system voltage drop calculations and system battery backup calculations.

ii. A general description of lighting to be used and any associated controls.
iii. Special grounding requirements, lightning protection and/or surge protective devices.

5.2 Interim Design Requirements (60%)

5.2.1 Interim Design Drawings

The drawings provided shall include all modified drawings [and documents] from the Preliminary Review (with comments addressed) and:

1. All existing CAP drawings that are affected by this project shall be identified by this phase of the design. All new drawings shall be included in this submittal for review.
2. Architectural Specific (FP):
   a. Prior requirements finished to at least 60%.
   b. Identify all rate floor and wall assemblies, indicating UL system or other acceptable rating information. Coordinate and detail the wall framing for all mechanical opening protectives (fire damper and smoke dampers). Address continuity of fire rated construction around membrane penetrations greater than 16 sq. in. such as fire hose cabinets, electrical panels, valve boxes, etc.
3. FP Drawings:
   a. Prior requirements finished to at least 60%.
   b. All fire protection sheets should be completely set up by this submittal and any piping modifications made on the drawings accordingly.
   c. Sprinkler system drawings:
      i. Sprinkler plans and elevation drawings.
      ii. Updated piping diagram with new valve tags.

d. FP water system schematic flow diagrams:
    i. Flow arrows.
    ii. GPM for all segments.
e. Suppression system drawings:
    i. Suppression system plan and elevation drawings.
    ii. Suppression system piping diagrams and piping detail or isometric drawings.

4. FAS Drawings:
    a. Drawings for each level showing the following:
        i. Fire alarm initiating devices, notification appliances, equipment, and components.
        ii. Room names, room numbers, door swings, stairs, windows, etc.
    b. Indicate a layout of the fire alarm system including:
        i. Location of the initiation and/or detection devices to be used.
        ii. Location of notification appliances (indicate strobe candela ratings as necessary).
        iii. Control panel, transponder, sub-panel, and remote annunciator panel locations.
        iv. Information concerning items such as tie-ins to existing fire alarm or building management system.
        v. Local fire department notification, supervising station, central station, central campus monitoring system connections.
        vi. Fan shutdown and damper operation.
        vii. Elevator recall, shunt trip and smoke hatch.
    c. Provide a fire alarm system riser diagram indicating the following:
        i. Information concerning power supply and grounding.
        ii. Floor by floor schematic indicating typical initiating devices and notification appliances.
        iii. FA Control and data gathering panels, remote annunciators.
        iv. Relay and modules.
        v. Typical circuits/loops, including alternating circuits for notification appliances.
    d. The drawings must indicate the following:
        i. Manual fire alarm systems.
        ii. Fire/smoke detection systems.
        iii. Emergency one and two-way voice communication systems.
        iv. Fire command center (when required) with the following features:
            1. Elevator monitoring annunciator.
            2. Emergency voice/alarm communication system.
            3. Fire department communications unit.
            4. Status indicators and controls for HVAC systems.
            5. Controls for unlocking stair doors.
            6. Emergency and standby power status indicators.
            7. Telephone for fire department use.
            8. Fire Alarm annunciator.
            9. Generator supervision devices, manual start and transfer features.

v. Fire alarm control matrix for all functions with associated devices and systems.
vi. For renovation work show existing equipment to be demolished and existing equipment to reused.

5.3 Final Design Requirements (100% Un-Reviewed)

5.3.1 Final Design Drawings

1. All drawings updated and developed to 100%.
2. FP Drawings:
    a. All fire protection modifications on the drawings should be completed by this stage including all associated keynotes and any pertinent details required for installation.
    b. Sprinkler and suppression system plan, elevation and detail view drawings.
    c. All equipment identified on FP equipment schedules, tables completed, and construction key notes complete.
    d. Scheduled items are to be tagged and referenced to the schedule.
    e. FP Piping floor plans indicating:
        i. All piping labeled with system type and sizes. Six inch and greater piping depicted with double lines.
        ii. All valves identified and labeled.
        iii. Equipment and fixtures with labels or tags identifying each.
    f. Equipment elevations and sections indicating all materials, features and dimensions.
        i. Other important FP equipment or spaces.
        ii. Any fire dampers and/or smoke dampers identified and specified.
        iii. Equipment schedules with all fields complete.
3. FA Drawings:
    a. Fire Alarm System: Provide final layout of the fire alarm system.
    b. Fire Alarm Riser Diagram: Finalize the fire alarm system riser diagram.
4. Provide final Fire Alarm points schedule.

6.0 Mechanical – HVAC Design

This chapter identifies criteria, requirements and guidance for mechanical HVAC design in addition to the requirements of Section 1.5.

6.1 Preliminary Design Requirements (30%)

6.1.1 Preliminary Drawings

1. All existing CAP drawings that are affected by this project to be identified by this phase of the design. Include final drawing list as provided by CAP and include all associated drawings in this submittal for initial review.
2. Ductwork floor plans for each level.
3. All major pieces of equipment shall be located on the floor plans.
4. Existing services located and sized.
5. Piping floor plans for each level.
6. Existing services located and sized.

7. System Schematics and preliminary Process and Instrumentation Diagrams (P&ID) (see section 13.4).Flow Diagrams.
8. Equipment schedules set up.
9. For renovation work, show existing equipment to be demolished and existing equipment to be reused.

6.1.2 Preliminary Design Analysis

1. Narrative
    a. Provide a narrative of the scope of HVAC work including the system design intent.
    b. Include general descriptions of all major building HVAC components and systems to be incorporated into the project and why they were selected as well as the types of energy plants considered and reasons for selection. The recommended location for the energy plants. Include drawings, specifications, reports to show scope and extent of project. Explicitly delineate systems' zoning and isolation.
    c. Identify and describe anticipated special systems such as (but not limited to):
        i. Variable frequency drives.
        ii. Emergency generators.
        iii. Building Management System (BMS) system being proposed and tie into any existing facility BMS system.
2. When tying into existing systems:
    a. Verify and demonstrate that the existing systems have sufficient capacity to support the new work (heating, cooling, pumping, specialty systems, etc.)
    b. List all existing major equipment or systems to be reused or salvaged.
3. System design criteria.
4. Complete set of preliminary heating and cooling load calculations.
5. Outside air ventilation requirements.
6. Diversity factors used and justification.
7. Safety factor(s) used.
8. Equipment redundancy.
9. Energy conservation/efficiency opportunities.

6.2 Interim Design Requirements (60%)

6.2.1 Interim Drawings

The drawings provided shall include all modified drawings [and documents] from the Preliminary Review (with comments addressed) and:

1. Drawings
    a. Updated and developed drawings provided at 30% submission.
    b. Ductwork floor plans indicating:
        i. All ductwork.
        ii. All equipment.
        iii. Registers, dampers, fire dampers, smoke dampers, diffusers, grilles and louvers. Coordinate fire, smoke, and fire/smoke dampers with the fire protection plans.
        iv. Piping floor plans indicating:
            1. All piping labeled with system type (HWS, HWR, etc.).
            2. All valves.

    c. Equipment and fixtures with labels or tags identifying each.
    d. Roof plan(s) indicating locations of all mechanical equipment, ductwork and piping.
    e. Equipment elevations and sections indicating all materials, features and dimensions.
    f. Sections of all congested areas. Sections to show all systems/components of all trades (e.g., interstitial ceiling space showing ceiling grid, insulated and non-insulated pipe, ductwork, sprinkler pipe, conduit, beams with fireproofing, lights, etc.).
2. Large scale plans:
    a. Boiler rooms.
    b. Chiller rooms.
    c. Mechanical rooms.
    d. Cooling towers.
    e. Other similar large equipment.
3. Equipment schedules with equipment manufacturers name and model as well as sizing information listed.
4. Detail drawings:
    a. Details and elevations necessary to completely describe the scope of work.
    b. Details must be specific for project scope of work.
    c. Large scale details for all mechanical equipment not shown in elevations or sections.
5. Air system schematic flow diagrams, completely labeled.
6. Duct riser diagrams.
7. Water system schematic flow diagrams.
8. Interim Process and Instrumentation Diagrams (P&ID) (see section 13.4), if applicable.
9. BMS points schedule.
10. Provide catalog cuts of major equipment and manufacturer's installation instructions where appropriate.

6.3 Final Design Requirements (100% Un-reviewed)

6.3.1 Final Design Drawings

1. Updated and developed drawings provided at 60% submission.
2. Ductwork floor plans indicating:
    a. All ductwork, depicted double lines, supply and return indicated, with all sizes shown.
    b. All equipment showing connections, flexible connectors, transitions.
    c. Registers, dampers, fire dampers, smoke dampers, diffusers, grilles and louvers all labels with appropriate sizing, neck size and flow information (if not shown on a schedule).
3. Scheduled items are to be tagged and referenced to the schedule.
4. Piping floor plans indicating:
    a. All piping labeled with system type (HWS, HWR, etc.) and sizes. Six inch and greater piping depicted with double lines.
    b. All valves.
    c. Equipment and fixtures with labels or tags identifying each.
5. Roof plan(s) indicating locations of all HVAC equipment, ductwork and piping.
6. Equipment elevations and sections indicating all materials, features and dimensions.

7. Large scale plans completely labeled and all sizes and dimensions indicated for:
    a. Boiler rooms.
    b. Chillers rooms.
    c. Mechanical rooms.
    d. Cooling towers.
8. Other important HVAC equipment or spaces.
9. Equipment schedules with all fields complete.
10. Large-scale details for all HVAC equipment not shown in elevations or sections with all components labeled and sizes indicated where appropriate.
11. Air system schematic flow diagrams showing CFM of all segments.
12. Final Process and Instrumentation Diagrams (P&ID) (see section 13.4), if applicable.
13. Water system schematic flow diagrams:
    a. Flow arrows.
    b. GPM for all segments.
14. BMS points schedule.

7.0 Mechanical – Domestic Plumbing Design

This section provides guidance for preparation and development of plumbing (domestic water, waste, and vent piping) in addition to the requirements of section 1.5. Industrial plant piping addressed in the next section (if applicable to the project).

7.1 Technical Requirements

1. Coordinate space requirements, foundations, supports, pipe routing, electrical service, and the like for mechanical items with architectural, structural, and electrical design elements. Coordinate exterior mechanical distribution systems with design elements handling other exterior utility designs and site work.
2. Standard or "packaged" equipment shall be used to the greatest extent possible to simplify specifying, purchasing, installation, and maintenance of equipment.
3. Piping System. Piping materials and sizes shall comply with the recommendations in the latest plumbing code adopted by CAP. Flow velocities in water pipe shall not exceed 8 feet per second. All piping shall be sloped to permit complete drainage and shall be properly supported with allowances for expansion and contraction. Expansion loops or expansion joints and anchor points shall be shown on plumbing drawings. Piping subject to freezing shall be suitably protected.
4. Floor Drains. Floor drains shall be provided in all boiler and mechanical equipment rooms and adjacent to each indoor emergency deluge shower. Provide trap primers for all floor drains unless specified otherwise. Floor drains are not allowed in rooms used as plenums and rooms requiring floor drains shall not be used as plenums.
5. Backflow Prevention. The water distribution system shall be protected against the flow of water or other liquids into the distributing pipes from any unintended source or sources which would compromise its' potability.
6. Domestic Hot Water. In the design of any buildings in which water closets and showers are installed, the designer shall exercise the necessary precautions to prevent personnel from being scalded while taking showers due to simultaneous operation of water closets equipped with flush valves or other fluctuations in the hot and cold water supplies to these fixtures.

7. Domestic Hot Water Temperature. Domestic hot water supply maximum temperatures at the point of use will be as follows for the indicated facilities or areas unless higher temperatures are required for sanitizing or special processes:
8. Compressed Air. Unless requirements are stated in specific instructions, compressed air system and compressor sizes will be determined by the designer from analysis of equipment layout and/or coordination with the customer's requirements.
9. Equipment Schedules. Each set of drawings for a project or building shall include one or more fixture schedules that will designate the symbols, P numbers, outfit numbers, description, and sizes of connections.
10. Plumbing shall not traverse over or under electrical panels or switchboards.

7.2 Preliminary Design Requirements (30%)

7.2.1 Preliminary Drawings

The Preliminary Design drawings should include, but not be limited to, the following items as applicable:

1. Indicate locations and general arrangement of plumbing fixtures and major equipment.
2. Indicate location and extent of any demolition that will be required concerning the plumbing system.

7.2.2 Preliminary Design Analysis

1. General Considerations
    (a) During the Preliminary Design Stage of project development, it is recognized that all calculations are preliminary for analysis purposes and only indicate approximate capacities of equipment. Any dimensions and sizes required are rough-order-of-magnitude figures to insure adequate space for installation and maintenance of equipment and utility elements such as piping, etc., in congested areas.
    (b) Equipment shown in plans and sections need not be shown in great detail but is shown merely as simple geometric forms with approximately correct dimensions.
    (c) Piping layouts shown are simple main pipe runs showing general location, routing and, when applicable, approximate rough order of magnitude sizes.
    (d) Schematic diagrams are simplified. The purpose of the schematic is only to show system design intent and the basic principle of system operation.
2. The Preliminary Design Analysis shall include but not be limited to the following items as applicable:
    (a) Provide justification and a brief description of the types of plumbing fixtures, piping materials, and equipment proposed for use.
    (b) Prepare basic preliminary calculations for systems such as sizing of domestic hot water heater and piping, compressed air piping, and compressors and receivers.
    (c) Describe any demolition required.

7.3 Interim Design Requirements (60%)

7.3.1 Interim Drawings

In addition to the following items, the designer shall incorporate or answer all comments received concerning the Preliminary Submittal.

The Interim Drawings should show all information given on the Preliminary Drawings but in greater detail. In addition, the Interim Drawings should include, but not be limited to, the following items as applicable:

1. Include plan and isometric riser diagrams of all areas including hot water, cold water, waste, and vent piping as applicable. Piping layouts and risers should also include compressed air systems and other specialty systems as applicable.
2. Include equipment and fixture schedules with descriptions, capacities, locations, connection sizes, and other information as required.

8.0 Mechanical – Industrial Piping Design

This section provides guidance for preparation and development of industrial (plant) piping design in addition to the requirements in section 1.5.

8.1 Technical Requirements

1. Coordinate space requirements, foundations, supports, pipe routing, electrical service, and the like for mechanical items with architectural, structural, and electrical design elements. Coordinate exterior mechanical distribution systems with design elements handling other exterior utility designs and site work.
2. Standard or "packaged" equipment shall be used to the greatest extent possible to simplify specifying, purchasing, installation, and maintenance of equipment.
3. Piping System. Piping materials and sizes shall comply with the recommendations in the latest plumbing code adopted by CAP. Flow velocities in water pipe shall not exceed 8 feet per second. All piping shall be sloped to permit complete drainage and shall be properly supported with allowances for expansion and contraction. Expansion loops or expansion joints and anchor points shall be shown on plumbing drawings. Piping subject to freezing shall be suitably protected.
4. Floor Drains. Floor drains shall be provided in all boiler and mechanical equipment rooms and adjacent to each indoor emergency deluge shower. Provide trap primers for all floor drains unless specified otherwise. Floor drains are not allowed in rooms used as plenums and rooms requiring floor drains shall not be used as plenums.
5. Backflow Prevention. The water distribution system shall be protected against the flow of water or other liquids into the distributing pipes from any unintended source or sources which would compromise its' potability.
6. Compressed Air. Unless requirements are stated in specific instructions, compressed air system and compressor sizes will be determined by the designer from analysis of equipment layout and/or coordination with the customer's requirements.
7. Equipment Schedules. Each set of drawings for a project or building shall include one or more fixture schedules that will designate the symbols, P numbers, outfit numbers, description, and sizes of connections.
8. Plumbing shall not traverse over or under electrical panels or switchboards.

8.2 Preliminary Design Requirements (30%)

8.2.1 Preliminary Drawings

The Preliminary Design drawings should include, but not be limited to, the following items as applicable:

1. Indicate locations and general arrangement of major equipment.
2. Indicate location and extent of any demolition that will be required concerning the piping system.
3. If part of a process piping system, include preliminary Process and Instrumentation Diagrams (P&ID)

8.2.2 Preliminary Design Analysis

1. General Considerations
    (a) During the Preliminary Design Stage of project development, it is recognized that all calculations are preliminary for analysis purposes and only indicate approximate capacities of equipment. Any dimensions and sizes required are rough-order-of-magnitude figures to insure adequate space for installation and maintenance of equipment and utility elements such as piping, etc., in congested areas.
    (b) Equipment shown in plans and sections need not be shown in great detail but is shown merely as simple geometric forms with approximately correct dimensions.
    (c) Piping layouts shown are simple main pipe runs showing general location, routing and, when applicable, approximate rough order of magnitude sizes.
    (d) Schematic diagrams are simplified. The purpose of the schematic is only to show system design intent and the basic principle of system operation.
2. Drawings and sketches. Plans and sections shall properly show pertinent information. Some mechanical information required in the Preliminary Submittal may logically be included on other discipline drawings in the design analyses and need not be completed on formal drawings.
3. The Preliminary Design Analysis shall include but not be limited to the following items as applicable:
    (a) Provide justification and a brief description of the types of piping materials and equipment proposed for use.
    (b) Prepare basic preliminary calculations for systems such as sizing of water piping, compressed air piping, and compressors and receivers.
    (c) Describe any demolition required.

8.3 Interim Design Requirements (60%)

8.3.1 Interim Drawings

In addition to the following items, the designer shall incorporate or answer all comments received concerning the Preliminary Submittal.

The Interim Drawings should show all information given on the Preliminary Drawings but in greater detail. In addition, the Interim Drawings should include, but not be limited to, the following items as applicable:

1. Include plan and isometric riser diagrams of all areas including hot water, cold water, waste, and vent piping as applicable. Piping layouts and risers should also include compressed air systems and other specialty systems as applicable.

2. Include equipment and fixture schedules with descriptions, capacities, locations, connection sizes, and other information as required.

9.0 Electrical – General Electrical Design

9.1 General

9.1.1 Scope

This chapter identifies the requirements to clearly define the major components of new or existing electrical systems to be modified as part of the work. This chapter includes, but is not limited to, systems such as electric power, lighting, and grounding.

9.2 Preliminary Design Requirements (30%)

The 30% submittal should contain a high level view of what the proposed design should be. The main focus should be on the design narrative, and enough detail in drawings to convey the general ideas presented in that narrative.

9.2.1 Preliminary Design Analysis

Written design narrative to include, as applicable:

1. Electrical service and distribution.
2. Emergency or standby power.
3. A general description of lighting to be used and any associated controls.
4. Special requirements for grounding.
5. Lightning protection and/or surge protective devices.
6. Electrical requirements for fire alarm or fire protection equipment.
7. Security or other alarm systems.
8. Approximate electrical demand for new equipment.
9. Identify major equipment to be demolished as part of the work.

9.2.2 Preliminary Drawings

Drawings to include, as applicable:

1. Preliminary single-line diagrams showing ratings (current, voltage, number of phases) for major equipment.
2. Power floor plans showing major equipment.
3. Site plan showing routing of services to the facility and the location of major equipment.

9.3 Interim Design Requirements (60%)

The main effort in the 60% submittal should be focused on the drawings. 90% of the expected drawings should be submitted, to a 60% design level. In addition to drawings, voltage drop calculations should be submitted for new loads.

9.3.1 Interim Drawings

1. Single-line diagrams showing incoming service, switchboards, transformers, panelboards, transfer switches, generators, MCCs, and other major equipment with ratings for each.

    a. Include feeder and conduit sizes for all circuits shown on the single-line diagrams.
    b. Include AIC ratings for all equipment shown on the single-line diagrams.
        i. Note to designers: CAP maintains electrical system models for the purpose of performing short circuit, coordination, and arc flash studies. CAP will provide available short circuit data to consultants as required.
2. Power floor plans showing all new electrical equipment including, but not limited to, the following: receptacles, disconnect switches, control panels, switchboards, transformers, panelboards, transfer switches, generators, MCCs.
    a. Note to designers: circuiting details for each electrical utilization device (receptacle, fan, control panel, etc.) should be provided during this submittal.
3. Lighting floorplans showing lighting layout, emergency fixtures, switching, and control equipment.
4. Special systems floorplans: provide separate floorplan drawings for the following systems.
    a. Security or other alarms.
    b. Telecommunications (voice, data, CATV) and audiovisual outlets, backbone, cabling, cable trays, racks.
5. Site plans:
    a. Electrical service, including underground circuits, and the location of major equipment.
    b. Site lighting.
    c. Site grounding.
    d. Installation details including manholes, vaults, handholes, ductbanks, trenching, pole bases, and other site features.
    e. Telephone, CATV, data services.
6. Schedules:
    a. Panelboards: indicate rating for voltage, phases, ampacity, short circuit rating, circuit breaker sizes, and feeder size.
    b. Light Fixture: indicate type, finish, ballasts, voltage, bulbs, accessories, manufacturer, and wattage.
    c. Equipment (e.g. mechanical): indicate voltage, phases, ampacity, and accessory requirements.
    d. Load Summary: Identify approximate load being removed along with load added in order to indicate the net change in load on each panelboard, switchboard, or MCC.
    e. Conduit and cable schedules
7. Voltage drop/load calculations:
    a. Provide voltage drop calculations for new loads, show justification for selected wire size.
8. Riser diagrams for all special systems, identifying equipment type and location, cabling and conduit, and connections to other systems:
    a. Telecommunications (voice, data, CATV).
    b. Security and other alarms.
    c. Audiovisual.
9. Detail drawings:
    a. Details and elevations, specific to the project scope of work, necessary to completely describe the scope of work.

9.4 Final Design Requirements (100% Un-reviewed)

The 100% un-reviewed submittal should be a complete, 100% submittal. 100% of the expected drawings to a 100% design level. This gives CAP an opportunity to review and provide comments on the complete submittal.

9.4.1 Final Design Drawings

Drawings to include, as applicable:

1. Fully developed drawings with review comments from previous submittal fully addressed.
2. Final layout of the electrical systems, including diagrams, details, circuiting and schedules.

9.5 Ready-to-Advertise Design Requirements (100% Reviewed)

The 100% reviewed submittal is the complete, 100% submittal with CAP comments incorporated from the 100% un-reviewed submittal.

9.5.1 Ready-to-Advertise Design Drawings

Drawings to include, as applicable:

Fully developed drawings from previous submittal addressing any comments provided by CAP.

10.0 Electrical – Instrumentation and Controls Design

This section identifies the requirements to define the major components of the electrical control systems to be modified as part of the design in addition to the requirements of section 1.5. This chapter includes, but not limited to, systems such as low voltage control or protection circuits, instrumentation, programmable controllers, and automated equipment.

10.2 Preliminary Design Requirements (30%)

10.2.1 Preliminary Drawings

Drawings to include, as applicable:

1. Process Flow Diagram
2. Piping and Instrumentation Diagram
3. Control Block Diagram
4. Control System Architecture Diagram
5. Instrumentation Schedule

10.2.2 Preliminary Design Analysis

Written narrative to include, as applicable:

1. Control system description to include:
    a. Type of control system required, such as relay logic, programmable logic controller, distributed control system, or supervisory control.
    b. Modes of operation
    c. Sequence of operations

    d. Operating permissives
    e. Monitoring and alarming functions
    f. Input and output requirements
2. Instrumentation, devices, or functions to monitor and control the process.
    a. Field instrumentation to be removed or replaced.
    b. Design instrumentation requirements
    c. Performance requirements
    d. Installation and selection criteria
    e. Tag names
3. Control system architecture to include:
    a. Existing control panels which require design changes.
    b. New control panels
    c. Local or remote operator interface
    d. Connection to supervisory control and data acquisition
    e. Network connections to other control systems, devices or core network.

10.3 Interim Design Requirements (60%)

10.3.1 Interim Drawings

The interim instrumentation and control design drawings will convey all the work required for construction. The DC will identify any existing drawings that will become obsolete or superseded during the design. Interim drawings to include, as applicable:

1. Piping and Instrumentation Diagram depicting and identifying instruments or devices and their functions. Refer to ANSI/ISA 5.1 -2009 Instrumentation Symbols and Identification. Include as a minimum:
    a. Instrumentation graphic symbol with identification number
    b. Inputs and outputs identification
    c. Control devices and functions
    d. Network connections
2. Control System Architecture Diagram
3. Electrical control schematic design will include revisions to the existing equipment control schematics and may require new schematic drawings. The design will include all devices, to be removed or replaced by the new construction. Unit Control, Unit Protection, and Annunciation drawings must convey all the circuit information required to complete the work.
4. Electrical wiring diagram design will include revisions to the existing equipment wiring diagrams and may require new wiring diagrams. Wiring diagrams shall agree with the corresponding system electrical schematic.
5. Electrical Control Panel Arrangement
    a. Component layout
    b. Bill of Materials List
6. Equipment and Device Location Plan
7. Installation Details

10.3.2 Interim Technical Documents

1. Control narrative
2. Instrumentation Data Sheet
3. Control input and output schedule

10.4 Final Design Requirements (100% Un-reviewed)

All drawings and specifications are to be fully complete at this submission and are to be considered CONSTRUCTION READY. CAP to perform final drawing review at this point to review all comments have been addressed, there are no drawing standard issues, etc. The designer shall incorporate or answer all comments received during the Interim Submittal review.

11.0 Electrical Power and Control Drawing Standard

This section of the Design Guidelines Manual is intended to provide standard procedures, instruction and examples for the interpretation and creation of CAP power and control drawings. This document is issued for guidance in developing design drawings that will integrate into the existing CAP drawings and new drawings. The term “panel” in this section is interchangeable with the term “enclosure” and is defined as any enclosure with more than two electrical device.

11.1 Recommended Publications

1. C37.2-2008 – IEEE Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.
2. NEMA Standards Publication ICS 19-2002 (R2007) Diagrams, Device Designations, and Symbols for Industrial Control and Systems
3. ANSI/ISA-5.1-2009 Instrumentation Symbols and Identification
4. NFPA70 National Electrical Code 2017

11.2 Standard Drawings

CAP will provide standard electrical symbol drawings. All symbols will be individual blocks that can be copied and used in the design drawings. Attributes are incorporated in the blocks as needed for assigning size, name, rating, or other designations. If the design requires the use of a symbol, not included in the standard drawings, the designer shall create the new symbol to meet all CAP block requirements.

11.2.1 Functions and Acronym Definitions

Device function numbers and acronym definitions are included in the reference drawing STD-E-C07527 FUNCTIONS AND DESIGNATIONS (Appendix A). CAP utilizes the ANSI/IEEE Standard device function numbers for control and protection. This standard drawing includes tables for instrumentation and metering, control and protection, transformers, switches, contacts, relays, and conductor color acronym to be used.

The device function numbers and acronyms are used to create a unique device designation. No device function shall be duplicated. When two or more devices perform exactly the same function, a number starting at one (1), will follow the designation. For example, three auxiliary relays to device 469U are labeled 469U1, 469U2, and 469U3.

11.2.3 Single-line and Schematic Diagram Symbols

Graphical symbols used for single-line and schematic diagrams are included in the reference drawing STD-E-C07528 SINGLE-LINE AND SCHEMATIC SYMBOL (Appendix B). NEMA Standards ICS 19-2002 diagram symbols can be used for symbols not included in the standard drawing.

Contacts in control circuits are shown in the de-energized position. Liquid level switches are shown with the liquid container empty. Vacuum and pressure switches are shown at ambient pressure. Temperature switches are shown at ambient temperature. Where polarity marks are used, the (+) sign is positive and the (–) sign is negative.

Make wire connection with a solid dot connection. Wire that do not connect, are allowed to cross with no solid dot.

11.2.3 Instrumentation Legend and Symbols

The standard drawing STD-E-C19717 INSTRUMENTATION LEGEND AND SYMBOL (Appendix C), contains the most common legends and symbols used to graphically depict measurement and control instrumentation, and control devices and functions. This standard drawing is used to develop Conceptual Design drawing such as a Process Flow Diagram (PFD) and Construction Design Piping and Instrumentation Diagrams (P&ID).

If the control system requires a designation or symbol not shown on the standard drawing, use the ANSI/ISA-5.1-2009 Standard.

11.3 Nomenclature and Numbering

11.3.1 Electrical Equipment List

The electrical equipment designation include designation, description, and location of the principle electrical equipment. Electrical equipment is designated by means of a group of three symbols.

The first symbol in an equipment designation is a single capital letter and represents the type of equipment according to the KEY LIST FOR EQUIPMENT SYMBOLS (Appendix D).

The second symbol in an equipment designation represents the physical location of the equipment. It is a capital letter (or letters) or a number according to the KEY LIST FOR LOCATION SYMBOLS (Appendix E).

The third symbol in an equipment designation is a capital letter, starting from A, used to differentiate between various pieces of equipment of the same type and in the same location.

As an example of an equipment designation, consider an electrical control panel for Unit No. 3 in a Pumping Plant. Assume that this panel is located in the same bay as Unit No. 3.

The designation for this control panel is as follows: The first symbol always represents the type of equipment from the KEY LIST OF EQUIPMENT SYMBOLS. The symbol “C” represents control or terminal boards. Therefore, “C” is the first symbol of the designation. The next symbol represents the physical location from the KEY LIST FOR LOCATION SYMBOLS. The number “2” represent the location of Main Unit Bay No. 2. Therefore, it is the second symbol. Assuming that there are no other control panels in the Main Unit Bay No. 2, the third symbol is a differentiation letter “A”. The complete designation is “C2A”.

Type of Equipment	Location	Differentiation
C	2	A

If the design requires the addition of a new control panel in the location of the Main Unit Bay No. 3, regardless of the elevation within the Pumping Plant, its designation would be C2B.

11.3.2 Cables and Conduits List

Cable and conduit designations for power, control, and lighting systems are designated in a similar manner. Refer to Appendix G for an example of a Routing List.

Cables and conduits are designated in two parts separated by a dash. The first part consists of the equipment designation, as determined by 11.2.1 above, (plus a panel or compartment number, if this equipment has more than one panel or compartment). The second part consists of the designation of the equipment at the other end of the cable or conduit, (plus a panel or compartment number if necessary). This represents a “From – To” designation, such as H1A–M1A.

In addition to this, control cable designation will be preceded by a numeral consecutively numbering the cables extending from the same piece of equipment or from each panel or cubicle of equipment. The numerals for cables from the next panel would start again with 1. For example, if three cables extend from H1A and enter M1A at the other end, they would be designated as 1H1A–M1A, 2H1A–M1A, and 3H1A–M1A.

The circuit number will precede the designation for power cables and conduits. For example, 4DSA-M1A would be the fourth power circuit exiting the “A” power distribution board, located in the Service Bay.

All conduit designations will be preceded by the nominal diameter of the conduit in inches separated from the rest of the conduit designation by a dash. In the example above, if all three cables are located within a 3 inch diameter conduit, the conduit designation would be 3-1H1A-M1A.

When conduits enter and terminate at an undesignated junction or terminal point and then continue as two or more conduits as a branch, each branch is designated with the designation of the original conduit plus a suffix (lower case letter). Each suffix is to be consecutive. All branches of the original conduit are to be designated in this manner, regardless of the number of branches or number of undesignated junction and/or terminal points associated with the original conduit. For example, the main or original conduit would designated 1"-2BSA and each branch would be designated the same as the main conduit with the addition of a suffix as 3/4"-2BSAa, for the first branch out of the junction box, 3/4"-2BSAb for the second branch, etc.

Control and/or power cable installed in the branch conduit described previously will also be designated by adding a suffix (lower case letter) to the designation of the original cable.

In the event the conduit enters a trench under a switchboard, the designation of the conduit should not show the panel number. The omission of the panel number in this event is desired because the physical termination of the conduit may not be at the location of the panel with which it is to be associated.

In some instances, where the equipment at the terminal end is not designated, a cable or conduit designation will have no second part or intervening dash.

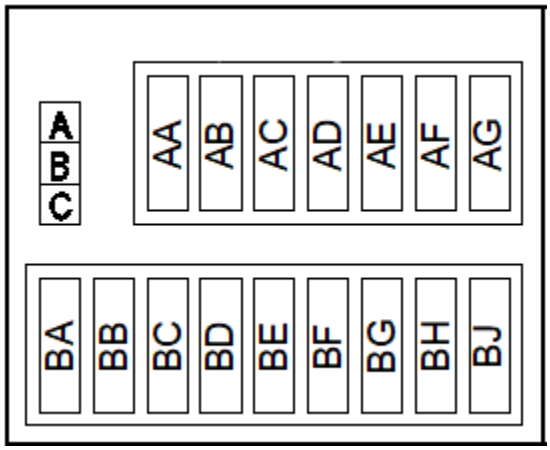
Designations of conduits for lighting consist only of the designation of the panelboard at which the conduits originate preceded by a number; the number will be different for each conduit 1”-2LDCA.

11.4 Devices

11.4.1 Panel Components

It is common to mount devices such as relays, terminal blocks, power supplies, signal conditioners, Programmable Logic Controllers, etc. on panels within an electrical enclosure. Devices mounted on panels inside control cabinets are identified with a two letter designation by

their location on the panel in a row, column format. Groups of terminal blocks are usually identified by a single letter (A though C below). Individual terminals blocks within a grouping are identified by by a number. So, if group A has 12 terminals blocks they are individually referred to as A1, A2…A12. All Device Location designations are unique on a panel.



Panel Layout with Device Locations

11.5 Piping and Instrumentation (P&ID) Diagram Development

P&IDs are Piping and Instrumentation Drawings though they are sometimes referred to as Process and Instrumentation Drawings due to their use in defining control processes. P&IDs are classified by CAP as Electrical drawings though they may fall under Mechanical or Electrical Instrumentation and Control requirements depending upon the project. CAP requires adherence to the ANSI/ISA 5.1-2009 Instrumentation Symbols and Identification standard which is also illustrated in CAP drawing STD-E-C19717 INSTRUMENTATION LEGEND AND SYMBOL.

11.6 Schematic Diagram Development

The purpose of the schematic diagram should be to provide a representation all the circuit elements and how their function relate to each other to control the process. The schematic should include the main circuit and all auxiliary circuits for control, signaling, annunciation, and protection. A schematic diagram must be developed for all circuits that include a controlling device beyond a circuit breaker or fuse. The circuit representation must be shown with sufficient detail to explain local and remote control functions

11.6.1 Device Designation

The device designation is to be descriptive of the function of the device and unique within the system. Device function numbers and acronym definitions are included in the reference drawing STD-E-C07527 FUNCTIONS AND DESIGNATIONS (Appendix A). CAP utilizes C37.2-2008 ANSI/IEEE Standard for device function numbers in control and protection.

The example in Figure 1(callout 2) would represent the first time delay relay used on a Fire System control. From STD-E-C07527:

02F1 = (02) TIME-DELAY RELAY + (F) FIRE AND CO2 SYSTEM + (1) First numeric Identifier

A second time delay relay located in the same enclosure and associated with the fire control system would have the device designation 02F2.

When multiple pumping units have similar control or protection systems, they often have devices with similar functions. In this instance, the unit number will be used as the unique identifier. The unique identifier (Unit Number) may be a prefix or suffix to the device designation. For example, the device designation 233DVC or 33DVC2 may be used for a limit switch that is triggered when the discharge valve is closed on unit number 2. Refer to the existing plant drawings to determine which method is preferred.

11.6.2 Device Symbol

The CAP standard device symbols are included in the reference drawing STD-E-C07528 SINGLE-LINE AND SCHEMATIC DIAGRAMS. Each device should include a unique device designation. The device designation is shown above a horizontally placed symbol or to either side of a vertically placed symbol.

As applicable, use a word or letter to describe the function of a device, such as “STOP”, “START”, “R” for remote, or “L” for local. The function description is shown below a horizontally placed symbol or to either side of a vertically placed symbol.

If the device is physically located in a different enclosure, than listed on the drawing title block, the location enclosure designation will be shown in parenthesis. The enclosure designation will be shown below a horizontally symbol or to either side of a vertically placed symbol.

The device terminal connections are represented by small hollow circles at either side.

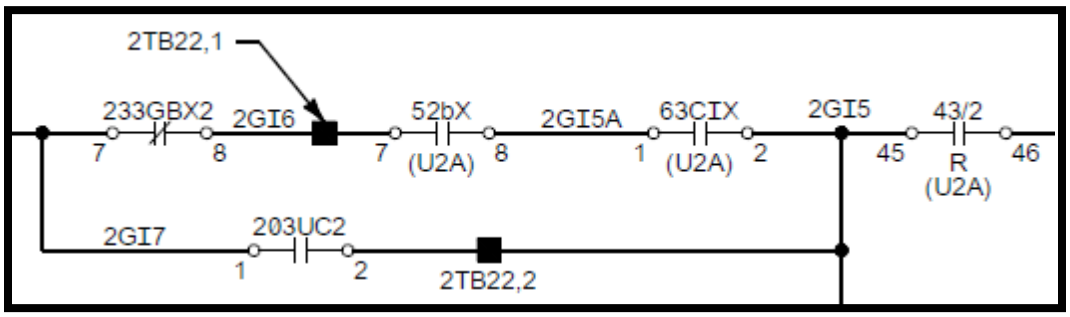


FIGURE 1: DEVICE SYMBOLS, TERMINAL BLOCKS, AND WIRE DESIGNATION (HORIZONTAL)

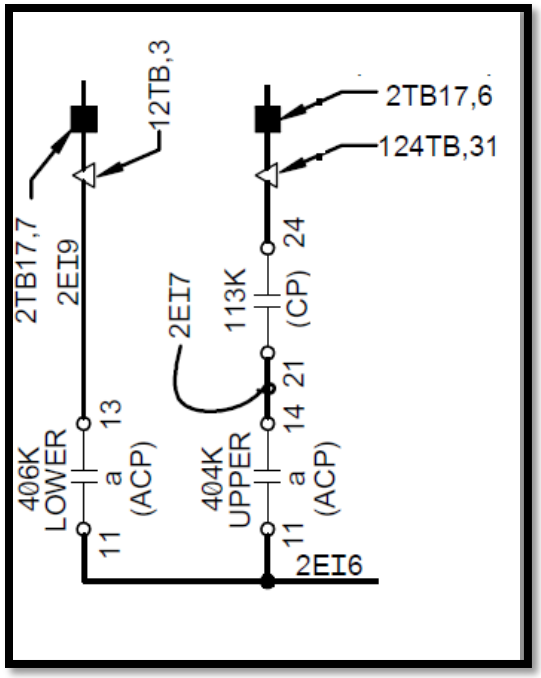


FIGURE 2: DEVICE SYMBOLS, TERMINAL BLOCKS, AND WIRE DESIGNATION (VERTICAL)

11.6.3 Terminal Blocks

The terminal block graphic is a unique geometric shape that shall also represent the enclosure location of the terminal. The terminal block designation and number must match the wiring diagram. A legend will be included in each sheet with the geometric shape and text, which denotes the terminal block enclosure.

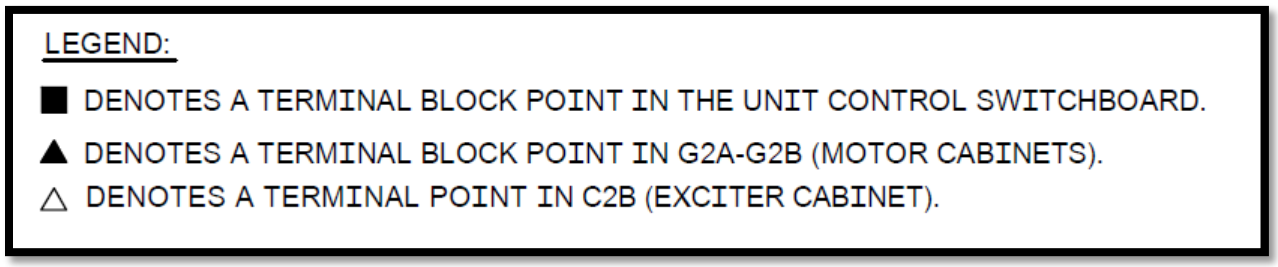


FIGURE 3: TERMINAL BLOCK LEGEND

11.6.4 Coils and Contacts

Each coil must have the associated contact developed. The preferred method is to show the contacts on the same sheet as the coil. If the sheet does not have available space, a separate sheet may be used to show the contact development.

Contacts are shown in the de-energized state. All contacts must be shown, even if they are spare or not used. The contact development shall include the coil designation, de-energized state, terminal numbers, wire designation, purpose, and reference drawing. The reference

drawing is the drawing in which the contact can be located. CAP drawings do not use rung numbers to reference the location of the contact. The reference drawing number is used and shown in parenthesis. If the contact is located in the same sheet as the coil, use (THIS DWG).

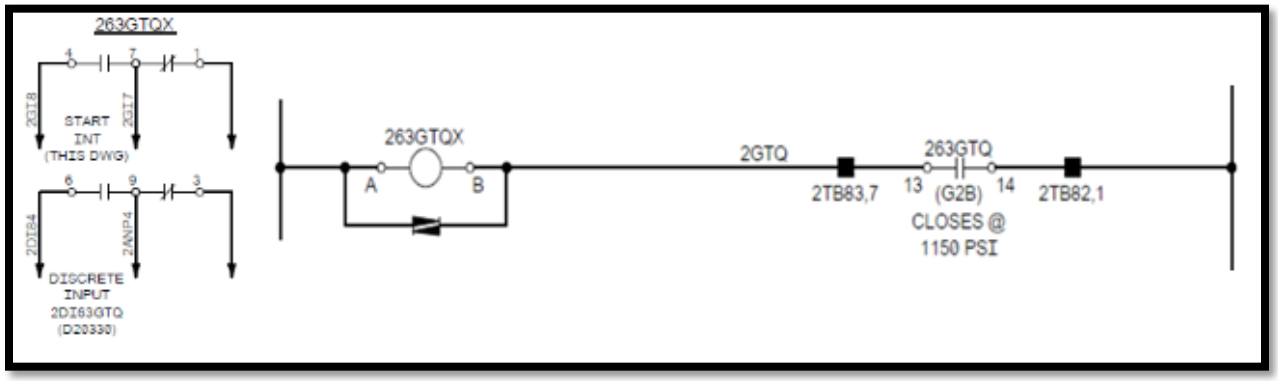


FIGURE 4: RELAY COIL AND CONTACTS

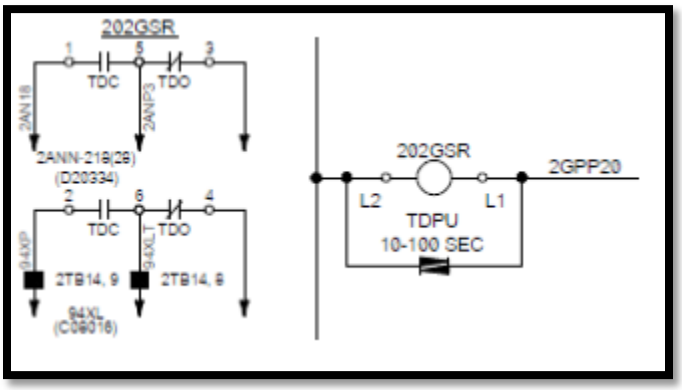


FIGURE 5: TIMER COIL AND CONTACTS

11.6.5 Device Names and Functions Table

Each sheet shall contain a device names and function table. The table must include:

1. The device designation (Number) as assigned using drawing STD-E-C07527 FUNCTIONS AND DESIGNATIONS (Appendix A).
2. The manufacturer's OEM number, if applicable.
3. Description of the device function.

EXPLANATIONS		
DEVICE		DESCRIPTION
USBR NUMBER	MFR. NUMBER	
201AG		UNIT GOVERNOR INTERLOCK AUXILIARY RELAY
201EG		UNIT EXCITER INTERLOCK AUXILIARY RELAY
201GG		UNIT PUMP/GENERATOR INTERLOCK AUXILIARY RELAY
201HG		UNIT TURBINE INTERLOCK AUXILIARY RELAY

FIGURE 6: DEVICE NAMES AND FUNCTIONS TABLE

11.6.6 Wire Designations (Name)

Wire designations are always unique within the system. The wire designation does not change across terminal block connections. Wire designations will only change across a control device. Several unique alpha and/or numeric wire designations may be required to complete a circuit.

CAP standard is to use descriptive wire designations. For example in Figure 1, the wire from terminal block 2TB22,1 and terminal 8, on normally contact from device 233GBX2, is 2GI6. This is the sixth wire on the unit control circuit for Unit #2 generator interlock.

2GI6 = (2) Unit Number + (G) Generator + (I) Interlock + (6) sixth wire

The next wire in the same circuit may be a designation as 2GI7 and continue to increment by one.

2GI7 = (2) Unit Number + (G) Generator + (I) Interlock + (7) seventh wire

An alphabetic character can be used, only after a numeric character to differentiate wires in a circuit.

2GI7A = (2) Unit Number + (G) Generator + (I) Interlock + (7) seventh wire + (A) section

When multiple pumping units have similar control or protection systems, they often have similar wire designations, with the exception of a first identifier. The first identifier, in this example, is the unit number.

2GI6 = (2) Unit # 2 Control + (G) Generator + (I) Interlock + (6) sixth wire

3GI6 = (3) Unit # 3 Control + (G) Generator + (I) Interlock + (6) sixth wire.

11.7 Wiring Diagram Development

The wiring diagram is a graphical representation of the physical layout and wiring of the electrical enclosure. The wiring diagram must have the devices arranged on the drawing, as they are physically located within the enclosure. On the wiring diagram, place devices mounted on a door as installed with the door open and viewed from the rear. Wiring diagrams must

include the device location, device designation, wire designation, wire color, wire destination, wire tags and terminal identification as referenced in this guide. Design drawings must show the complete circuit wiring diagram changes, even if the circuit is shown in multiple drawings.

11.7.1 Device Location

The placement of the device in panel determines the device location designation. The enclosure is segmented into a grid of alphabetic rows and columns. Begin the grid on the top-left corner. The rows start at the top with the letter “A”. The columns start at the far left with the letter “A”. The same applies to devices mounted on a door or side panel. Show devices mounted on the door viewed from the back, with the door open.

The example in Figure 1 (callout 1) would represent a relay in row “B”, column “D”. It is in the second row of devices and the fourth column from the left.

11.7.2 Device Designation

The device designation is to be descriptive of the function of the device and unique within the system. Device function numbers and acronym definitions are included in the reference drawing STD-E-C07527 FUNCTIONS AND DESIGNATIONS (Appendix A). CAP utilizes C37.2-2008 ANSI/IEEE Standard for device function numbers in control and protection.

The example in Figure 1(callout 2) would represent the first time delay relay used on a Fire System control. From STD-E-C07527:

02F1 = (02) TIME-DELAY RELAY + (F) FIRE AND CO2 SYSTEM + (1) First numeric Identifier

A second time delay relay located in the same enclosure and associated with the fire control system would have the device designation 02F2.

When multiple pumping units have similar control or protection systems, they often have devices with similar functions. In this instance, the unit number will be used as the unique identifier. The unique identifier (Unit Number) may be a prefix or suffix to the device designation. For example, the device designation 233DVC or 33DVC2 may be used for a limit switch that is triggered when the discharge valve is closed on unit number 2. Refer to the existing plant drawings to determine which method is preferred.

11.7.3 Terminal Block Designation

The terminal block designation is a single, underlined letter Figure 4(callout 1). The letter is shown on the top of vertically placed blocks and at the far left of horizontally placed blocks. Designate the first terminal block as “A” and increase alphabetically throughout the enclosure. The block terminal numbers will always begin at number one and increase numerically until the end of the block. For example, terminal block “C” is the third block in the enclosure. The first terminal number will be the number one, regardless of the quantity of terminals that are in terminal blocks “A” or “B”.

In some cases, the original equipment manufacturer may have used a non-standard terminal block designation. This non-standard terminal block is shown under the established standard letter designation Figure 4(callout 2).

11.7.4 Wire Designations (Name)

Wire designations are always unique within the system. The wire designations do not change across terminal block connections. Wire designations will only change across a control device. Several wire designations may be required to complete a circuit. A unique alpha and/or numeric identifier may be used to create the wire designations in a circuit.

CAP standard is to use descriptive wire designations. For example in Figure 1(callout 4), the circuit that contains the normally open contact across terminals 2 and 6, has the wire designations 1FCT1 and 1FCT2. The unique identifier is increased by one as the wire crosses the normally open contact.

Whenever possible, incorporate the function of the circuit into the wire designation. In this example, 1FCT1 is representative of a wire that is part of the fire control timer (02F1). Refer to section 13.6.2 Device designations.

1FTC1 = (1) First timing relay 02F1 circuit + (FCT) Fire Control Timer + (1) First numeric identifier

1FTC2 = (1) First timing relay 02F1 circuit + (FCT) Fire Control Timer + (2) Second numeric identifier

When multiple pumping units have similar control or protection systems, they often have similar wire designations, with the exception of a second identifier. The second identifier is the unit number. For example, 4A10C and 5A10C wire designations can be used on the third wire of the tenth annunciation point. However, one is used in the annunciation system of unit 4 and the other on unit 5.

4A10C = (4) Unit #4 + (A) Annunciation + (10) Annunciation Circuit #10 + (C) Third alpha identifier

5A10C = (5) Unit #5 + (A) Annunciation + (10) Annunciation Circuit #10 + (C) Third alpha identifier

11.7.5 Wire Destination

In a wiring diagram use wire destinations to allow for an extension reference to the same wire in the drawing. The wire destination details where the other end of the wire terminates. This is often required to prevent lines from crowding the drawing. A wire destination includes several parts. Refer to Figure 2. A proper wire destination will include the wire designation, device or terminal stud number, device location or terminal block name, and destination enclosure. There are two different methods used to document the wire destination. One method is required when referencing the wire destination on a device and the second is used on a terminal block.

11.7.6 Wire Destination for Devices

The wire destination on devices are arrange in the following order (Figure 2):

1. Place the wire designation closest to the device and followed by a dash.
2. Next, include the destination device location or terminal block name.
3. The device or terminal block stud is next. If the placement of the device location or terminal block name, from step 2, and the device or terminal block stud, results in adjacent numbers or letter, a comma is used as a separator. If the characters are not of a similar type, then no separator is used.
4. Finally, if the wire exits the enclosure or terminates in a different cubicle of the same equipment, the destination enclosure or cubicle designation, as determined by 11.2.1 Electrical Equipment, is placed in parentheses.

Some examples are shown:

Figure 1 (callout 3) the wire destination is S2,3-1FCT21. The wire designation is 1FCT21 and terminates at device S2 on stud number 3. Because the terminal block and stud number create adjacent numbers, a comma separates two and three.

Figure 1 (callout 4) the wire destination is 1FCT2-S1,7. The wire designation is 1FCT2 and terminates at device S1 on stud number 7. Because the terminal block and stud number create adjacent numbers, a comma separates two and seven.

Figure 1 (callout 5) the wire destination is F11-2FCT2. The wire designation is 2FCT2 and terminates at terminal block F on stud number 11. Because there is no comma between the characters following F, it is determined that the stud number is 11, not 1. (Note: F1,1 would mean the wire terminates at fuse 1 on stud number 1)

Figure 1 (callout 6) the wire destination is (C8)H6-1FCT. The wire designation is 1FCT. It terminates on terminal block H on stud number 6, in panel C8. It terminated in a different enclosure with the equipment name C8, because it is in parenthesis.

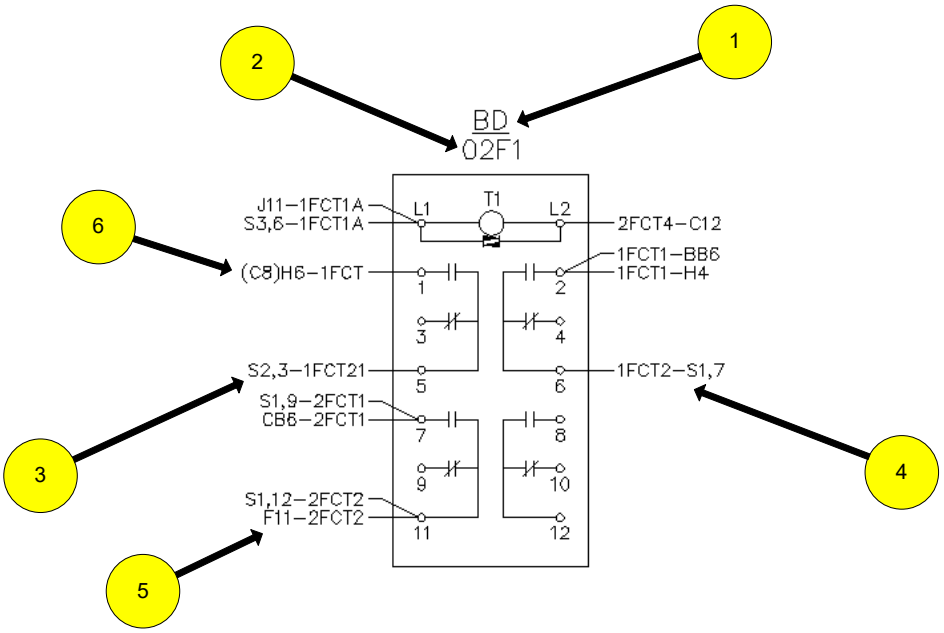
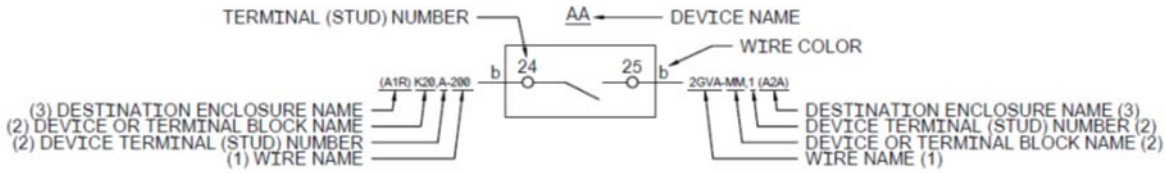


FIGURE 1: RELAY IN A WIRING DIAGRAM



1. WIRE NAME DESIGNATION IS CLOSEST TO THE DEVICE FOLLOWED BY A DASH.
2. DESTINATION INCLUDES THE DEVICE OR TERMINAL BLOCK NAME AND THE TERMINAL (STUD) DESIGNATION SEPERATED BY A COMMA.
3. IF THE WIRE DESTINATION LEAVES THE ENCLOSURE, THE DESTINATION ENCLOSURE IS SHOWN IN PARENTHESES ( ).
4. ONLY THE WIRE NAME SHALL BE ON THE WIRE LABEL. DEVICE NAME, TERMINAL BLOCK NAME OR (STUD) DESIGNATION NUMBER SHALL NOT BE ON THE LABEL.

FIGURE 2: SWITCH IN A WIRING DIAGRAM

11.7.7 Wire Destination for Terminal Blocks

Use the terminal block standard layout to create the wire destination for terminal blocks Figure 3.

1. Place the wire designation inside the terminal block rectangle.
2. On the corresponding terminal number, place the wire associated with the wire designation.
3. At the end of the wire, place the destination device location or terminal block designation.
4. The destination device or terminal block stud is next. Use a comma to separate the device location or terminal block designation, from step 3, and the device or terminal block stud.
5. If the wire terminates in a different cubicle of the same equipment, the destination cubicle designation, as determined by 11.3.1 Electrical Equipment, is placed in parentheses.
6. If the wire exits the enclosure, it is shown as a cable. Refer to 11.7.8 CABLE LIST AND CABLE DESIGNATION. In this instance, even a single conductor is considered a cable. The cable is given a cable designation number and listed in a Cable List, Figure 5. The cable designation is assigned per 11.3.2 CABLES AND CONDUIT LIST.

11.7.8 Cable List and Cable Designation

Use a cable list and cable designation number for any wire or wires that exit the enclosure. In wiring diagrams, single conductors that have the same destination enclosure or external device are represent by a cable. The color code designation of each conductor must be included in the wiring diagram (Figure 3). For multi-conductor cable, use color code designation per ICEA Method 1, Table E-2 (Appendix H). Assign each cable a unique cable designation as detailed in 11.3.2 CABLES AND CONDUIT LIST.

Develop the cable list to include the cable designation number, cable designation, destination drawing number, and size of the single or multiple conductor cable. Refer to Figure 4 and Figure 5 for an example of a cable and cable list in a wiring diagram.

Note that the wiring diagram for the destination enclosure must be updated to match with the originating enclosure.

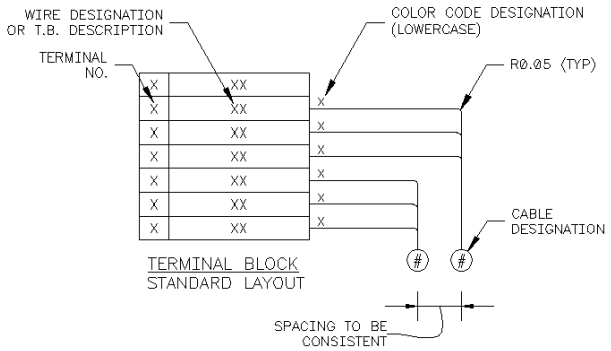


FIGURE 3: TERMINAL BLOCK STANDARD LAYOUT

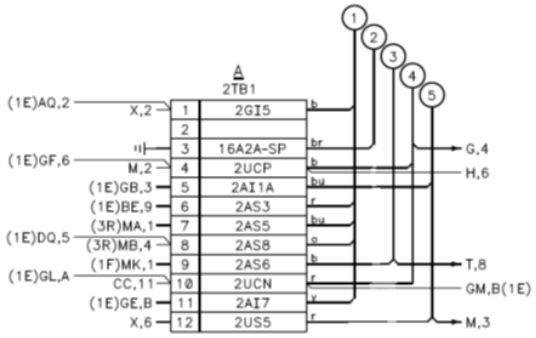


FIGURE 4: TERMINAL BLOCK IN A WIRING DIAGRAM

CABLE LIST

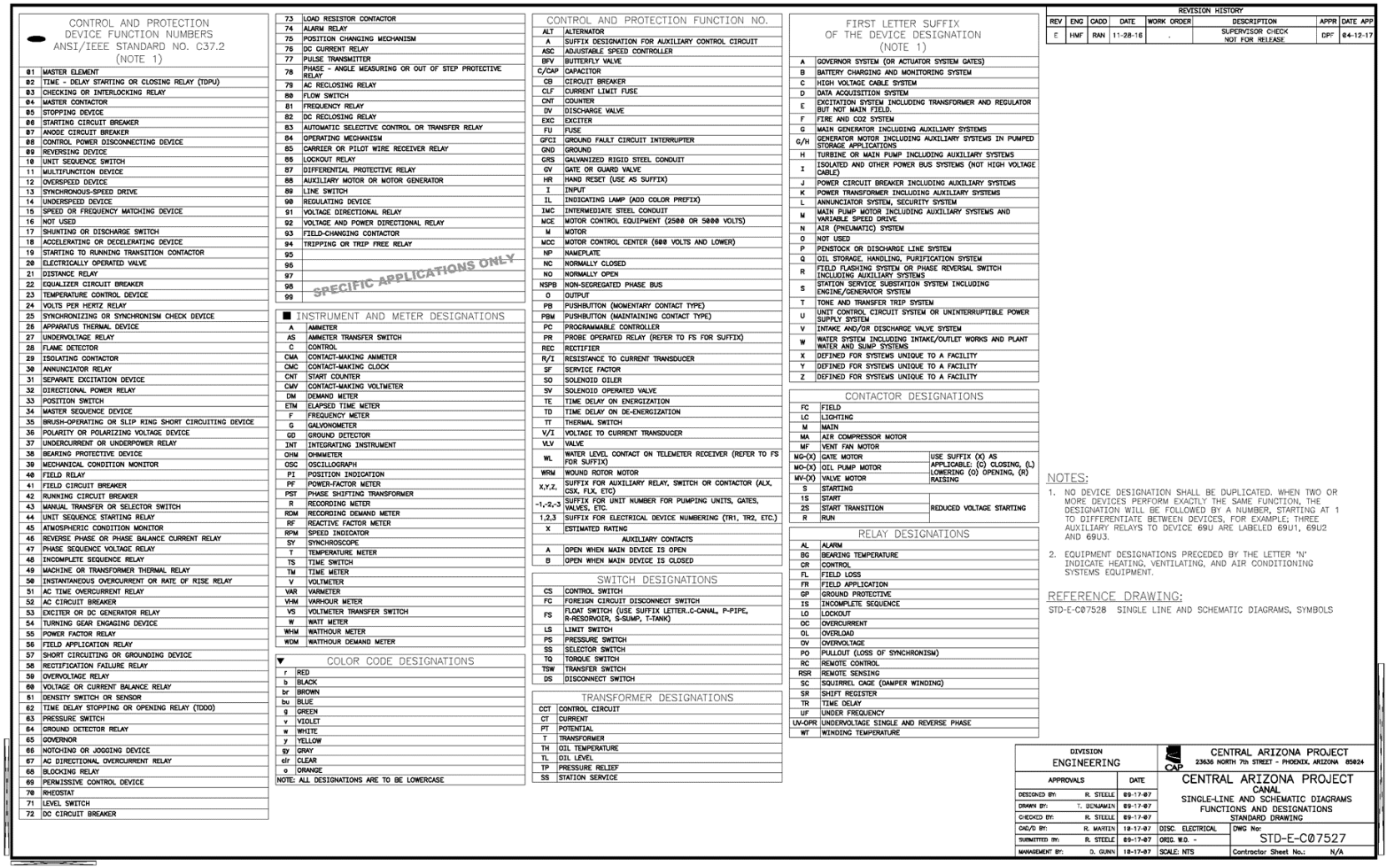
◯	DESIGNATION	PRINT	SIZE
1	18A2A-C2A1R	D20663	1-12/C-10
2	16A2A-C2A1R	D20663	1-12/C-10
3	3A2A-C2A1R	D20662	1-12/C-10
4	5A2A-C2A1R	D20662	1-5/C-10
5	14A2A-C2A1R	D20662	1-9/C-10

FIGURE 5: CABLE LIST IN A WIRING DIAGRAM

APPENDICES

APPENDIX A1: STD-E-C07527 FUNCTIONS AND DESIGNATIONS
APPENDIX A2: STD-E-C07528 SINGLE-LINE AND SCHEMATIC SYMBOLS
APPENDIX A3: STD-E-C19717 INSTRUMENTATION LEGEND AND SYMBOLS
APPENDIX A4: KEY LIST FOR EQUIPMENT SYMBOLS
APPENDIX A5: KEY LIST FOR LOCATION SYMBOL
APPENDIX A6: KEY PLAN – LOCATION
APPENDIX A7: ROUTING LIST
APPENDIX A8: COLOR CODE STANDARD FOR CONTROL CABLES
APPENDIX A9: SCHEMATIC DIAGRAM EXAMPLE
APPENDIX A10: WIRING DIAGRAM EXAMPLE

APPENDIX A1: STD-E-C07527 FUNCTIONS AND DESIGNATIONS



CONTROL AND PROTECTION DEVICE FUNCTION NUMBERS ANSI/IEEE STANDARD NO. C37.2 (NOTE 1)

01	MASTER ELEMENT
02	TIME - DELAY STARTING OR CLOSING RELAY (TDPU)
03	CHECKING OR INTERLOCKING RELAY
04	MASTER CONTACTOR
05	STOPPING DEVICE
06	STARTING CIRCUIT BREAKER
07	ANODE CIRCUIT BREAKER
08	CONTROL POWER DISCONNECTING DEVICE
09	REVERSING DEVICE
10	UNIT SEQUENCE SWITCH
11	MULTIFUNCTION DEVICE
12	OVERSPEED DEVICE
13	SYNCHRONOUS-SPEED DRIVE
14	UNDERSPEED DEVICE
15	SPEED OR FREQUENCY MATCHING DEVICE
16	NOT USED
17	SHUNTING OR DISCHARGE SWITCH
18	ACCELERATING OR DECELERATING DEVICE
19	STARTING TO RUNNING TRANSITION CONTACTOR
20	ELECTRICALLY OPERATED VALVE
21	DISTANCE RELAY
22	EQUALIZER CIRCUIT BREAKER
23	TEMPERATURE CONTROL DEVICE
24	VOLTS PER HERTZ RELAY
25	SYNCHRONIZING OR SYNCHRONISM CHECK DEVICE
26	APPARATUS THERMAL DEVICE
27	UNDERVOLTAGE RELAY
28	FLAME DETECTOR
29	ISOLATING CONTACTOR
30	ANNUNCIATOR RELAY
31	SEPARATE EXCITATION DEVICE
32	DIRECTIONAL POWER RELAY
33	POSITION SWITCH
34	MASTER SEQUENCE DEVICE
35	BRUSH-OPERATING OR SLIP RING SHORT CIRCUITING DEVICE
36	POLARITY OR POLARIZING VOLTAGE DEVICE
37	UNDERCURRENT OR UNDERPOWER RELAY
38	BEARING PROTECTIVE DEVICE
39	MECHANICAL CONDITION MONITOR
40	FIELD RELAY
41	FIELD CIRCUIT BREAKER
42	RUNNING CIRCUIT BREAKER
43	MANUAL TRANSFER OR SELECTOR SWITCH
44	UNIT SEQUENCE STARTING RELAY
45	ATMOSPHERIC CONDITION MONITOR
46	REVERSE PHASE OR PHASE BALANCE CURRENT RELAY
47	PHASE SEQUENCE VOLTAGE RELAY
48	INCOMPLETE SEQUENCE RELAY
49	MACHINE OR TRANSFORMER THERMAL RELAY
50	INSTANTANEOUS OVERCURRENT OR RATE OF RISE RELAY
51	AC TIME OVERCURRENT RELAY
52	AC CIRCUIT BREAKER
53	EXCITER OR DC GENERATOR RELAY
54	TURNING GEAR ENGAGING DEVICE
55	POWER FACTOR RELAY
56	FIELD APPLICATION RELAY
57	SHORT CIRCUITING OR GROUNDING DEVICE
58	RECTIFICATION FAILURE RELAY
59	OVERVOLTAGE RELAY
60	VOLTAGE OR CURRENT BALANCE RELAY
61	DENSITY SWITCH OR SENSOR
62	TIME DELAY STOPPING OR OPENING RELAY (TDDO)
63	PRESSURE SWITCH
64	GROUND DETECTOR RELAY
65	GOVERNOR
66	NOTCHING OR JOGGING DEVICE
67	AC DIRECTIONAL OVERCURRENT RELAY
68	BLOCKING RELAY
69	PERMISSIVE CONTROL DEVICE
70	RHEOSTAT
71	LEVEL SWITCH
72	DC CIRCUIT BREAKER
73	LOAD RESISTOR CONTACTOR
74	ALARM RELAY
75	POSITION CHANGING MECHANISM
76	DC CURRENT RELAY
77	PULSE TRANSMITTER
78	PHASE - ANGLE MEASURING OR OUT OF STEP PROTECTIVE RELAY
79	AC RECLOSING RELAY
80	FLOW SWITCH
81	FREQUENCY RELAY
82	DC RECLOSING RELAY
83	AUTOMATIC SELECTIVE CONTROL OR TRANSFER RELAY
84	OPERATING MECHANISM
85	CARRIER OR PILOT WIRE RECEIVER RELAY
86	LOCKOUT RELAY
87	DIFFERENTIAL PROTECTIVE RELAY
88	AUXILIARY MOTOR OR MOTOR GENERATOR
89	LINE SWITCH
90	REGULATING DEVICE
91	VOLTAGE DIRECTIONAL RELAY
92	VOLTAGE AND POWER DIRECTIONAL RELAY
93	FIELD-CHANGING CONTACTOR
94	TRIPPING OR TRIP FREE RELAY
95	
96	
97	
98	
99	

SPECIFIC APPLICATIONS ONLY

INSTRUMENT AND METER DESIGNATIONS

A	AMMETER
AS	AMMETER TRANSFER SWITCH
C	CONTROL
CMA	CONTACT-MAKING AMMETER
CMC	CONTACT-MAKING CLOCK
CNT	START COUNTER
CMV	CONTACT-MAKING VOLTMETER
DM	DEMAND METER
ETM	ELAPSED TIME METER
F	FREQUENCY METER
G	GALVONOMETER
GD	GROUND DETECTOR
INT	INTEGRATING INSTRUMENT
OHM	OHMMETER
OSC	OSCILLOGRAPH
PI	POSITION INDICATION
PF	POWER-FACTOR METER
PST	PHASE SHIFTING TRANSFORMER
R	RECORDING METER
RDM	RECORDING DEMAND METER
RF	REACTIVE FACTOR METER
RPM	SPEED INDICATOR
SY	SYNCHROSCOPE
T	TEMPERATURE METER
TS	TIME SWITCH
TM	TIME METER
V	VOLTMETER
VAR	VARMETER
VHM	VARHOUR METER
VS	VOLTMETER TRANSFER SWITCH
W	WATT METER
WHM	WATTHOUR METER
WDM	WATTHOUR DEMAND METER

COLOR CODE DESIGNATIONS

r	RED
b	BLACK
br	BROWN
bu	BLUE
g	GREEN
v	VIOLET
w	WHITE
y	YELLOW
gy	GRAY
clr	CLEAR
o	ORANGE

NOTE: ALL DESIGNATIONS ARE TO BE LOWERCASE

CONTROL AND PROTECTION FUNCTION NO. (NOTE 1)

ALT	ALTERNATOR
A	SUFFIX DESIGNATION FOR AUXILIARY CONTROL CIRCUIT
ASC	ADJUSTABLE SPEED CONTROLLER
BFV	BUTTERFLY VALVE
C/CAP	CAPACITOR
CB	CIRCUIT BREAKER
CLF	CURRENT LIMIT FUSE
CNT	COUNTER
DV	DISCHARGE VALVE
EXC	EXCITER
FU	FUSE
GFCI	GROUND FAULT CIRCUIT INTERRUPTER
GND	GROUND
GRS	GALVANIZED RIGID STEEL CONDUIT
GV	GATE OR GUARD VALVE
HR	HAND RESET (USE AS SUFFIX)
I	INPUT
IL	INDICATING LAMP (ADD COLOR PREFIX)
IMC	INTERMEDIATE STEEL CONDUIT
MCE	MOTOR CONTROL EQUIPMENT (2500 OR 5000 VOLTS)
M	MOTOR
MCC	MOTOR CONTROL CENTER (600 VOLTS AND LOWER)
NP	NAMEPLATE
NC	NORMALLY CLOSED
NO	NORMALLY OPEN
NSPB	NON-SEGREGATED PHASE BUS
O	OUTPUT
PB	PUSHBUTTON (MOMENTARY CONTACT TYPE)
PBM	PUSHBUTTON (MAINTAINING CONTACT TYPE)
PC	PROGRAMMABLE CONTROLLER
PR	PROBE OPERATED RELAY (REFER TO FS FOR SUFFIX)
REC	RECTIFIER
R/I	RESISTANCE TO CURRENT TRANSDUCER
SF	SERVICE FACTOR
SO	SOLENOID OILER
SV	SOLENOID OPERATED VALVE
TE	TIME DELAY ON ENERGIZATION
TD	TIME DELAY ON DE-ENERGIZATION
TT	THERMAL SWITCH
V/I	VOLTAGE TO CURRENT TRANSDUCER
VLV	VALVE
WL	WATER LEVEL CONTACT ON TELEMETER RECEIVER (REFER TO FS FOR SUFFIX)
WRM	WOUND ROTOR MOTOR
X,Y,Z,	SUFFIX FOR AUXILIARY RELAY, SWITCH OR CONTACTOR (ALX, CSX, FLX, ETC)
-1,-2,-3	SUFFIX FOR UNIT NUMBER FOR PUMPING UNITS, GATES, VALVES, ETC.
1,2,3	SUFFIX FOR ELECTRICAL DEVICE NUMBERING (TR1, TR2, ETC.)
X	ESTIMATED RATING
	AUXILIARY CONTACTS
A	OPEN WHEN MAIN DEVICE IS OPEN
B	OPEN WHEN MAIN DEVICE IS CLOSED

SWITCH DESIGNATIONS

CS	CONTROL SWITCH
FC	FOREIGN CIRCUIT DISCONNECT SWITCH
FS	FLOAT SWITCH (USE SUFFIX LETTER..C-CANAL, P-PIPE, R-RESORVOIR, S-SUMP, T-TANK)
LS	LIMIT SWITCH
PS	PRESSURE SWITCH
SS	SELECTOR SWITCH
TQ	TORQUE SWITCH
TSW	TRANSFER SWITCH
DS	DISCONNECT SWITCH

TRANSFORMER DESIGNATIONS

CCT	CONTROL CIRCUIT
CT	CURRENT
PT	POTENTIAL
T	TRANSFORMER
TH	OIL TEMPERATURE
TL	OIL LEVEL
TP	PRESSURE RELIEF
SS	STATION SERVICE

FIRST LETTER SUFFIX OF THE DEVICE DESIGNATION (NOTE 1)

A	GOVERNOR SYSTEM (OR ACTUATOR SYSTEM GATES)
B	BATTERY CHARGING AND MONITORING SYSTEM
C	HIGH VOLTAGE CABLE SYSTEM
D	DATA ACQUISITION SYSTEM
E	EXCITATION SYSTEM INCLUDING TRANSFORMER AND REGULATOR BUT NOT MAIN FIELD.
F	FIRE AND CO2 SYSTEM
G	MAIN GENERATOR INCLUDING AUXILIARY SYSTEMS
G/H	GENERATOR MOTOR INCLUDING AUXILIARY SYSTEMS IN PUMPED STORAGE APPLICATIONS
H	TURBINE OR MAIN PUMP INCLUDING AUXILIARY SYSTEMS
I	ISOLATED AND OTHER POWER BUS SYSTEMS (NOT HIGH VOLTAGE CABLE)
J	POWER CIRCUIT BREAKER INCLUDING AUXILIARY SYSTEMS
K	POWER TRANSFORMER INCLUDING AUXILIARY SYSTEMS
L	ANNUNCIATOR SYSTEM, SECURITY SYSTEM
M	MAIN PUMP MOTOR INCLUDING AUXILIARY SYSTEMS AND VARIABLE SPEED DRIVE
N	AIR (PNEUMATIC) SYSTEM
O	NOT USED
P	PENSTOCK OR DISCHARGE LINE SYSTEM
Q	OIL STORAGE, HANDLING, PURIFICATION SYSTEM
R	FIELD FLASHING SYSTEM OR PHASE REVERSAL SWITCH INCLUDING AUXILIARY SYSTEMS
S	STATION SERVICE SUBSTATION SYSTEM INCLUDING ENGINE/GENERATOR SYSTEM
T	TONE AND TRANSFER TRIP SYSTEM
U	UNIT CONTROL CIRCUIT SYSTEM OR UNINTERRUPTIBLE POWER SUPPLY SYSTEM
V	INTAKE AND/OR DISCHARGE VALVE SYSTEM
W	WATER SYSTEM INCLUDING INTAKE/OUTLET WORKS AND PLANT WATER AND SUMP SYSTEMS
X	DEFINED FOR SYSTEMS UNIQUE TO A FACILITY
Y	DEFINED FOR SYSTEMS UNIQUE TO A FACILITY
Z	DEFINED FOR SYSTEMS UNIQUE TO A FACILITY

CONTACTOR DESIGNATIONS

FC	FIELD	
LC	LIGHTING	
M	MAIN	
MA	AIR COMPRESSOR MOTOR	
MF	VENT FAN MOTOR	
MG-(X)	GATE MOTOR	USE SUFFIX (X) AS APPLICABLE: (C) CLOSING, (L) LOWERING (O) OPENING, (R) RAISING
MO-(X)	OIL PUMP MOTOR	
MV-(X)	VALVE MOTOR	
S	STARTING	
1S	START	
2S	START TRANSITION	REDUCED VOLTAGE STARTING
R	RUN	

RELAY DESIGNATIONS

AL	ALARM
BG	BEARING TEMPERATURE
CR	CONTROL
FL	FIELD LOSS
FR	FIELD APPLICATION
GP	GROUND PROTECTIVE
IS	INCOMPLETE SEQUENCE
LO	LOCKOUT
OC	OVERCURRENT
OL	OVERLOAD
OV	OVERVOLTAGE
PO	PULLOUT (LOSS OF SYNCHRONISM)
RC	REMOTE CONTROL
RSR	REMOTE SENSING
SC	SQUIRREL CAGE (DAMPER WINDING)
SR	SHIFT REGISTER
TR	TIME DELAY
UF	UNDER FREQUENCY
UV-OPR	UNDERVOLTAGE SINGLE AND REVERSE PHASE
WT	WINDING TEMPERATURE

REVISION HISTORY

REV	ENG	CADD	DATE	WORK ORDER	DESCRIPTION	APPR	DATE APP
E	HMF	RAN	11-28-16	.	SUPERVISOR CHECK NOT FOR RELEASE	DPF	04-12-17

NOTES:

1. NO DEVICE DESIGNATION SHALL BE DUPLICATED. WHEN TWO OR MORE DEVICES PERFORM EXACTLY THE SAME FUNCTION, THE DESIGNATION WILL BE FOLLOWED BY A NUMBER, STARTING AT 1 TO DIFFERENTIATE BETWEEN DEVICES. FOR EXAMPLE: THREE AUXILIARY RELAYS TO DEVICE 69U ARE LABELED 69U1, 69U2 AND 69U3.
2. EQUIPMENT DESIGNATIONS PRECEDED BY THE LETTER 'N' INDICATE HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS EQUIPMENT.

REFERENCE DRAWING:

STD-E-C07528 SINGLE LINE AND SCHEMATIC DIAGRAMS, SYMBOLS

DIVISION ENGINEERING

CAP CENTRAL ARIZONA PROJECT
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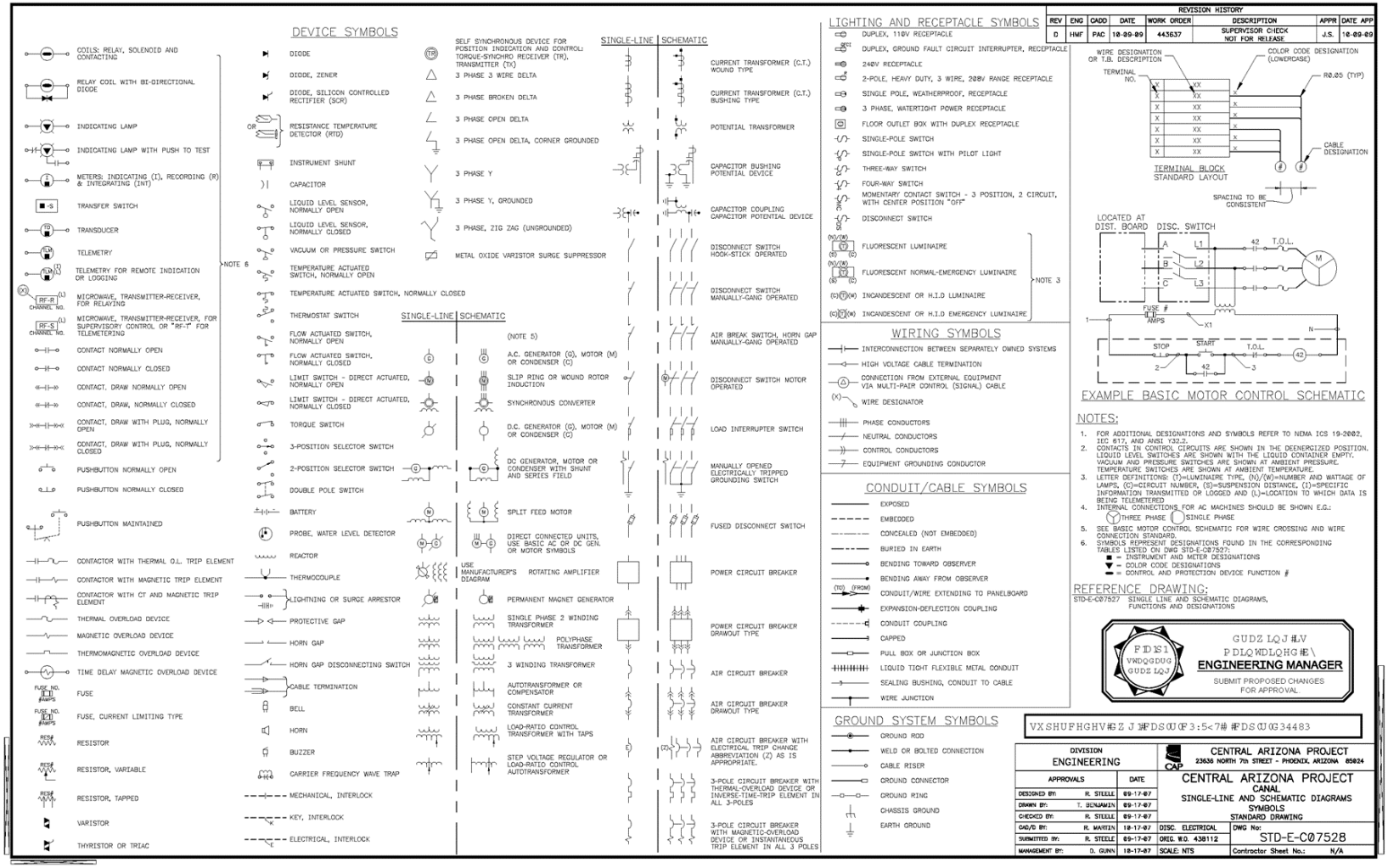
CHECKED BY:	R. STEELE	09-17-07
CAD/D BY:	R. MARTIN	10-17-07
SUBMITTED BY:	R. STEELE	09-17-07
MANAGEMENT BY:	D. GUNN	10-17-07

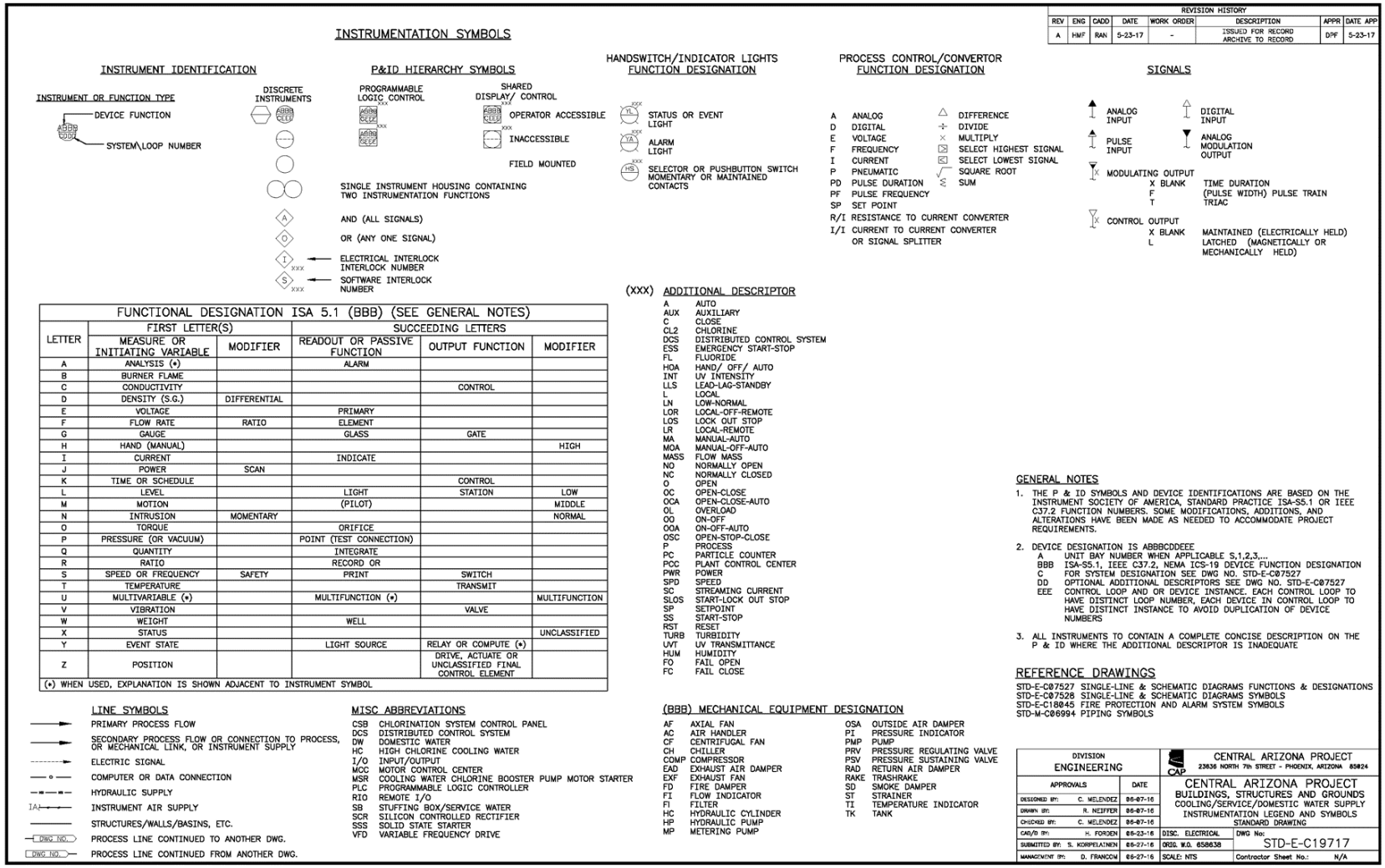
CENTRAL ARIZONA PROJECT
CANAL
SINGLE-LINE AND SCHEMATIC DIAGRAMS
FUNCTIONS AND DESIGNATIONS
STANDARD DRAWING

DISC. ELECTRICAL | DWG No: STD-E-C07527
ORIG. W.O. - | SCALE: NTS | Contractor Sheet No.: N/A

APPENDIX A2: STD-E-C07528 SINGLE-LINE AND SCHEMATIC SYMBOLS



APPENDIX A3: STD-E-C19717 INSTRUMENTATION LEGEND AND SYMBOLS



INSTRUMENTATION SYMBOLS

REVISION HISTORY

REV	ENG	CADD	DATE	WORK ORDER	DESCRIPTION	APPR	DATE APP
A	HMF	RAN	5-23-17	-	ISSUED FOR RECORD ARCHIVE TO RECORD	DPF	5-23-17

INSTRUMENT IDENTIFICATION

INSTRUMENT OR FUNCTION TYPE
- DEVICE FUNCTION
- SYSTEM\LOOP NUMBER

DISCRETE INSTRUMENTS

P&ID HIERARCHY SYMBOLS

PROGRAMMABLE LOGIC CONTROL

SHARED DISPLAY/ CONTROL

OPERATOR ACCESSIBLE

INACCESSIBLE

FIELD MOUNTED

SINGLE INSTRUMENT HOUSING CONTAINING TWO INSTRUMENTATION FUNCTIONS

AND (ALL SIGNALS)

OR (ANY ONE SIGNAL)

ELECTRICAL INTERLOCK
INTERLOCK NUMBER

SOFTWARE INTERLOCK
NUMBER

HANDSWITCH/INDICATOR LIGHTS FUNCTION DESIGNATION

STATUS OR EVENT LIGHT

ALARM LIGHT

SELECTOR OR PUSHBUTTON SWITCH MOMENTARY OR MAINTAINED CONTACTS

PROCESS CONTROL/CONVERTOR FUNCTION DESIGNATION

A	ANALOG	△	DIFFERENCE
D	DIGITAL	÷	DIVIDE
E	VOLTAGE	×	MULTIPLY
F	FREQUENCY	⊠	SELECT HIGHEST SIGNAL
I	CURRENT	⊡	SELECT LOWEST SIGNAL
P	PNEUMATIC	√	SQUARE ROOT
PD	PULSE DURATION	Σ	SUM
PF	PULSE FREQUENCY		
SP	SET POINT		
R/I	RESISTANCE TO CURRENT CONVERTER		
I/I	CURRENT TO CURRENT CONVERTER OR SIGNAL SPLITTER		

SIGNALS

- ANALOG INPUT
- DIGITAL INPUT
- PULSE INPUT
- ANALOG MODULATION OUTPUT
- MODULATING OUTPUT
  - X BLANK — TIME DURATION
  - F — (PULSE WIDTH) PULSE TRAIN
  - T — TRIAC
- CONTROL OUTPUT
  - X BLANK — MAINTAINED (ELECTRICALLY HELD)
  - L — LATCHED (MAGNETICALLY OR MECHANICALLY HELD)

FUNCTIONAL DESIGNATION ISA 5.1 (BBB) (SEE GENERAL NOTES)

LETTER	FIRST LETTER(S)		SUCCEEDING LETTERS		
	MEASURE OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS (*)		ALARM		
B	BURNER FLAME				
C	CONDUCTIVITY			CONTROL	
D	DENSITY (S.G.)	DIFFERENTIAL			
E	VOLTAGE		PRIMARY		
F	FLOW RATE	RATIO	ELEMENT		
G	GAUGE		GLASS	GATE	
H	HAND (MANUAL)				HIGH
I	CURRENT		INDICATE		
J	POWER	SCAN			
K	TIME OR SCHEDULE			CONTROL	
L	LEVEL		LIGHT	STATION	LOW
M	MOTION		(PILOT)		MIDDLE
N	INTRUSION	MOMENTARY			NORMAL
O	TORQUE		ORIFICE		
P	PRESSURE (OR VACUUM)		POINT (TEST CONNECTION)		
Q	QUANTITY		INTEGRATE		
R	RATIO		RECORD OR		
S	SPEED OR FREQUENCY	SAFETY	PRINT	SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE (*)		MULTIFUNCTION (*)		MULTIFUNCTION
V	VIBRATION			VALVE	
W	WEIGHT		WELL		
X	STATUS				UNCLASSIFIED
Y	EVENT STATE		LIGHT SOURCE	RELAY OR COMPUTE (*)	
Z	POSITION			DRIVE, ACTUATE OR UNCLASSIFIED FINAL CONTROL ELEMENT	

(*) WHEN USED, EXPLANATION IS SHOWN ADJACENT TO INSTRUMENT SYMBOL

(XXX) ADDITIONAL DESCRIPTOR

A	AUTO
AUX	AUXILIARY
C	CLOSE
CL2	CHLORINE
DCS	DISTRIBUTED CONTROL SYSTEM
ESS	EMERGENCY START-STOP
FL	FLUORIDE
HOA	HAND/ OFF/ AUTO
INT	UV INTENSITY
LLS	LEAD-LAG-STANDBY
L	LOCAL
LN	LOW-NORMAL
LOR	LOCAL-OFF-REMOTE
LOS	LOCK OUT STOP
LR	LOCAL-REMOTE
MA	MANUAL-AUTO
MOA	MANUAL-OFF-AUTO
MASS	FLOW MASS
NO	NORMALLY OPEN
NC	NORMALLY CLOSED
O	OPEN
OC	OPEN-CLOSE
OCA	OPEN-CLOSE-AUTO
OL	OVERLOAD
OO	ON-OFF
OOA	ON-OFF-AUTO
OSC	OPEN-STOP-CLOSE
P	PROCESS
PC	PARTICLE COUNTER
PCC	PLANT CONTROL CENTER
PWR	POWER
SPD	SPEED
SC	STREAMING CURRENT
SLOS	START-LOCK OUT STOP
SP	SETPOINT
SS	START-STOP
RST	RESET
TURB	TURBIDITY
UVT	UV TRANSMITTANCE
HUM	HUMIDITY
FO	FAIL OPEN
FC	FAIL CLOSE

GENERAL NOTES

1. THE P & ID SYMBOLS AND DEVICE IDENTIFICATIONS ARE BASED ON THE INSTRUMENT SOCIETY OF AMERICA, STANDARD PRACTICE ISA-S5.1 OR IEEE C37.2 FUNCTION NUMBERS. SOME MODIFICATIONS, ADDITIONS, AND ALTERATIONS HAVE BEEN MADE AS NEEDED TO ACCOMMODATE PROJECT REQUIREMENTS.
2. DEVICE DESIGNATION IS ABBBCDDEEE
   - A — UNIT BAY NUMBER WHEN APPLICABLE S,1,2,3,...
   - BBB — ISA-S5.1, IEEE C37.2, NEMA ICS-19 DEVICE FUNCTION DESIGNATION
   - C — FOR SYSTEM DESIGNATION SEE DWG NO. STD-E-C07527
   - DD — OPTIONAL ADDITIONAL DESCRIPTORS SEE DWG NO. STD-E-C07527
   - EEE — CONTROL LOOP AND OR DEVICE INSTANCE. EACH CONTROL LOOP TO HAVE DISTINCT LOOP NUMBER, EACH DEVICE IN CONTROL LOOP TO HAVE DISTINCT INSTANCE TO AVOID DUPLICATION OF DEVICE NUMBERS
3. ALL INSTRUMENTS TO CONTAIN A COMPLETE CONCISE DESCRIPTION ON THE P & ID WHERE THE ADDITIONAL DESCRIPTOR IS INADEQUATE

REFERENCE DRAWINGS

STD-E-C07527 SINGLE-LINE & SCHEMATIC DIAGRAMS FUNCTIONS & DESIGNATIONS
STD-E-C07528 SINGLE-LINE & SCHEMATIC DIAGRAMS SYMBOLS
STD-E-C18045 FIRE PROTECTION AND ALARM SYSTEM SYMBOLS
STD-M-C06994 PIPING SYMBOLS

LINE SYMBOLS

- PRIMARY PROCESS FLOW
- SECONDARY PROCESS FLOW OR CONNECTION TO PROCESS, OR MECHANICAL LINK, OR INSTRUMENT SUPPLY
- ELECTRIC SIGNAL
- COMPUTER OR DATA CONNECTION
- HYDRAULIC SUPPLY
- INSTRUMENT AIR SUPPLY
- STRUCTURES/WALLS/BASINS, ETC.
- DWG NO. — PROCESS LINE CONTINUED TO ANOTHER DWG.
- DWG NO. — PROCESS LINE CONTINUED FROM ANOTHER DWG.

MISC ABBREVIATIONS

CSB	CHLORINATION SYSTEM CONTROL PANEL
DCS	DISTRIBUTED CONTROL SYSTEM
DW	DOMESTIC WATER
HC	HIGH CHLORINE COOLING WATER
I/O	INPUT/OUTPUT
MCC	MOTOR CONTROL CENTER
MSR	COOLING WATER CHLORINE BOOSTER PUMP MOTOR STARTER
PLC	PROGRAMMABLE LOGIC CONTROLLER
RIO	REMOTE I/O
SB	STUFFING BOX/SERVICE WATER
SCR	SILICON CONTROLLED RECTIFIER
SSS	SOLID STATE STARTER
VFD	VARIABLE FREQUENCY DRIVE

(BBB) MECHANICAL EQUIPMENT DESIGNATION

AF	AXIAL FAN
AC	AIR HANDLER
CF	CENTRIFUGAL FAN
CH	CHILLER
COMP	COMPRESSOR
EAD	EXHAUST AIR DAMPER
EXF	EXHAUST FAN
FD	FIRE DAMPER
FI	FLOW INDICATOR
FI	FILTER
HC	HYDRAULIC CYLINDER
HP	HYDRAULIC PUMP
MP	METERING PUMP
OSA	OUTSIDE AIR DAMPER
PI	PRESSURE INDICATOR
PMP	PUMP
PRV	PRESSURE REGULATING VALVE
PSV	PRESSURE SUSTAINING VALVE
RAD	RETURN AIR DAMPER
RAKE	TRASHRAKE
SD	SMOKE DAMPER
ST	STRAINER
TI	TEMPERATURE INDICATOR
TK	TANK

DIVISION: ENGINEERING

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CAD/D BY:	H. FORDEN	05-23-16
SUBMITTED BY:	S. KORPELAINEN	05-27-16
MANAGEMENT BY:	D. FRANCOM	05-27-16

CENTRAL ARIZONA PROJECT
BUILDINGS, STRUCTURES AND GROUNDS
COOLING/SERVICE/DOMESTIC WATER SUPPLY
INSTRUMENTATION LEGEND AND SYMBOLS
STANDARD DRAWING

DISC. ELECTRICAL | DWG No: STD-E-C19717
ORIG. W.O. 658638
SCALE: NTS | Contractor Sheet No.: N/A

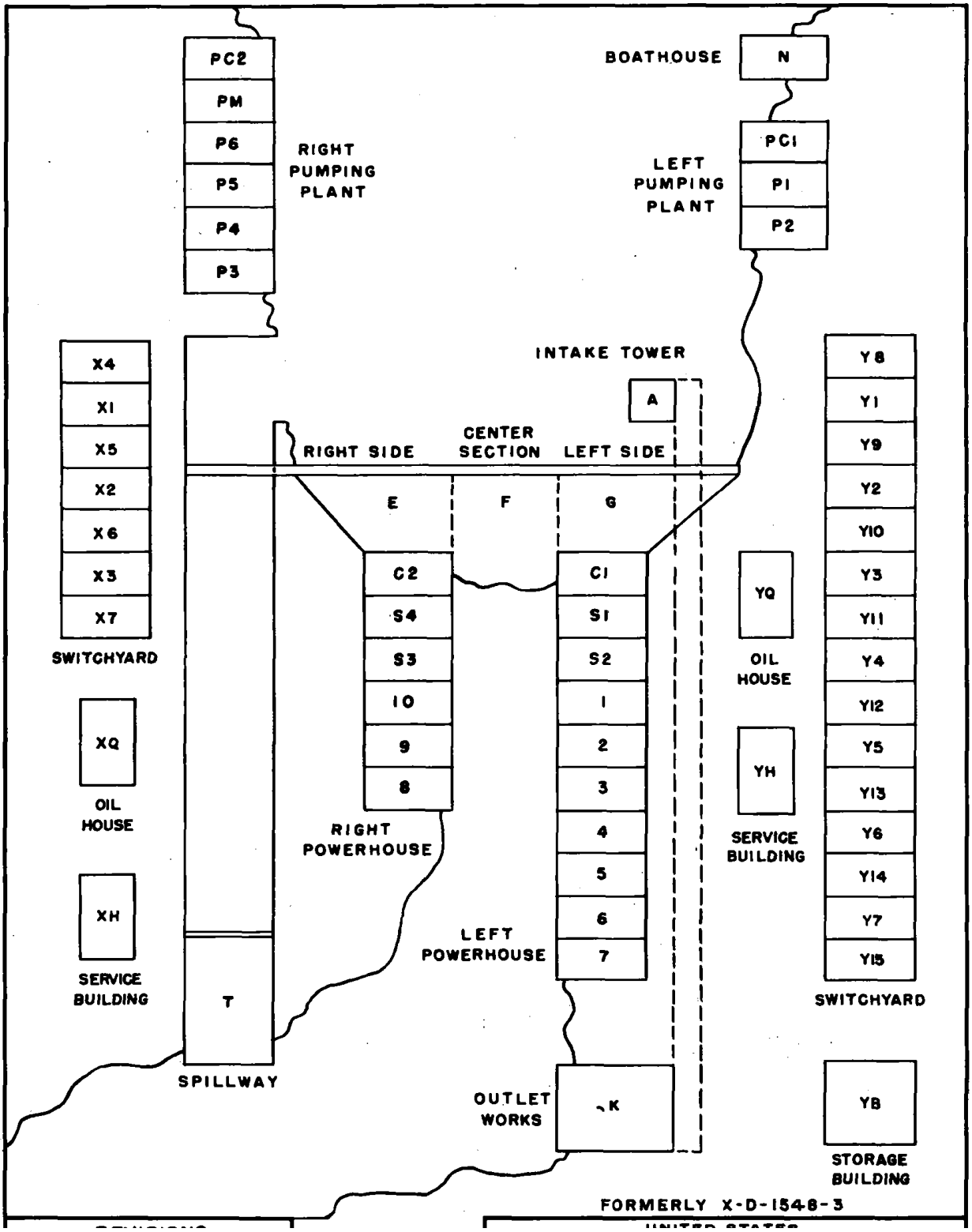
APPENDIX A4: KEY LIST FOR EQUIPMENT SYMBOLS

Table 1 – Key List for Equipment Symbols	
Symbol	**Type of Equipment**
A	Actuator, turbine governor
B	Battery, DC distribution board, charger
C	Control board, high voltage cable
D	Station service switchgear, distribution board (except for lighting and HVAC), unit substation rated less than 600 V
E	Static exciter, junction box, pull box, trench
F	Fuses, fused disconnect switch, fire and carbon dioxide equipment
G	Generator
H	Hydraulic board, turbine or main pump
I	Not used.
J	Power circuit breaker (above 600 V)
K	Transformer (except lighting), reactor, regulator, or metering equipment
L	Lighting system equipment
M	Motor controller, pump, valve board
N	HVAC system equipment
O	Not used.
P	(Reserved)
Q	Current transformer, oil storage or handling equipment
R	Cable rack
S	Motor-generator sets
T	Telephone and communication.
U	AC power switchgear above 600 V
W	Bus disconnect switch, phase reversal switch
X	Bypass switch
Y	Line or selector disconnect switch
Z	Grounding switch

APPENDIX A5: KEY LIST FOR LOCATION SYMBOL

Table 2 – Key List for Location Symbols	
A	(Reserved)
B	Separate warehouse or storage building
C	Control Bay
D	Dam - general (Do not use this symbol if E, F, or G are used.)
E	Dam - right side
F	Dam - center or spillway section
G	Dam - left side
H	Service building
I	(Reserved)
J	Separate outlet works - primary, upper. or right side.
K	Separate outlet works - secondary, lower or left side.
L	(Reserved)
M	Machine or work shop in location other than service bay.
N	(Reserved)
O	(Reserved)
P	Pumping plant
Q	Separate oil house
R	(Reserved)
S	Service bay
T	Separate spillway on right side.
U	Separate spillway on left side.
W	230 kV Switchyard
X, Y	115 kV Switchyard
Z	Switchyard
1	Main Unit Bay Number 1
2	Main Unit Bay Number 2
3	Main Unit Bay Number 3
4	Main Unit Bay Number 4
5	Main Unit Bay Number 5
6	Main Unit Bay Number 6
7	Main Unit Bay Number 7
8	Main Unit Bay Number 8
9	Main Unit Bay Number 9
10	Main Unit Bay Number 10

APPENDIX A6: KEY PLAN – LOCATION



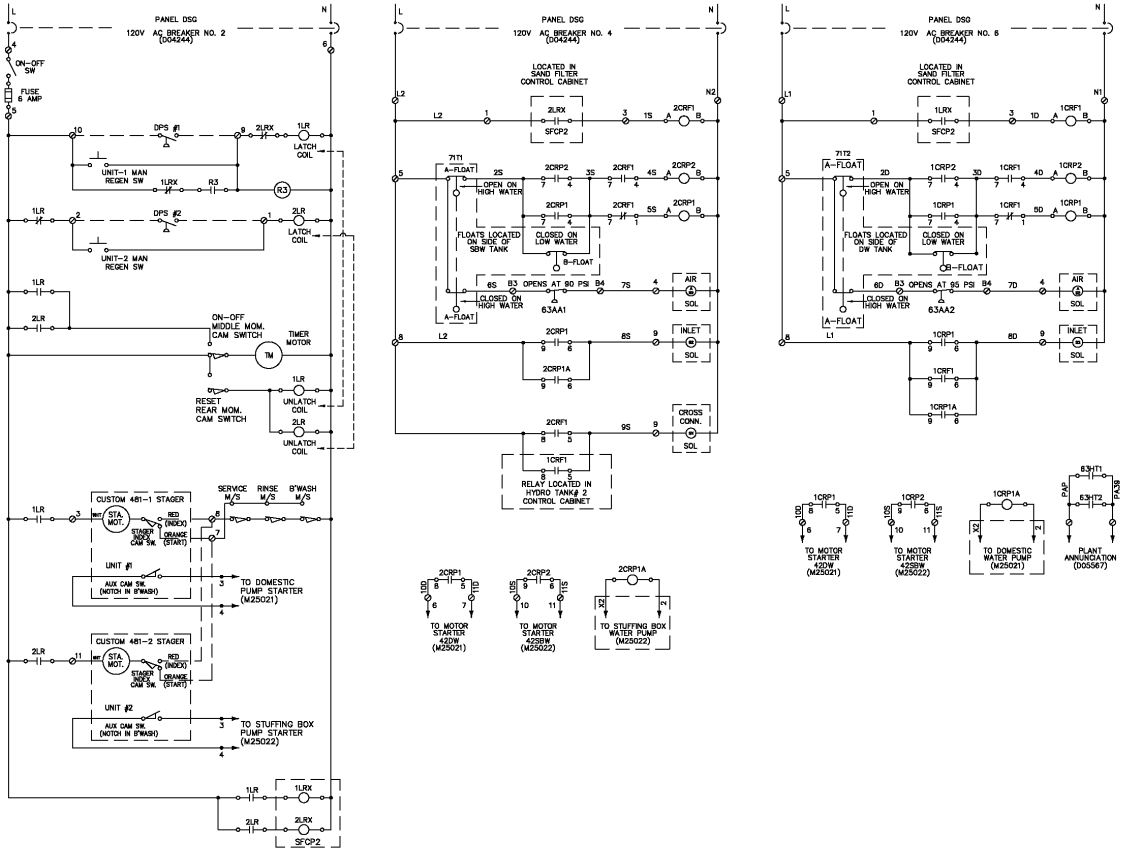
APPENDIX A7: ROUTING LIST

ROUTING LIST									
CONDUCTORS AND CABLES						CONDUIT / ROUTING			
CABLE DESIGNATION	NO. of COND.	SIZE of COND.	INS. VOLTS	INS. TYPE	PURPOSE	EST. LTH.	CONDUIT SIZE	CONDUIT TYPE	CONDUIT DESIGNATION
1C1A - M1B	5/C	#16	600		A.C. CONTROL	70 ft	1½	GRC	1½ - 1C1A - M1B
5D3A - M1B	3 - 1/C	#12	600	XHHW-2	A.C. POWER	120 ft	¾	GRC	¾ - 5D3A - M1B

APPENDIX A8: COLOR CODE STANDARD FOR CONTROL CABLES

ICEA Method 1, Table E-2 Colored compound with tracers			
CABLE	**NUMBER**	**BASE**	**TRACER**
2/C	1	Black	–
	2	Red	–
3/C	3	Blue	–
5/C	4	Orange	–
	5	Yellow	–
7/C	6	Brown	–
	7	Red	Black
9/C	8	Blue	Black
	9	Orange	Black
12/C	10	Yellow	Black
	11	Brown	Black
	12	Black	Red
16/C	13	Blue	Red
	14	Orange	Red
	15	Yellow	Red
	16	Brown	Red
36/C	17	Black	Blue
	18	Red	Blue
	19	Orange	Blue
	20	Yellow	Blue
	21	Brown	Blue
	22	Black	Orange
	23	Red	Orange
	24	Blue	Orange
	25	Yellow	Orange
	26	Brown	Orange
	27	Black	Yellow
	28	Red	Yellow
	29	Blue	Yellow
	30	Orange	Yellow
	31	Brown	Yellow
	32	Black	Brown
	33	Red	Brown
	34	Blue	Brown
	35	Orange	Brown
	36	Yellow	Brown

APPENDIX A9: SCHEMATIC DIAGRAM EXAMPLE



DEVICE	DESCRIPTION
1CRF1	SAND FILTER CONTROL RELAY
1CRP1,2	DOMESTIC WATER CONTROL RELAY
1CRP1A	HYDROPNEUMATIC TANK CONTROL RELAY
1LR,2LR	LATCHING RELAY
2CRF1	SAND FILTER CONTROL RELAY
2CRP1,2	STUFFING BOX WATER CONTROL RELAY
2CRP1A	HYDROPNEUMATIC TANK CONTROL RELAY
DPS1,2	DIFFERENTIAL PRESSURE SWITCHES
R3	RELAY
1LRX	1LR AUXILIARY RELAY
2LRX	2LR AUXILIARY RELAY
M/S	MOMENTARY CAM SWITCH
63AA1,2	ADD AIR SWITCH
63HT1,2	HIGH TANK WATER LEVEL ALARM
71T1,2	TANL LEVEL SWITCH

NOTES:

1. ALL SPARE CONDUCTORS SHALL BE GROUNDED AT BOTH ENDS
2. ALL CONTACTS LOCATED INSIDE THE BOXED AREA MARKED STARTER ARE CONTACTOR (42DW) CONTACTS UNLESS OTHERWISE MARKED
3. ⌀ – DESIGNATES TERMINAL BOARD IN SFCP1 PANEL

APPENDIX A10: WIRING DIAGRAM EXAMPLE