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AC Power Distribution

System Design, Installation and Acceptance Criteria

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About This Document

Purpose

The purpose of this document is to establish the minimum AC power distribution system design criteria.

Intended Audiences

This document is intended for use by NSD engineering personnel.

Reason for Reissue

This practice is being reissued to include the new design requirements, as set forth.

How to Use This Document

This document provides the information needed to establish the minimum AC power distribution system design criteria. The subjects in each chapter are broken down as follows:

Chapter 1	**General —** provides general information about the AC design criteria.
Chapter 2	**General Design Criteria** — covers criteria which apply to all ACEDS design configurations and equipment listed in the chapters three through eight.
Chapter 3	**Utility Service Entrance** — covers criteria which apply specifically to the utility service entrance, power transformers, and surge arrestor devices.
Chapter 4	**Switchgear and Switchboards** — covers criteria which apply specifically to medium and low-voltage switchgear and switchboards.
Chapter 5	**Distribution** — covers criteria which apply specifically to bus duct, distribution transformers, distribution panels, panel boards, and disconnect devices, cables and raceways.
Chapter 6	**Motor Control Centers -** covers criteria which apply specifically to low-voltage motor control centers.
Chapter 7	**Programmable Logic Controllers** — covers criteria which apply specifically to programmable logic controllers.
Chapter 8	**Acceptance** — covers criteria which apply specifically to the installation acceptance of all ACEDS equipment and systems.
Appendix A	**References** — covers practices and standards which are referenced in this manual.

Standards and Conventions

The chapters in this manual are separated by tabs. The title of each chapter is printed on the tab at the beginning of that chapter.

The following standards and conventions are used consistently throughout this document:

- Tables and figures are located as closely as practical to the point in the text where they are referenced
- Hardware labels and equipment stamping, when referenced in the text, are shown in boldface type
- Responses to actions or occurrences within the procedures (e.g., lighted or extinguished lamps, system alarms, etc.) are listed immediately following the action or occurrence that initiated them.

Important Reminders

Following are items which should be read and understood before performing any work or procedures on the AC power systems:

- Ask Yourself
- Technical Support 1-800-874-4545.

Admonishments

Admonishments are reminders that are used to assure the safety of personnel and to minimize service interruptions, loss of data, and damage to equipment, products, and software. There are three types of admonishments used in this document. The three types are identified and defined below in descending order of priority:

- **DANGER** indicates the presence of a hazard that **will** cause death or severe personal injury if the hazard is not avoided
- **WARNING** indicates the presence of a hazard that **can** cause death or severe personal injury if the hazard is not avoided
- **CAUTION** indicates the presence of a hazard that **wil**l or **can** cause minor personal injury or property damage if the hazard is not avoided.

Related Documentation

The following documents were used in the development of this Practice:

Document Number	Title
ANSI/ASTM B187	Specification for Copper Bus, Rod and Shapes
ANSI/ASTM B236	Specification for Aluminum Bar for Electrical Purposes (Bus Bar)
ANSI/ASTM B317	Specification for Aluminum Alloy Extruded Bar, Rod, Pipe and Structural Shapes for Electrical Purposes
ANSI C2	National Electrical Safety Code
ANSI C37.04	Definition and Rating Structure for AC High Voltage Circuit Breakers Rated on a Total Current Basis
ANSI C37.06	Schedules of Preferred Ratings and Related Required Capabilities of AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

Document Number	Title
ANSI C37.072	Requirements for Transient Recovery Voltage AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI C37.09	Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
ANSI C37.13	Low-Voltage AC Power Circuit Breakers Used in Enclosures
ANSI C37.16	Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
ANSI C37.17	Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers
ANSI C37.20	Switchgear Assemblies Including Metal Enclosed Bus
ANSI C37.20.1	Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
ANSI C37.20.2	Metal-Clad and Station-Type Cubicle Switchgear
ANSI C37.20.3	Metal-Enclosed Interruption Switchgear
ANSI C37.50	Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures
ANSI C37.9	Test Procedure for AC High Voltage Circuit Breakers Rated on a Total Current Basis
ANSI C37.90	Relays and Relay Systems Associated with Electric Power Apparatus
ANSI C37.100	Definitions for Power Switchgear
ANSI C57.12.00	IEEE General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
ANSI C57.12.13	Conformance Requirements for Liquid-Filled Transformers used in Unit Installations, Including Unit Substations
ANSI C57.12.27	American National Standard Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations
ANSI C57.12.28	Switchgear and Transformers - Pad Mounted Equipment Enclosure Integrity
ANSI C57.12.50	Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase and 15 to 500 kVA, Three-Phase, with High Voltage 601 to 34,500 V, Low-Voltage 120 to 600 V
ANSI C57.12.51	American National Standard Requirements for Ventilated Dry-Type Power Transformers, 501kVA and Larger

Document Number	Title
ANSI C57.12.55	Dry-Type Transformers Used in Unit Installations, Including Unit Substations - Conformance Standard
ANSI C57.12.80	Terminology for Power and Distribution Transformers
ANSI C57.12.92	Guide for Loading Mineral-Oil-Immersed Power Transformers up to and Including 100 MVA with 55 C or 65 C Winding Rise
ANSI C57.13	Definitions for Instrument Transformers
ANSI C57.109	Guide for Transformer Through-Fault-Current Duration
ANSI C57.110	Recommended Practice for Establishing Transformer Capability when Supplying Nonsinusoidal Load Currents
ANSI/IEEE 28	Surge Arresters for Alternating Current Power Circuits
ANSI/IEEE 472	Guide for Surge Withstand Capability Tests
ANSI Z55.1	Gray Finishes for Industrial Apparatus and Equipment
ICEA P-32-382	Short-Circuit Characteristics of Insulated Cable
ICEA S-19-81	Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (Applies to rubber and rubberlike cable assemblies and their testing)
ICEA S-66-524	Standard for Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (Applies to cross-linked polyethylene cable assemblies and their testing)
ICEA S-68-516	Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (Applies to ethylene-propylene-rubber insulation and testing)
IEEE C57.12.01	Standard General Requirements for Dry Type Distribution and Power Transformers, Including those with Solid Cast and/or Resin Encapsulated Windings
IEEE C57.12.59	Guide for Dry Type Transformer Through Fault Current Duration
IEEE C57.12.91	Guide for Loading Mineral Oil Immersed Overhead and Pad Mounted Distribution Transformers Rated 500 kVA and Less with 65 C or 55 C Average Winding
IEEE C57.94	Recommended Practice for Installation, Application, Operation and Maintenance of Dry Type General Purpose Distribution and Power Transformers
IEEE C57.96	Guide for Loading Dry Type Distribution and Power Transformers

Document Number	Title
IEEE Std. 142	Recommended Practice for Grounding of Industrial and Commercial Power Systems
IEEE Std. 242	Chapter 7 - Ground-Fault Protection
NEC	Articles 250, 318, 345 through 351, 384 and 450
NEMA SG-3	Standards for Low-Voltage Power Circuit Breakers
NEMA SG-4	Standards for Power Circuit Breakers
NEMA SG-5	Power Switchgear Assemblies
NEMA SG-6	Standards for Power Switching Equipment
NEMA ST-20	Dry-Type Transformers for General Application
NFPA 70	National Electrical Code
UBC	Uniform Building Code
UL 44	Electric Wires and Cables
UL 977	Fused Power Circuit Devices
010-515-170	Ask Yourself
154-103-101	Alarms Standards Manual
760-200-023	Earthquake Design Loads
760-400-310	Building Electrical Systems Transformers
800-200-100	Electrodes
802-001-180	Protective Grounding Systems, General Grounding Requirements for Communication Systems in Central Offices, Radio Stations and Other Structure Power Systems
802-001-198	Protective Grounding Systems
803-500-150	Grounding Practices - Telecommunication Systems Grounding in New Buildings Housing Digital and/or Analog Telecommunication Equipment, General Equipment Requirements, and Engineering Information
810-610-155	Earthquake and Disaster Bracing for Central Office Equipment General Equipment Requirements
876-101-100	Electrical Protective Devices
876-200-100	Electrical Protection - Central Offices

Training

For information about any training courses related to power systems, call Network Operation Education & Training (NOET) at 1-404-728-6100.

To register for a power course, contact your local training coordinator or call 1-800-NETRAIN (638-7246).

For additional information on training, refer to AT&T Practice 154-001-000AC, “Network Power Management”.

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General

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General

1

1.01 Purpose

This document establishes the minimum criteria to address the following design requirements:

1. To provide a highly reliable source of AC power to the AT&T Telecommunication Network
2. To minimize common mode failure in the AC Electrical Distribution System
3. To provide equipment criteria that allow testing and maintenance to be performed with minimum impact to service
4. To provide design and selection criteria that can be used to standardize the AC distribution system at AT&T locations.

1.02 Scope

The scope of these criteria includes the configuration, equipment, wiring, raceway, and other components of the AC Electrical Distribution System (ACEDS) and its interface with the utility power source. It provides system criteria, equipment design, and selection criteria. Throughout this document the AC Electrical Distribution System will be described as ACEDS.

The ACEDS generally consists of the following major equipment:

- Medium and/or low-voltage switchgear/switchboards
- Low-voltage motor control centers
- Distribution panels
- Power and distribution transformers
- Transfer switches
- Surge protective devices
- Grounding
- Cable, raceway, and bus duct
- Programmable Logic Controllers.

The boundaries of the ACEDS encompass all AC electrical apparatus from the secondary of the utility transformer to the DC electrical distribution system. The DC electrical distribution system includes the Power Distribution Supply Cabinets (PDSC) and the Rectifiers.

Where the utility does not own and maintain the transformer, transformer disconnect, and protective equipment, consider them part of the ACEDS. Utility interface design requirements are addressed in this document, regardless of transformer ownership.

These criteria supplement rather than supersede local or national code requirements.

Where this document is in conflict with other AT&T Practices with regard to ACEDS, this document takes precedence. Conflicts shall be documented and reported to the Power and Infrastructure Standards Group.

1.03 System Design Goals

The ACEDS provides a reliable and cost-effective power source, of sufficient capacity to power the required loads during all designed operating conditions.

The ACEDS shall be designed to withstand the highest short-circuit current available for a given point within the system, and to selectively isolate the short circuit as quickly as possible, minimizing loss of loads and damage to equipment.

The ACEDS shall provide adequate voltage and frequency to connected equipment within the tolerances of equipment operating voltages during all design ranges of the electrical system.

General Design Criteria

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General Design Criteria

2

2.01 Reliability Criteria - Infrastructure Segmentation Strategy (AC Power Distribution Systems)

The overall objective for all NCS-managed Network locations is to provide a safe, secure, reliable infrastructure supporting the AT&T Network at a best-in-class cost. The Infrastructure Segmentation Strategy is a risk management plan that focuses on providing appropriate infrastructure reliability to segmented categories of Network offices or sites in a cost-effective manner.

The approximately 5,000 NCS Network offices and sites have been segmented into five categories based on the relative impact on the AT&T Network of a location-specific service outage. Greater infrastructure reliability objectives are assigned to the more critical office or site categories. While our goal should be to have virtually no service outages, practical experience tells us that we cannot reduce this probability to zero. The incremental costs of increasing our infrastructure reliability beyond certain levels may become unacceptable. This Segmentation Strategy proposes infrastructure reliability objectives appropriate for the Network service risk associated with each office or site category.

The Segmentation Strategy considered the infrastructure at each NCS office or site to be composed of three major functional systems: DC Power, AC Power, and HVAC. AC power systems are composed of AC power distribution systems and standby AC power systems. This practice addresses the AC power distribution system architectures recommended to meet reliability objectives of the Infrastructure Segmentation Strategy. Standby AC power plant architecture recommendations are included in AT&T 760-400-102, Standby AC Plant Design, Installation and Acceptance Criteria.

It is important to note that, in the case of new construction, these standards **shall** be employed. In the case of existing infrastructure, upgrades to bring offices/sites into compliance with these standards may be affected by variables such as capital availability, the relative reliability of commercial AC power at the office/site, or the availability of Network restoration facilities in the event of a failure of infrastructure or primary Network facilities.

Office/Site Category Definitions

Critical - Platinum Office

A Network service outage in any of these offices can have a catastrophic impact on Network operations and hence to the AT&T brand name. Subjective judgement is applied on the relative importance of the services provided from an office; that is, what customers would be affected by an outage and what the resulting impact would be. Each Critical-Platinum office should be configured and maintained to meet an infrastructure-related MTBF of 2000 years. The top 60 of the 145 Critical Offices have been placed in this category.

Critical - Gold Office

A Network service outage in any of these offices can have serious impact on Network operations and hence to the AT&T brand name. Each Critical-Gold office should be configured and maintained to meet an infrastructure-related MTBF of 1200 years. Critical offices not placed in the Platinum category have been assigned to the Gold office category.

Major Office

A Network service outage in any of these offices can have a major impact on some AT&T customers, however, the AT&T brand name impact may be minimal. Subjective judgement will be applied as to the relative importance of service provided from an office. Major offices will include significant Network switching locations not included in the above Critical Office categories. Each major office should be configured and maintained to meet an infrastructure related MTBF of 600 years. There are approximately 150 Major offices in the Network.

Node Office

A Network service outage in any of these offices can have a major impact on specific AT&T customers with an overall impact less than that of a Major Office. Nodes include all offices with significant terminating traffic not designated as Critical or Major. Each Node office should be configured and maintained to meet an infrastructure-related MTBF of 400 years. There are approximately 500 Node offices in the Network, with a cumulative total of approximately 800 Critical, Major and Node Offices.

Site

Any other Network location not assigned to the Critical, Major or Node Office categories. Sub-categories within the definition of Site are to be developed for small POP's, lightwave regenerators and radio repeaters. Infrastructure reliability objectives for Sites are not established because of criteria that differ according to the Network restoration capability at each Site. Site operating characteristics will also differ based on various criteria such as commercial AC power reliability at the Site.

AC Systems Overview- Recommendations by Building Category

Critical-Platinum Office

- **AC Service Feeds -** N+1 dual/diverse AC service feeds should be provided from separate substations or from a city grid capable of being fed from separate substations. If dual service feeds are prohibitively costly, N+1 standby engines should be provided as an alternative.

NOTE:

— N = the minimum number of service feeds required to support the building.

— Physical separation (3-hour fire barrier or separate vaults) should be provided on all new service entrance equipment required to provide a second or diverse AC service entrance. Physical separation or fire barrier protection of existing service entrances must be evaluated for overall risk to service and estimated cost to upgrade. Only limited physical separation of dual AC feeds on the commercial side of the service entrance will be required. Diverse feeds sharing the same manhole or underground ductway will be acceptable as long as the feeds are in separate conduits. Overhead diverse feeds should not share the same utility pole.

— Buildings located in zone 4 seismic areas will require N+1 standby engines due to the susceptibility of commercial AC power to failures during seismic activity. This supersedes the requirement for dual AC service feeds in zone 4 buildings, and will be applied even to buildings which are equipped at present with dual AC feeds.

- **Building Main Service Entrance Boards -** When dual AC service feeds (as defined above) are provided, each service feed should terminate in the building at separate main service entrance boards. These boards should be equipped with a flexible switching arrangement so that AC power can be maintained to both boards in the case of failure of either service feed. A minimum 6-foot physical separation or a 3-hour fire barrier should be provided when a new main service entrance board is being installed. Physical separation or fire-barrier protection of **existing** main service entrance boards must be evaluated for risk to service and estimated cost to upgrade.
- **Dual AC Distribution System/Dual Risers -** A dual AC distribution/riser system is required in all buildings located in zone 4 seismic areas. Redundant/ essential equipment which has the capability of being powered from two AC sources should be split between the dual distribution systems (i.e., DC power plants, motor control centers, fuel pumps, HVAC fans, chillers, etc.).
- **Spare Breakers for Essential Load -** Spare breakers should be provided on site (one for each type) for main house service breakers, transfer breakers, and main distribution breakers which are determined to be a single point of failure for essential loads. (A separate spare breaker will not be required for transfer breakers when the identical/exchangeable “draw out” type breaker is used for both the commercial and standby sources.)
- **Standby Engines -** N standby engines will be the standard configuration for buildings which are equipped with dual/diverse AC service feeds. N+1 standby engines are required when one AC service feed is provided. All engines shall be auto-start, auto-transfer, auto-parallel (when paralleling is required), and auto-transfer back to the commercial source. See AT&T 760-400-102, Standby AC Plant Design, Installation and Acceptance Criteria for more details on standby power requirements.
- **Portable Engine Quick-Connect -** A quick-connect should be required in buildings that do not have dual AC service feeds and in buildings that have a high probability or past history of natural disasters such as hurricanes, tornados or earthquakes (zone 4 only). Buildings equipped with N+2 standby engines, except for those located in zone 4 seismic areas, will not require a portable engine quick-connect.
- **Single-Line Drawings -** Complete and accurate single-line drawings, riser diagrams and panel schedules are required. All drawings shall be built in Auto CAD Release 12 format per the AT&T Computer Aided Drafting Specification.

- **Studies** - Fault-current studies, coordination studies, and load studies are required for all buildings. All deficiencies should be evaluated as to extent of risk and cost to upgrade. Life safety issues should be addressed as a special project or as part of other capital projects. All studies should be documented in software programs, such as Dapper and Captor. Hard copies of the studies should be maintained at each building.
- **AC Power For DC Plants** - DC plants should be fed AC power per Power and Infrastructure Standard DCPWR-001 - DC Power Diversity Standards for AT&T designated Critical Offices.
- **AC Power for other Redundant/Essential Equipment** - If two sources of AC power are available within the building, essential redundant equipment (i.e., fuel pumps, fan units, motor control centers, chillers. etc.) should be powered from separate diverse sources as far back into the AC distribution system as practical.

NOTE:
Critical redundant equipment served from one MCC which is provided AC power from diverse sources will be acceptable.

Critical - Gold Office

- **AC Service Feeds** - A single AC service feed with N+1 engines is standard. If dual/diverse service feeds are already installed, this is acceptable and the location will not require N+1 engines for standby power.

NOTE:

- — N = the number of service feeds required to support the building essential loads
- — The addition of a second AC service offers greater availability and is the preferred option when the cost to provide is equal to or less than the cost to add N+1 engines.
- — Buildings located in seismic zone 4 will require N+1 standby engines due to the susceptibility of commercial AC to failure during seismic activity. This requirement applies to all buildings in zone 4, including those which may already have dual/diverse AC service feeds installed.

- **AC Distribution** - A single AC distribution system within the building is the standard. If a dual distribution system is presently installed it should be maintained and utilized for redundant essential loads.

- **Spare Breakers for Essential Load -** Spare breakers should be provided on site (one for each type) for main house service breakers, transfer breakers, and main distribution breakers which are determined to be a single point of failure for essential loads. (A separate spare breaker will not be required for transfer breakers when the identical/exchangeable draw-out type breaker is used for both the commercial and standby sources.)
- **Standby Engines -** N standby engines will be the standard configuration for buildings which are equipped with dual/diverse AC service feeds. N+1 standby engines are required when one AC service feed is provided. All engines shall be auto-start, auto-transfer, auto-parallel (when paralleling is required), and auto-transfer back to the commercial source.
- **Portable Engine Quick-Connect -** A quick-connect shall be provided in buildings that do not have dual/diverse AC service feeds and in buildings that have a high probability or past history of natural disasters such as hurricanes, tornados or earthquakes (zone 4 only). Buildings equipped with N+2 standby engines, except for those located in zone 4 seismic areas, will not require a portable engine quick-connect.
- **Single-Line Drawings -** Complete and accurate single-line drawings, riser diagrams and panel schedules are required. All drawings shall be built in Auto Cad Release 12 format per AT&T Computer Aided Drafting Specification.
- **Studies -** Fault-current studies, coordination studies, and load studies are required for all buildings. All deficiencies should be evaluated as to risk and cost to upgrade. Life safety issues should be addressed as a special project or as part of other capital projects. All studies should be documented in software programs, such as Dapper and Captor. Hard copies of the studies should be maintained at each building.
- **AC Power For DC Plants -** DC plants are to be supplied separate and diverse AC power feeds per Power and Infrastructure Standard DCPWR-001, DC Power Diversity Standards for AT&T Designated Critical Offices.
- **AC Power for Other Redundant/Essential Equipment -** If two sources of AC power are available within the building, essential redundant equipment (i.e., fuel pumps, fan units, motor control centers, chillers. etc.) should be powered from separate diverse sources as far back into the AC distribution system as practical.

NOTE:

Critical redundant equipment served from one MCC which is provided AC power from diverse sources will be acceptable.

Major Offices

- **AC Power Feed** - Single AC power service feed and service entrance.
- **Service Entrance Board** - One Main Service Entrance Board.
- **Standby Engines** - N engines, auto-start and auto-transfer.
- **Portable Engine Quick Connect** - Provide hard-wired connection and disconnect.

Nodes

- **AC Power Feed -** Single AC power service feed and service entrance board.
- **Standby Engines -** N Engines, auto-start and auto-transfer.
- **Portable Engine Quick Connect -** Provide hard-wired connection and disconnect.

Sites

- **AC Power Feed** - Single AC power service feed.
- **Standby Engines** - Auto-start and auto-transfer on permanently installed engines.

  Radio - N engines.

  Lightguide - Standby AC power is provided by portable engines at a rate of 1 portable engine for every 3 regenerator sites. A permanently installed engine is not required, but may be provided at sites which have had a documented service failure due to site inaccessibility, or which are not fully restorable by FASTAR or a SONET ring.
- **Portable Engine Quick Connect**

  Radio- provide hard-wired connection point and disconnect switch.

  Lightguide - Plug and receptacles with disconnect should be provided per Power and Infrastructure Standard ACPWR-002.

Definitions

Automatic Load Shed - A mechanized system installed for the purpose of shedding non-essential and Priority 2 (essential) loads in order to maintain power to Priority 1 (essential) loads in the event of one or more standby engine failures.

N Standby Engines - The number of generators required to carry all building essential loads.

N+1 Standby Engines - A multiple standby engine configuration equipped with a single redundant standby generator for backup support of the other generators on site. The loss of any one generator should not limit the ability of the remaining generator or generators to support the building Priority 1 essential loads. In some locations this may require the automatic load shedding of building non-essential loads, and Priority 2 essential loads.

Non-essential Loads - Those AC loads which are not required to maintain service to telecommunications equipment. These loads may be included in an auto load-shed plan and will be the first loads to be shed.

Typical Non-essential loads:

1. Artificial load banks
2. Food/beverage service areas and equipment (cafeterias, kitchens, vending machine areas, etc.)
3. Non-essential office equipment (copiers, printers, terminals, etc.)
4. Non-essential lighting
5. AC panels and circuits supporting non-telecommunications equipment areas.
6. HVAC fans which are dedicated to non-telecommunications equipment areas
7. Chillers and HVAC equipment which are dedicated to non-telecommunications equipment areas.

Priority 1 (Essential) Loads -Those AC loads which are required to maintain telecommunications service and the absolute minimum infrastructure loads required to support critical telecommunications equipment. They will also include critical security, environmental, fire protection, and alarm systems. These loads should not be part of an auto load-shed plan.

Typical Priority 1 (Essential) Loads:

1. Any AC operated equipment required to maintain proper operation of the AC system. The following list is representative of most AC systems but may not be all inclusive:
   - Engine fuel pumps -
     - storage tank to day tanks
     - Day tanks to engines
     - AC operated controls for fuel pumps
   - Engine fans
     - remote radiator

- — room exhaust
- — combustion air
- — oil cooling fans
- — AC operated controls for fans
- — AC operated louvers and dampers required for combustion or cooling air flow.
- — Engine coolant water pumps for remote radiators and heat exchangers
- — AC operated engine control and alarm systems
- — Engine start and control battery chargers
- — Engine air start systems (compressors, controls, etc.)

2. Chillers (except for spare or “+1” chillers, which are Priority 2 loads)
3. Fan units and airhandling equipment required for telecommunications equipment areas
4. HVAC controls
5. DC power plants supporting communication equipment
6. DC power plants supporting switchgear control battery
7. AC power for switchgear controls
8. AC power required for PLC operation
9. Office communication system (PBX)
10. AC power for building alarm systems
11. AC feeds for UPS systems
12. Elevators required by life safety codes
13. Building security systems
14. Fire alarm systems
15. AC pumps for the fire suppression stand pipe system
16. Emergency lighting systems
17. Sump pumps and sewage pumps.

Priority 2 (Essential) Loads - Those AC loads which are significant but are not absolutely required to maintain service to telecommunications equipment. These loads may be included in an auto-load-shed plan and will be the last loads to be shed.

Typical Priority 2 (Essential) Loads:

1. Spare rectifiers (may be included in an auto-load-shed plan with a rectifier sequence controller)
2. Chillers (“+1” or spare chillers)
3. Elevators not required for life safety
4. General lighting for equipment areas.

Riser Diagram - A graphical block schematic of all AC electrical distribution and standby AC equipment on an elevation by building floor. All equipment will be represented with un-detailed blocks showing interconnections with other equipment.

Single-Line Drawings - a detailed graphical schematic of the AC distribution system from the AC service entrance to the loads, showing all distribution boards, breakers, panels, standby engines, transfer switches, motor control centers, and major equipment loads.

2.02 General Protection Philosophy

Electrical protection shall be designed to isolate a short-circuit or overload condition at the protective device closest to the fault and to minimize equipment damage and the removal of equipment from service.

Coordination

Coordination shall be maintained between overcurrent protection devices. Protection coordination studies shall be performed in accordance with IEEE 242, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems. Where this objective can not be practically achieved for fuses and thermal magnetic molded-case circuit breakers providing branch circuit protection, the uncoordinated condition shall be designed so it does not affect essential equipment.

In general, the coordinating time interval shall be 0.35 seconds between upstream and downstream relays on the medium-voltage distribution system and between upstream medium-voltage relays and downstream 480 V trip devices.

The 0.35 second interval is based on the following:

- 0.1 second relay reset time
- 0.1 second breaker clearing time
- 0.15 second safety margin

For coordination between upstream and downstream 480 V trip devices, the time/current characteristics can be as close as possible without overlapping. The upstream device shall have a short-time delay trip without instantaneous trip characteristics.

Where a 480 V trip device is to coordinate with a molded-case thermal magnetic circuit breaker or with a thermal overload relay and instantaneous circuit breaker at a motor control center, the time/current characteristic bands of both devices shall not overlap, and the upstream 480 V trip device shall have a short-time trip rather than an instantaneous trip characteristic.

Where thermal magnetic molded-case circuit breakers are used in 480 V motor control centers to protect a feeder which supplies a number of branch circuits, each protected with a local device, the molded case circuit breakers need not coordinate with the local devices.

Where thermal magnetic molded-case circuit breakers in 480Y/277 V, 208Y/120 V and 120/240 V panels are used to protect both incoming supply circuits and outgoing branch circuits, the upstream breaker characteristic shall not overlap with the downstream breaker characteristics.

Fuses shall be coordinated by providing visible separation between the fuse characteristics and the device with which it is to be coordinated. Upstream devices shall be coordinated with the fuse clearing characteristic. Downstream devices shall be coordinated with the fuse melting characteristic.

Fuse-to-fuse coordination shall be established by sizing the incoming fuse at twice the rating of the feeder circuit or at the ratio established in ANSI/IEEE 242, Table 27.

Coordination studies shall conform to guidelines set forth in Section 2.08, Quality Assurance.

Protection philosophy specific to the electrical equipment is addressed in Sections 4.02, 4.03 and 5.02.

2.03 Fire Protection

Manual Suppression

Standpipe and Hose

All areas shall be accessible for fire fighting by manual suppression systems including standpipe and hose. Coverage of all areas shall be capable within 150 feet of a standpipe hose station and in compliance with AT&T 760-640-310, Standpipe and Hose Systems, or as required by local codes.

Portable

All electrical areas shall be furnished with portable fire extinguishers. A combination of CO_2, dry chemical, or approved substitute shall be utilized. For further requirements, refer to AT&T 760-640-105, Fire Safety Selection and Distribution of Portable Fire Extinguishers.

Automatic Suppression

Automatic suppression systems may be required by code for particular equipment.

Compartmentation

Compartmentation shall be utilized to reduce the spread of fire and smoke throughout the building by use of floor-to-floor vertical fire separation assemblies and partitions, and floor- to-floor horizontal fire separations. Refer to AT&T 760-630-400, Compartmentation.

Fire Detection

Fire detection shall be provided for all areas of the telephone equipment building. Early warning fire detectors include smoke (photoelectric, aspirated Vesda type, etc.), heat (fixed-temperature, rate-of-rise, etc.), ultraviolet (UV), infrared (IR) or combination UV/IR. Refer to AT&T 760-650-100, Fire Detection Systems.

NOTE:
The type of detector shall be dependent on the type of automatic suppression systems protecting the area.

Penetration Sealing and Fire Stopping

All penetrations of fire-rated assemblies, horizontal and vertical, shall be sealed with a qualified fire penetration and smoke seal. Refer to AT&T 760-630-410AC, Fire Stopping Considerations for Floor and Wall Penetration and Protection of Cable Runs, NFPA-251, Standard Methods of Fire Tests of Building Construction and Materials, and ASTM E-119, Standard Methods of Fire Tests of Building Construction and Materials.

NOTE:
All information above on fire suppression is based on the building having a fire-resistive Type 1-443 construction. Refer to NFPA-220, Standard on Types of Building Construction.

2.04 Separation and Redundancy

Equipment and Cable

To minimize common point failure and adverse interactions between redundant power equipment, all new designs shall provide separation where possible and practical between redundant AC Distribution equipment that supplies power to essential loads. Separation of redundant power equipment is defined as both physical separation and electrical isolation.

The physical separation of redundant equipment shall make effective use of features inherent in the building design (i.e., using different rooms, raceway chases, or opposite sides of rooms or areas). Electrical isolation of connected redundant equipment may be achieved by interposing two normally-open circuit breakers between them. The separation criteria in this section are based on the use of cables meeting the fire propagating requirements of IEEE Std. 383.

General

The areas through which the above redundant cables are routed and in which equipment is located shall be reviewed for the existence of potential hazards such as combustible material sources and flooding.

The areas shall be classified as follows:

- Low Hazard - Contents of the area are of such low combustibility that no self-propagating fire can occur therein.

- Ordinary hazard - Contents of the area are likely to burn with moderate rapidity or give off a considerable volume of smoke.
- High hazard - Contents are likely to burn with extreme rapidity or from which explosions are likely.

The amount of separation provided shall depend on the damage potential of the hazard. Provisions for separation of cables located in ordinary or high hazard areas shall be made early in the design through the use of features such as separate rooms or physical separation. The minimum separation for electrical equipment shall be as set forth in the NEC Articles 110 and 384.

Internal Separation

Where switchboard materials are flame-retardant, the minimum separation between redundant circuits in common switchgear, panels, or cabinets shall be:

1. One foot separation between redundant power, control and instrumentation equipment and/or associated cables (cables larger than No. 10 AWG).
2. Six-inch separation between redundant power, control and instrumentation equipment and cables (cables equal to or smaller than No. 10 AWG).
3. One-inch separation between redundant equipment and cables where a barrier exists.

2.05 Environmental

Heating and Ventilation

The HVAC system shall be capable of maintaining ambient temperature in the electrical equipment areas within the operating temperature limits of the equipment.

The HVAC control system shall include provision for monitoring ambient equipment room temperatures and alarming, in the event of abnormal conditions, at a central location (which may not be located on site) staffed 24 hours a day. The control system shall also monitor the operating status of all cooling and ventilation system equipment and shall provide an alarm in the event of failure. For further requirements, see AT&T 154-103-101, Alarms Standards Manual.

Flood Control (Internal Flooding)

Electrical equipment areas subject to flooding from above or adjacent areas, or located below grade, shall be protected from the effects of flooding by use of a floor drain system, and sump pumps where required.

All floor mounted electrical equipment **subject to flooding** shall be mounted on a 6 inch concrete pad.

All penetrations entering an electrical area from above shall be sealed watertight.

Floor drains for transformer vaults and stand-by generator rooms shall be provided with oil separators.

Pipe Routing

Pipe routing of fluid systems (potable water, chilled water, condenser water, etc.) shall be restricted within electrical equipment areas/rooms.

Electrical equipment in new installations shall be protected from pipe leakage primarily by routing piping outside electrical equipment areas. Piping that is less than 25 feet AFF shall not pass directly over Network Elements such as rectifiers, switchboards, battery strings, panel boards and distribution boards for light and power. Efforts should be made to avoid locating sprinkler system piping directly over Network Elements. Coordination of piping and electrical equipment shall be done between the Design Engineers. An overlay drawing showing piping and electrical equipment shall be submitted to the AT&T Building Engineer responsible for the project for review and approval prior to release of documents for construction. Electrical equipment shall be located in accordance with the NEC Articles 110 and 384.

Where existing pipe is routed over existing electrical equipment, every effort should be made to relocate and isolate the electrical equipment. If this is not feasible then Network Elements as well as AC distribution equipment shall be protected by the use of drip pans or other means of preventing leakage directly onto equipment.

Leak detection systems shall be provided whenever piping is routed through an electrical equipment area.

2.06 Instrumentation and Control

Equipment in the ACEDS shall be provided with local instrumentation, alarm and control systems suitable for the operation, control and monitoring of equipment. The criteria for specific equipment are listed in Chapters 3 through 8.

In addition to equipment controls and instrumentation, consideration should be given to providing a local alarm and control center which may contain the indication, alarms and controls to operate and control selected equipment from a central location. The provisioning of a local control and alarm center is discretionary, and depends on the size and complexity of the building AC distribution system.

The local alarm center may contain alarms and instrumentation for equipment as detailed below.

Control Switches for:

- Feeder breakers to main distribution (essential and nonessential) buses
- Bus tie breakers connecting main distribution (essential and nonessential) buses
- Feeder breakers to stand-by AC plants
- Feeder breakers to selected HVAC equipment
- Selected telecommunications equipment controls
- Control switches to start, synchronize, load, stop and run the standby AC plants

Indication for:

- Main distribution (essential and nonessential) bus current and voltage
- Standby AC plant voltage
- Automatic transfer switch position
- On/off status of selected HVAC equipment
- Transfer breaker position

Alarms

Local and remote alarms should be provided per AT&T 154-103-101, Alarms Standards Manual.

Communications

Provide inter-office communication phones connected directly to the local operating company and not routed through the office PBX.

2.07 Electrical Protective Systems

Grounding

Equipment Grounding

An intentional ground of all metal enclosures and adjoining metal surfaces shall be installed to limit the potential difference between noncurrent-carrying metal parts and ground. Equipment grounding shall also provide a low impedance path for ground-fault current flow to ensure positive operation of protective devices. This grounding shall be in addition to the electrical grounding circuit, and shall be connected to the central office ground system.

All grounding materials shall be resistant to, or protected from corrosion.

Grounding conductors and ground fittings shall resist deterioration and fusing under the most adverse combination of fault-current magnitude and duration.

All non-current carrying metallic parts which might accidentally become energized (including but not limited to: transformer tanks, motor frames, raceways and switching assemblies) shall be connected to the equipment ground system.

The equipment grounding system shall comply with all requirements of the NFPA-70 (NEC), Article 250 and with AT&T 802-001-180, Protective Grounding Systems - General Grounding Requirements, and 802-001-198, Protective Grounding Systems - General Equipment Ground Requirements.

All equipment grounding shall be bonded to the central office grounding system.

Grounding conductors shall be no smaller than #6 AWG, and connected using two hole bolted circumferential-crimp type connectors.

In addition, an AC Equipment Grounding (ACEG) conductor shall be provided in the metallic raceway and bonded to equipment enclosures to provide continuity between enclosures, independent of raceway continuity per NEC 250.

Neutral conductors shall not be used for equipment grounding. A separate grounding conductor shall be provided for all circuits to ensure an adequate ground-fault return path.

The ACED system equipment and frame grounding conductors shall be insulated or bare. If insulated, the color of the insulation shall be green.

AC System Grounding

Where the utility supply source is 600 V or less, or where the supply source is 4,160 V and the utility owns the power transformers, the main distribution system shall be solidly grounded. Refer to AT&T 760-400-510, Building Electrical Systems Grounding.

Where the supply source is 4160 V or higher and AT&T owns the power transformers, the main distribution system shall be low-resistance grounded to limit available ground-fault current while still allowing coordination of protective devices.

Surge Protective Arresters

Surge protective arrester connections shall be designed to be disconnected when the connecting equipment or distribution feeders are energized to facilitate testing. Refer to section 3.03 for more information covering surge protective arrestors.

Lockout/Tagout

All AC circuits must be provided with features which enable maintenance personnel to lock out and tag out said circuits in compliance with OSHA 1910.147 and ACP 010-160-212, Procedures For The Control of Hazardous Energy - Lockout/Tagout.

2.08 Quality Assurance/Documentation

The following procedures shall be employed to assure that design activities are carried out in a planned, controlled, orderly and correct manner:

- The design responsibilities, authorities and interfaces among the contributing organizations (AT&T Corp., building owner, architect/engineer, equipment supplier, other contractors, and local utility), both internal and external, shall be identified and clearly delineated.
- The AT&T Building Engineer shall be copied on any correspondence between project team members. This shall include telephone conversation records on conversations concerning the project in which design decisions are made.
- Exchange of technical information across external and internal interfaces shall be planned and coordinated and shall be sufficient to ensure that the organization responsible for development of an appropriate design has complete and up-to-date information.
- Coordination of piping, mechanical equipment and electrical equipment shall be done between the Design Engineers. An overlay drawing showing piping and electrical equipment shall be submitted to the AT&T Building Engineer responsible for the project for review and approval prior to release of documents for construction.
- Electrical equipment shall be located in accordance with NEC Article 110. Voltages on mechanical equipment shall be coordinated between Design Engineers prior to release of documents.
- Voltage coordination of equipment shall also take place during the equipment submittals. This process shall continue through the design and installation of the project.
- Design documents such as calculations and drawings shall be prepared in a manner which reflects actual and existing or proposed conditions which clearly identifies which state (actual or proposed) the document purports to represent.
- Appropriate design input for design documents shall be identified. For example:
  - — Basic functions of each item of equipment, system, and component
  - — Performance requirements such as load, capacity, rating and protective coordination
  - — Codes and standards, including the applicable issue and/or date
  - — Design conditions such as short-circuit current and system voltage characteristics.

- Design documents shall be retained at each AT&T site and shall be easily accessible to potential users. Calculations and studies shall be maintained in a three-ring binder. Drawings shall be kept in order by date in a protective sleeve.
- As a minimum, the following design documents shall be developed and maintained current for the location with a copy maintained at the location:
  - Electrical drawings, including single-line drawings, riser diagrams, panel directories and floor plans identifying locations of panels on the floor and routing of main feeders. All drawings are to be completed in AutoCAD® Release 12 format per the AT&T Computer Aided Drafting Specification.
  - Electrical load calculation or analysis
  - Short-circuit calculation or analysis
  - Voltage profile calculation defining voltage levels throughout the AC system
  - Cable sizing calculation
  - Protective device coordination calculation with graphic representation
  - System description including operation of the system
  - Integrated wiring diagrams which include all wiring from termination point to termination point.
- The above mentioned studies and calculations shall be submitted in a computer generated format. Identification of devices in these reports shall coordinate with that on the electrical riser diagram. Programs to be used are Dapper®or Captor®. The load calculations shall also include switchboard, motor control center and panelboard schedules for each floor in the building. These reports shall be kept on file and updated with each project. The Design Engineer on each project will be responsible for obtaining the latest calculations and studies and updating them with the new project parameters in a computer generated format.
- All design drawings shall be produced in accordance with AT&T Computer Aided Drafting Specification. The system used shall be AutoCAD® Release 12. The Design Engineer on each project will be responsible for obtaining the latest “as built” drawings and updating them with the new project parameters in a computer generated format.
- Changes to design documents shall be controlled in such a manner that the most recent document is:
  - Available for use at each location
  - Appropriately identified as the most recent issue through the use of a sequential numbering system

  - Appropriately marked to indicated where the change occurred, what the change was and the reason for the change
  - Approved “In- process” by the AT&T Building Engineer
  - Issued as an “As-Built” within three months of final acceptance of system or modifications by AT&T.
- Operating and maintenance manuals and manufacturer's drawings shall be submitted to the AT&T location being modified prior to final acceptance of system or modifications by AT&T.
- On-site or factory training shall be provided as needed.

Utility Service Entrance

3

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Utility Service Entrance

3

3.01 General Design Criteria

Design

The utility power service may consist of one or more sources. When one source is used, every effort should be made to obtain that source from a power company grid, secondary network, or secondary selective network system to decrease the likelihood of an outage.

Fire Protection

Where the utility power sources include power transformers owned by AT&T, the transformers shall meet the fire protection requirements described in Section 3.02 in addition to any fire protection requirements given by the utility.

Where the power transformers are owned and/or maintained by the utility and located in the AT&T facility, the fire protection recommendations given by the utility shall be followed as a minimum.

Additional fire protection requirements listed in NFPA-70 (NEC) Article 450, and applicable to ACEDS transformer design shall be implemented in new installations.

Separation and Redundancy

Where two utility power sources are provided, 6 foot feeder cable separation shall be maintained when economically feasible. Each utility primary distribution feeder cable shall be routed from its separate utility substation or its separate distribution bus, using a separate and diverse route from its redundant feeder cable, with separate entry into the building. If separate entry is not possible, use a common building entry with a 3 hour fire-rated barrier between the cables.

Physical separation (3 hour fire barrier or separate vaults) should be provided for all NEW service entrance equipment required to provide a second or diverse AC service feed.

Electrical Protective Systems

Surge Protective Devices

The incoming utility power sources, run either overhead or underground, shall be protected by surge protective arresters. Refer to Section 3.03 of this practice, AT&T 876-200-100, Electrical Protection - Central Offices, and 876-101-100, Electrical Protective Devices.

3.02 Power Transformers

Design

The following equipment criteria apply to all power transformers located on AT&T property:

- The transformers shall be of either dry-type or liquid filled, but preferably enclosed dry-type. Transformers located indoors shall be ventilated dry-type. All outdoor dry-type transformers shall be constructed using vacuum pressure impregnation (VPI) epoxy encapsulated windings.
- Three-phase transformers shall be connected delta primary with wye secondary and shall be capable of delivering 70 per cent rated kVA output at 10 per cent above rated secondary voltage without exceeding limiting temperatures. The transformer shall be equipped with two 2 1/2-percent full capacity primary taps above and below rated voltage unless otherwise required, based on the results of the voltage profile calculation.
- The transformer impedance selected shall be verified at completion of the voltage profile and short-circuit calculations.

- Unless otherwise indicated, the transformer load current will have a harmonic factor not exceeding 0.05 per unit. Harmonic factor is defined in ANSI C57.12.80 and ANSI C57.110.
- The transformer shall have a copper-faced ground pad. The BIL for each winding shall be at the level shown in bold face type in IEEE Standard C57.12.00. In cases where two values are shown, the higher value shall apply.
- If a forced-cooling rating is provided, all necessary equipment shall be furnished and mounted.
- Floor space allocation should consider the addition of future transformers. Location layout shall comply with NEC and separation requirements in Section 2.03.

Dry-Type Transformers

The transformers shall be constructed using a 220° C insulation system and shall not exceed 115° C average winding rise above standard ambient at rated load conditions.

Indoor transformers shall be provided with a ventilated metal enclosure. Refer to the environmental section in this chapter for more information.

Outdoor transformers and unit substation transformers 2,500 kVA and below shall be protected and marked as provided in ANSI C57.12.55-1987, Dry-Type Transformers Used in Unit Installations, Including Unit Substations - Conformance Standard. For units above 2,500 kVA, refer to ANSI C57.12.51-1981, American National Standard Requirements for Ventilated Dry-Type Power Transformers, 501kVA and Larger.

Liquid Filled Transformers

Transformers rated at 2,500 kVA, 34.5 kV and below shall be protected and marked as provided in ANSI C57.12.27-1982, American National Standard Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations. Transformers rated above 2,500 KVA, 34.5 KV, shall comply with ANSI C57.12.00-1987, IEEE Standard General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers.

Protection Philosophy

Transformers Supplying Medium Voltage Distribution

Connect AT&T-owned transformers delta on the high-voltage side and low-resistance-grounded wye on the low side. In general, the local utility owns and maintains the transformers which supply main distribution buses. These transformers are most often solidly grounded at the low-voltage side.

Differential Protection

Provide for transformers larger than 3,000 KVA, three high speed, harmonic-restrained, percentage-differential relays for differential protection against internal 3-phase, phase-to-phase, and phase-to-ground faults in each transformer. The relays will provide protection for the medium-voltage connections up to the bus supply circuit breakers. The relays shall energize the transformer lockout relay which trips the transformer high-side and low-side circuit breakers.

Sudden Pressure Protection

One rate-of-rise gas pressure relay shall be provided to supply sudden pressure protection for each main power supply transformer for protection against turn-to-turn faults and for backup protection for each respective differential relay. The relay shall alarm and energize the transformer lockout relay. Sudden pressure relays are factory set, require no field setting and would be provided by the local utility if they supply the transformers.

Thermal Protection

A temperature detector shall provide thermal protection by sensing actual temperature rise and energizing alarms and protective devices. This protection shall initiate an alarm at 105° C and energize an auxiliary relay which energizes the transformer lockout relay at 125° C.

Overcurrent Phase Protection

Backup overcurrent phase protection shall be provided on the high-voltage side of the transformer by three extremely inverse time-overcurrent relays with instantaneous trip units for faults on the high and low-voltage connections of each transformer. The instantaneous units will provide protection for faults in the high-voltage transformer leads halfway through the transformer and the time-overcurrent unit will provide backup protection to the switchgear bus supply breaker relaying. These relays shall energize the transformer lockout relay.

The instantaneous overcurrent unit shall be set to override transformer inrush and secondary asymmetrical faults.

The pickup of the time-overcurrent unit shall be set to allow the transformer to carry a minimum of 120 percent of the maximum rated current while operating at 95 percent of transformer rated voltage. The time dial setting shall coordinate with the downstream protection and protect the transformer against thermal damage due to through fault current as per ANSI/IEEE C37.91.

Ground Overcurrent Protection

Provide two ground-overcurrent relays at the low side wye neutral. One of these relays trips the bus incoming feeder breaker for bus ground faults and the second relay energizes the transformer lockout relay. These relays are set to coordinate with each other and with the bus feeder ground-fault protection. Also, at the transformer neutral, independent, sensitive ground-fault detection shall annunciate for low level ground faults anywhere at the medium-voltage distribution system. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

15k & 4,160 - 480V Transformer Feeder Protection

When the transformer feeding the low voltage distribution system is protected by fuses at the high side, protection shall comply with NFPA-70 (NEC), Article 450-3 and protect the transformer for through faults per ANSI/IEEE C37.91, IEEE C57.12.59 and NEMA STD-20.

Feed each transformer from a single medium-voltage breaker and protect it by three single-phase, time/instantaneous overcurrent relays at the high side. Set the instantaneous elements of these relays to detect faults halfway into the transformer winding. The settings of the time/overcurrent elements are described below:

- The settings shall coordinate with the protective device at the low side of the transformer.
- Maximum pickup shall not exceed 200 percent of the transformer's full-load current rating based on its forced-air rating.
- The setting shall not exceed the thermal limit of the short-circuit capability of the transformer.
- The setting shall comply with NEC Section 450-3.
- The medium-voltage feeder cable shall be protected by the secondary protective device at the 480 V low voltage metal-enclosed switchgear.
- Ground protection shall be provided by a ground sensor scheme.

At the low side, at the solidly grounded neutral, a ground-overcurrent relay shall protect against ground faults at the low-voltage distribution. The pickup and time dial of this relay should be set to coordinate with the ground protection downstream. This relay will energize the transformer lockout relay. Also, at the transformer neutral, independent ground-fault detection shall annunciate for low-level ground faults anywhere at the low-voltage distribution system.

The phase and ground-overcurrent relays at the high side shall energize a lockout relay which shall trip the transformer medium-voltage breakers and the low-voltage 480 V circuit breakers.

Fire Protection

Fire protection criteria for power transformers are given in NFPA-70 (NEC), Article 450, Sections 21 through 48.

Additional fire protection criteria for oil-cooled transformers are as follows:

- For transformers rated less than 75 kVA, portable extinguishers shall be provided.
- For transformers rated between 75 kVA and 50,000 kVA, 1-1/2 inch fire hose and portable extinguishers shall be provided.

Refer to NFPA-10, Fire Extinguishers - Portable and NFPA-14, Installation of Standpipe and Hose Systems.

Separation and Redundancy

A power transformer requiring a fire-rated enclosure shall be separated from switchgear by a 3 hour, fire-rated barrier.

The transformer ratings and types requiring separation are as follows:

- Dry-Type, transformers rated greater than 35 kV
- Oil-Cooled, Less-Flammable Fluid Filled transformers rated 250 kVA and above
- Oil-Cooled, Mineral-transformers rated 75 kVA and above.

General separation criteria for all equipment are addressed in Section 2.04.

Environmental

The power transformers shall be capable of operating at their design capacity under the ambient conditions of temperature, humidity and altitude. Where required, transformer vaults shall be located where they can be ventilated to the outside without use of flues or ducts. Transformer vaults shall be provided with adequate ventilation for removal of generated heat. Accomplish ventilation by either natural circulation or mechanical means. Vault openings to the outside shall be provided for explosion venting as well as ventilation. Explosion vents shall be a minimum of one square foot per cubic foot of vault volume. The above addresses non-PCB transformers. Refer to AT&T 760-620-200, Considerations During Central Office Equipment Installation and Removal and 760-630-400, Compartmentation.

Electrical equipment areas subject to flooding from above or adjacent areas or located below grade shall be protected from the effects of flooding by the use of a floor drain system. Floor drains for transformer vaults shall be provided with oil separators. General environmental criteria are addressed in Section 2.05.

Instrumentation and Control

Local instrumentation shall be provided for each transformer to monitor winding temperature. If applicable, local instrumentation shall also be provided to measure liquid/gas temperature, liquid level and gas pressure.

Electrical Protective Systems

Grounding

Power transformers shall be grounded in accordance with AT&T 802-001-198, Protective Grounding Systems.

Where the utility supply source is 480 V or less, or where the supply source is 15kV or 4,160 V and the power transformers are owned by the utility, the main distribution system shall be solidly grounded. Refer to AT&T 760-400-510, Building Electrical Systems Grounding, and 800-200-100, Electrodes.

Where the supply source is 15kV or 4,160 V and the power transformers are owned by AT&T, the main distribution system shall be low-resistance grounded to limit available ground-fault current while still allowing coordination of protective devices.

Acceptance Testing

For acceptance testing criteria, refer to Chapter 8 of this practice.

Seismic and Structural

Transformers shall be mounted and supported in accordance with the manufacturer's recommendation.

Transformers shall be mounted on concrete pads with vibration isolators installed between the transformer and floor slab.

Transformers determined to be hazardous to adjacent essential equipment because of their potential for movement during a seismic event, shall have seismically designed supports and attachments to conform with the seismic zone in which they are located. Refer to AT&T 760-200-023, Earthquake Design Loads.

Codes and Standards

Transformers shall conform to the requirements of and be suitable for application according to the following specifications:

Liquid Filled

- ANSI C57.12.00 - IEEE General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers
- ANSI C57.12.13 - Conformance Requirements for Liquid-Filled Transformers used in Unit Installations, Including Unit Substations
- ANSI C57.12.27-1982, American National Standard Conformance Requirements for Liquid-Filled Distribution Transformers Used in Pad-Mounted Installations, Including Unit Substations
- ANSI C57.12.28 - Switchgear and Transformers - Pad Mounted Equipment Enclosure Integrity
- ANSI C57.12.92 - Guide for Loading Mineral-Oil-Immersed Power Transformers up to and Including 100 MVA with 55 C or 65 C Winding Rise
- ANSI C57.110 - Recommended Practice for Establishing Transformer Capability when Supplying Nonsinusoidal Load Currents
- ANSI C57.109 - Guide for Transformer Through-Fault-Current Duration
- AT&T Practice 760-200-023, Earthquake Design Loads

- AT&T Practice 802-001-180, Protective Grounding Systems, General Grounding Requirements for Communication Systems in Central Offices, Radio Stations and Other Structure Power Systems
- AT&T Practice 760-400-310, Building Electrical Systems Transformers
- AT&T Practice 800-200-100, Electrodes.

Dry Type

- IEEE C57.12.01 - Standard General Requirements for Dry Type Distribution and Power Transformers, Including those with Solid Cast and/or Resin Encapsulated Windings
- ANSI C57.12.51-1981, American National Standard Requirements for Ventilated Dry-Type Power Transformers, 501kVA and Larger
- ANSI C57.12.55-1987, Dry-Type Transformers Used in Unit Installations, Including Unit Substations - Conformance Standard
- IEEE C57.12.59 - Guide for Dry Type Transformer Through Fault Current Duration
- ANSI C57.12.80 - Terminology for Power and Distribution Transformers
- IEEE C57.12.91 - Guide for Loading Mineral Oil Immersed Overhead and Pad Mounted Distribution Transformers Rated 500 kVA and Less with 65 C or 55 C Average Winding
- IEEE C57.94 - Recommended Practice for Installation, Application, Operation and Maintenance of Dry Type General Purpose Distribution and Power Transformers
- IEEE C57.96 - Guide for Loading Dry Type Distribution and Power Transformers
- ANSI C57.110 - Recommended Practice for Establishing Transformer Capability When Supplying Non-Sinusoidal Load Currents
- AT&T Practice 760-200-023, Earthquake Design Loads
- AT&T Practice 760-400-310, Building Electrical Systems Transformers
- AT&T Practice 802-001-180, Protective Grounding Systems, General Grounding Requirements for Communication Systems in Central Offices, Radio Stations and Other Structure Power Systems.

3.03 Surge Protective Devices

Design

Distribution-class Surge protective devices (arresters) shall be connected to each overhead or underground primary distribution feeder (or service entrance conductor) on the utility side of the service entrance equipment at a minimum distance of 24 inches from the device to the bus connection. Arresters shall be connected directly to the building neutral with short, low-impedance cable connections.

The leads from the bus connection to the device shall be laced together and all leads shall be run as straight as possible with a minimum bending radius of 8 inches and a maximum length of 3 feet.

Surge protective arrester connections, in order to facilitate testing, shall be designed to be disconnected when the connecting equipment or distribution feeders are energized.

Instrumentation and Control

Each surge protective arrester shall have a visible alarm indicating if the arrester is open. Both visual and audible local and remote alarms are required.

All surge arresters located inside switchgear cabinets shall be equipped with a separate visual alarm panel.

Seismic and Structural

Surge protective arrester supports, attachments and foundations shall be in accordance with the manufacturer's recommendations and in compliance with the seismic zone requirements for the zone in which they are located.

Codes and Standards

All surge arresters shall conform to the requirements of and be suitable for application in accordance with ANSI C62.11 - Standard for Metal Oxide Surge Arresters for AC Power Circuits, and NEC Article 280.

3.04 Portable Engine Quick-Connects (AC Tap Boxes)

General

Portable engine quick-connects provide the means to connect portable engine alternators to the AC distribution system at network central offices. They are normally located outside of the building in an area that is easily accessible for parking of a trailer-mounted engine-alternator. The tap box or quick-connect may be located immediately inside the building if local conditions warrant.

All new portable engine quick-connects will be equipped with a fully-rated bus duct or conductor(s) and conduit from the switchgear bus to the external portable engine quick-connect. The bus duct or conductor(s) rating must be equal to the switchgear rating or a protective device shall be used at the switchgear to protect the conductors.

A disconnect switch shall be supplied at the portable engine quick-connect location.

All new installations of portable engine quick-connects shall include a portable engine auxiliary termination box. From this auxiliary box, conduit shall be run with twenty-six No. 16 conductors and two No. 16 twisted shielded pairs. The conductors will be terminated on terminal strips in the auxiliary enclosure and at the switchgear. The switchgear will be labeled with a corresponding numbering system. These conductors are needed to allow the portable engine alarms to be brought to the building BAC cabinet and allow auto-start of the portable engine generator.

All new portable engine quick connects shall have a grounding bar installed which will be permanently connected to the CO ground system.

Buildings with an existing portable engine quick-connect DO NOT require the addition of an auxiliary termination box and associated ground bar.

AC Portable Engine Quick Connect (200 A or less)

Refer to AT&T 154-001-050, Power and Infrastructure Standards Manual, Section ACPWR-002, for design criteria and provisioning information for small portable engine connectors (200 amperes or less) associated with small network buildings.

AC Portable Engine Tap Box (200A or more)

Exterior tap boxes shall use NEMA type 4 or 4X rated enclosures and interior tap boxes shall use NEMA type 1 rated enclosures. All AC tap boxes shall be equipped with 5 copper bus bars for 3-phase service and 4 copper bus bars for single-phase service applications. Enclosures shall be constructed with a front access hinged door equipped with padlock compatible hardware.

The portable engine tap box shall be sized (at a minimum), to replace the largest permanent standby engine located at the building. In buildings with only one standby engine, the quick-connect shall be sized to support only the building essential loads.

Bottom openings shall be provided (intended for the entry of engine alternator cables with the front hinged cover closed and locked) with the following characteristics:

1. Adequately sized to provide access for engine alternator cables capable of supporting the ampacity range of the tap box.
2. Equipped with weather-tight plugs for placement when the tap box is not in use.
3. Cable openings shall be protected with nylon bushings.

Copper bus bars shall be provided as follows:

1. 3 phase buses, 1 neutral bus, and 1 ground bus (total of 5) for 3-phase service applications.
2. 2 phase buses, 1 neutral bus, and 1 ground bus (total of 4) for single-phase service applications.
3. Phase and neutral buses shall be insulated from ground, and sized per the National Electric Code (NEC) for maximum rated ampacity of the tap box, and shall be drilled for double-hole connectors per NEMA standards. Bus bars below 500 amperes capacity shall have at least 2 predrilled connector positions, and bus bars 500 amperes capacity and greater shall have at least 4 predrilled connector positions.
4. The ground bus shall be sized for the expected limit of the overcurrent device on the portable engine-alternator, electrically bonded to the metallic surface of the enclosure interior, and drilled for double-hole connectors per NEMA standards. The ground bus in the tap box shall be connected to the building equipment ground bus.

Bus bar mounting (insulators) shall be strong enough to physically support 4 feet of the largest cable expected at the site. Large installations (or where deemed appropriate) may be equipped with auxiliary cable support.

A phase rotation meter shall be provided for 3-phase tap box applications. The phase rotation meter should be permanently mounted in such a way that its face is clearly visible with the enclosure door open. The correct phase rotation for the site should be permanently stenciled adjacent to the phase rotation meter, and on the phase buses.

A control interface terminal block shall be provided. The terminal block shall be used to extend auto-start/stop control to the portable engine alternator.

A disconnect switch shall be placed between the tap box and the AC distribution system.

Sizing of the phase, neutral and ground conductors between the tap box and the AC distribution system shall conform to the NEC. All wire and cable connections shall be made using two-hole circumferential crimp-type bolted connectors. All equipment, cable, and connections to the AC Distribution system shall meet design requirements given in AT&T 760-400-102, Standby AC Plant Design, Installation and Acceptance Criteria.

Transfer Switch Criteria

For small locations equipped with portable engine quick connects (less than 200 amperes) refer to AT&T 154-001-050, Power and Infrastructure Standards Manual, ACPWR-002, for design criteria associated with transfer switch configurations.

Critical offices equipped with AC tap boxes shall meet transfer switch equipment criteria established in AT&T 760-400-102, Standby AC Plant Design, Installation and Acceptance Criteria.

Portable Engine Start Circuits

Normally open contacts and necessary wiring shall be provided for portable engine automatic start capability. The portable engine automatic start control shall be coordinated with the building standby plant start system to ensure the proper operation of the portable engine in an emergency situation.

Switchgear and Switchboards

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Switchgear and Switchboards

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4.01 General Design Criteria

Design criteria are provided for both metal-clad and metal-enclosed switchgear and switchboards. Metal-clad switchgear shall be the preferred switchgear assembly used. This design provides for ease of maintenance and testing without service interruption, provides automatic transfer capabilities and maximum security, and allows use of the minimum amount of space.

The switchgear shall consist of a rigid, freestanding metal enclosed structure with compartmentalized units designed for easy removal of power circuit breaker elements and associated equipment devices.

Each switchgear shall consist of one or more vertical sections and shall be designed to permit future additions, changes, or regrouping. Floor space allocations shall consider the addition of future sections and comply with NEC space requirements.

All doors (front and rear) shall be hinged for maximum safety and security.

Each assembly shall have front and rear access. Switchboards and switchgear may not be mounted against a wall and must meet NEC space requirements in front of and behind the board.

All control wiring shall be tinned, stranded copper, 90° C, Type SIS, XHHW and VW-1 flame-retardant construction.

Cable lugs of the compression-type, long-barrel double-hole copper-type lug, shall be provided for all power and grounding cable.

Breakers

Manually operated breakers shall be capable of being operated at the switchgear.

Electrically operated breakers shall be capable of being operated either remotely by an electrical control signal or locally at the switchgear by mechanical manual operation.

Drawout breakers of the same type and rating shall be physically interchangeable.

Means shall be provided for locally manually closing and tripping electrically operated breakers without opening the door of the breaker compartment.

Manually operated breakers shall be mechanically trip-free in all positions, and electrically operated breakers shall be mechanically and electrically trip-free in all positions.

All overcurrent devices in switchgear and switchboards shall have the capability of being locked-out in compliance with OSHA Standard 1910.147.

Where manual tie breaker operation is required, a key interlock system shall be used. Normally-closed breakers shall have one key interlock with key removable only when breaker is in the open position. Locks shall not be keyed the same. Breakers shall be unable to close without keys inserted and locks operated. Normally-open tie breakers shall have key interlock and no key. Tie breakers shall not be able to close until key from one of the closed breakers is keyed into lock and operated.

Control power transformers shall be furnished with current-limiting fuses on the primary side, mounted in dead-front fuse holders. Control transformers shall be of sufficient kVA rating to handle all required loads within the switchgear. The transformers shall be connected to the line side of all main devices. Preferably, control circuits shall be powered from a -48 VDC plant within the building. See Section 4.05 for further requirements.

The status of all control fuses shall be indicated on the front panel and the indicating devices shall have contacts for remote indication.

Current transformers shall have mechanical and one-second thermal ratings equal to the interrupting current rating of the circuit breaker in rms symmetrical amperes at the rated circuit voltage. Transformers shall be equipped with shorting bar.

All circuits shall be identified with permanent tags.

Each cable bundle shall be limited to a maximum of 12 cables.

Switchboards

Each feeder cubicle shall be a completely self-supporting structure, and the switch enclosures shall be bolted together to form one metal enclosed rigid switchboard. The sides and top shall be covered with removable screw-on code gauge steel plates. Each switch shall include all protective devices and equipment as required with necessary interconnections and control wiring, terminal blocks and mechanical solderless connectors for terminals. Each switch shall be designed, tested, and assembled in accordance with applicable standards of NEMA and ANSI.

Secondary wiring from the current and potential transformers shall be installed to a terminal block within the switchgear.

Any switch shall be capable of being operated without opening the switchboard door.

Fuses shall be the self-contained current-limiting type. Fuses shall have an interrupting capacity equal to or greater than the available fault current, as determined by the fault-current study.

All overcurrent devices in switchgear and switchboards shall have the capability of being locked-out in compliance with OSHA Standard 1910.147.

Control power transformers shall be provided with current-limiting fuses. Control transformers shall be of sufficient kVA rating to handle all required loads within the switchgear. Transformers shall be connected to the line side of all main devices. In multi-main switchboards a control power transfer scheme shall be designed such that all devices requiring control power shall have it available in the event of a failure in one of the incoming sources. Preferably, control circuits shall be powered from a -48 VDC plant within the building. See Section 4.05 for further requirements.

The status of all control fuses shall be indicated on the front panel and shall have contacts for remote indication.

Current transformers shall have mechanical and one-second thermal ratings equal to the interrupting current rating of the circuit breaker in rms symmetrical amperes at the rated circuit voltage.

All circuits shall be identified with permanent tags.

Each cable bundle shall be limited to a maximum of 12 cables.

Fire Protection

Switchgear areas located in a building of noncombustible construction do not normally require automatic suppression. However, where state and local codes, laws and ordinances require automatic suppression systems, a preaction type automatic sprinkler system shall be used. The activation (charging) of the system shall be through cross-zoned, diverse fire detection systems.

Separation and Redundancy

Switchgear or switchboards shall be separated from the following transformers by a 3 hour fire-rated barrier.

- Dry Type - transformers rated greater than 35 kV
- Oil-Cooled, Less Flammable Fluid Filled-transformers rated 250 kVA and above
- Oil-Cooled, Mineral-transformers rated 75 kVA and above.

Instrumentation and Control

Provide each medium-voltage switchgear and switchboard with local instrumentation and control systems suitable for automatic and manual operation of the equipment and for monitoring and control during operation. See Section 4.05, this Chapter for recommended switchgear control battery plants

Local instrumentation shall be provided for each circuit breaker and disconnect switch to monitor the currents and voltages which indicate correct operation. Voltmeters shall be provided at all service entrance main breakers and main distribution breakers. Provide ammeters for service above 800 amps.

Voltmeters shall be self-contained or power transformer (P.T.) rated, analog or digital full voltage rated, with an accuracy of 1%.

Voltmeter switch (analog) shall be seven-position with the ability to read phase-to-phase and phase-to-neutral voltages.

Ammeter scale shall read from zero to full amperage rating of breaker/switch, analog or digital, with 1% accuracy.

Current transformers shall be meter-accuracy class 600 volt, 10kV, BIL.

Each switchboard shall have test blocks and necessary test plugs, switch current jacks and potential jacks accessible in rear of switchboard for portable recording meters.

All meters and switches, control fuses, etc. shall be mounted on hinged doors.

All switchboards that do not have a mimic bus color scheme already established shall have a mimic bus on the front indicating connections using the recommended color scheme as follows:

- green - commercial
- yellow - alternator supply
- red - essential load.

The mimic bus shall be colored, hard phenolic strips anchored with brads. The mimic bus shall be a minimum size of 1/2-inch wide.

Indicating lights shall be provided both on the equipment and locally to indicate the status of the breaker or switch.

Indicating light recommended colors should be:

- red - closed
- green - open
- amber - trip.

Indicating lights shall be readily visible during daylight conditions and normal room lighting, and shall be rated for long life.

Audible and visual alarm indications shall be provided in the switchgear room.

All alarms and indication shall be in accordance with AT&T 154-103-101, Alarms Standard Manual.

Local indication shall be provided to indicate control power and bus availability and breaker and switch operation for critical circuits. Refer to Section 4.05 for further requirements.

Electrical Protective Systems

Grounding

A continuous copper ground bus shall be furnished over the full length of the structure which shall be capable of carrying the required short-circuit current.

Surge Protective Devices

The main switchgear or switchboard shall be furnished with surge protective arresters located on the incoming utility side of the main disconnect switch. The arrester connections shall be designed to be temporarily disconnected, in order to facilitate testing, when the switchgear is energized. Refer to Chapter 3, Section 3.03 for further requirements.

Seismic and Structural

Switchgear or switchboards shall be mounted on concrete pads, secured to the pad in accordance to the manufacturer's recommendations and seismic requirements for the zone in which the installation is located. The pad shall be secured to the floor in accordance with the same standards.

Switchgear and switchboards which supply essential loads shall be adequately designed to perform satisfactorily after an earthquake. Switchgear and switchboards determined to be hazardous to adjacent essential equipment due to their potential for movement during a seismic event shall have seismically designed supports and attachments to conform with the seismic zone in which they are located. Refer to AT&T 760-200-023, Earthquake Design Loads.

Codes and Standards

All switchgear and switchboards shall conform to the requirements of and be suitable for application in accordance with:

- NFPA 70 - National Electrical Code
- ANSI C2 - National Electrical Safety Code
- ANSI C37.04 - Definition and Rating Structure for AC High Voltage Circuit Breakers Rated on a Total Current Basis
- ANSI C37.06 - Schedules of Preferred Ratings and Related Required Capabilities of AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI C37.072 - Requirements for Transient Recovery Voltage AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI C37.09 - Test Procedure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- ANSI C37.9 - Test Procedure for AC High Voltage Circuit Breakers Rated on a Total Current Basis
- ANSI C37.20 - Switchgear Assemblies Including Metal Enclosed Bus

- ANSI C37.90 - Relays and Relay Systems Associated with Electric Power Apparatus
- ANSI C37.100 - Definitions for Power Switchgear
- ANSI C57.13 - Definitions for Instrument Transformers
- ANSI C37.90 - Relays and Relay Systems Associated with Electric Power Apparatus
- ANSI Z55.1 - Gray Finishes for Industrial Apparatus and Equipment
- NEMA SG-4 - Standards for Power Circuit Breakers
- NEMA SG-5 - Power Switchgear Assemblies
- NEMA SG-6 - Standards for Power Switching Equipment
- ANSI/IEEE 28 - Surge Arresters for Alternating Current Power Circuits
- ANSI/IEEE 472 - Guide for Surge Withstand Capability Tests
- AT&T Practice 760-200-023, Earthquake Design Loads"
- UBC - Uniform Building Code.
- ANSI C37.13 - Low-Voltage AC Power Circuit Breakers Used in Enclosures
- ANSI C37.16 - Preferred Ratings, Related Requirements and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors
- ANSI C37.17 - Trip Devices for AC and General Purpose DC Low-Voltage Power Circuit Breakers
- ANSI C37.50 - Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures
- NEMA SG-3 - Standards for Low-Voltage Power Circuit Breakers
- UL 44 - Electric Wires and Cables
- UL 977 - Fused Power Circuit Devices
- IEEE Std. 242, Chapter 7 - Ground-Fault Protection

4.02 Medium-Voltage (15kV & 4160V) Switchgear and Switchboards

This section defines additional requirements for medium-voltage metal-clad switchgear and switchboards.

Metal-Clad Switchgear

The switchgear assembly shall be of welded construction fabricated from No. 11 U.S.S. gauge or heavier sheet steel (side panels may be constructed of No. 14 U.S.S. or heavier sheet steel) and comply with ANSI C37.20. The assembly housing shall be divided into sections by vertical barriers. The barriers shall extend the full height and depth of the structure to provide a fire wall between sections.

Metal-clad switchgear and overcurrent protective devices shall be designed and constructed to withstand the mechanical and thermal stresses produced by the calculated short-circuit current.

The power bus shall consist of high-conductivity copper and shall be supported on insulators. The main connections shall be welded or bolted to the stationary primary contacts and bolted to the bus. The contact surfaces of the double-bolted joints shall be silver plated. All buses and bus joints shall be insulated with PVC molded boots with polyester bus supports.

Metal-clad switchgear shall be composed of a stationary housing and a draw-out circuit breaker element. The housing shall support the instruments and contain the instrument transformers and circuit connections. The circuit breaker shall be mounted on a wheeled frame constructed to engage stationary rails within the cubicle.

Terminal blocks suitable for use with closed crimp-type compression lugs shall be provided for connecting Nos. 10, 12, or 14 AWG size incoming control wiring.

Breakers

Each circuit breaker shall be capable of being withdrawn to test and disconnect positions with the door closed.

Breaker ratings shall have the capability called for in ANSI C37.06.

An indicator shall be provided to indicate the open, closed and tripped position of the breaker. It shall be visible without opening the door of the breaker compartment.

Switchboards (Metal Enclosed Load Interrupter Switchgear)

Switchboards shall be designed and constructed to withstand the mechanical and thermal stresses produced by specified external short circuits.

Power bus shall consist of high conductivity copper and shall be supported on insulators. The main connections shall be welded or brazed to the switches and bolted to the bus. The contact surfaces of the bolted joints shall be silver plated.

The interrupter switch shall operate via a stored-energy operating mechanism. All three poles shall operate simultaneously by a removable handle on the front of the cubicle. A mechanical position indicator shall indicate the position of the switch. Each switch shall be heavy duty. Each switch shall meet NEMA Standard SG-6 for power switching equipment.

Primary metering equipment shall be installed in a separate metal-enclosed cubicle within the switchboard.

Protection Philosophy

Medium-Voltage Distribution

Medium-Voltage Bus Tie Protection

High-speed differential relays sensitive to both phase and ground faults shall protect each medium-voltage tie connection between two buses for fast clearing of bus tie faults.

In addition, provide three single-phase time-overcurrent relays and one residually connected low burden time-overcurrent ground relay at both ends of the tie for phase and ground-fault backup protection. The differential and overcurrent relays shall energize a lockout relay to trip the tie breakers at each bus. The minimum pickup of the phase overcurrent relays shall be set at approximately 1.2 times the total bus demand load.

The 1.2 multiplication factor is based on the following:

- 10 percent tolerance on the relay pickup
- Allowance for the loads to be maintained at 90 percent of rated voltage (approximately 110 percent of rated current).

The time dial setting shall be set to allow the largest motor to accelerate when the bus is fully loaded. Both phase and ground overcurrent relays shall coordinate with the similar protection provided for the incoming supply breakers and for the feeder breakers.

Main Bus Supply Protection

Each medium-voltage bus shall be protected by high-speed differential relays sensitive to both phase and ground faults.

Three single-phase, time-overcurrent relays shall provide overload and backup phase fault protection. These relays shall be set so that minimum pickup will be equal to or greater than 1.2 times the rating of the supply transformer rating and the time dial setting shall allow the largest motor to start with the bus fully loaded. These relays shall be backed up by overcurrent relays on the high voltage side of the supply transformer. These relays shall energize a lockout relay, which trips and locks out the supply and tie breakers (if provided).

Ground protection shall be provided by a time-overcurrent relay connected across the transformer neutral current transformer. This relay shall provide a backup to the feeder breaker ground overcurrent relays, and shall be backed up by a ground time-overcurrent relay connected in the neutral of the transformer. Refer to AT&T 760-400-500, Building Electrical System Ground-Fault Protection.

Essential Bus Supply Protection

Each medium-voltage bus shall be protected by high speed differential relays sensitive to both phase and ground faults.

For a nonessential to essential bus supply feeder, each side of this tie line shall be equipped with three single-phase, time-overcurrent relays and a residually connected, low burden, time-overcurrent ground relay as described under bus tie protection.

Three single-phase directional overcurrent relays shall also be provided at the incoming breaker. When the standby generator is paralleled with the utility source and connected to the bus, three single-phase directional relays shall trip the essential bus side breaker of the tie line for a fault occurring on the tie line or on the associated nonessential bus. These relays shall be set as follows:

- The pickup of these relays shall be sensitive enough to be operated by the fault current supplied by the generator.
- The minimum pickup shall be selected to be above the current contributed by the generator while the largest motor at the essential bus is starting.

The overcurrent and ground-overcurrent relays at the nonessential bus side breaker shall energize a lockout relay and trip the nonessential bus side tie breaker. The overcurrent, directional-overcurrent, and ground-overcurrent relays at the essential bus side breaker shall energize a lockout relay to trip the essential bus side tie breaker. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

Main Bus Transfer Schemes

Whenever the utility power source to a main bus is lost due to a fault in the main transformer or on its supply, a transfer shall be made to the redundant main bus automatically by closing the normally open breakers. This is accomplished provided the bus voltage is less than 30 percent of normal after the normal source is tripped and the redundant bus has normal voltage and is not faulted.

Alternatively, whenever the normal utility power source to a main bus is lost due to a fault in the main transformer or on its supply, and no other utility power source is available, a transfer shall be made by automatically starting the standby AC plant generators and closing the associated breakers after an adequate time delay. This is accomplished provided the generators have reached appropriate speed and voltage, nonessential load has been shed and the bus to which the generators are connected is not faulted.

Transfer of power supply between main buses shall be of a delayed nature and shall be initiated by a sustained undervoltage sensed by an undervoltage relay at the line side of the main incoming breaker to the main bus. This transfer (one of the above alternates) is effected when the condition results in a voltage reduction for a minimum of five seconds and the bus voltage is less than 30 percent of normal after the normal source is tripped.

Essential Bus

The preferred method of transfer of power supply between essential buses is automatic. Automatic operation is preferred to ensure that if all power is lost to an essential bus, connection to the power supply of the redundant essential bus is done.

At unattended facilities, whenever standby AC plants supply the essential buses due to loss of the utility source, and the standby AC plant for one essential bus is lost, a transfer shall be made to the redundant essential bus automatically by closing the normally open breakers, unless a swing standby AC plant is available. The transfer is made provided the bus voltage is less than 30 percent of the normal after the standby AC plant is tripped, and the redundant bus has normal voltage and is not faulted. If a swing standby AC plant is available, it will automatically connect to the essential bus whose standby AC plant is lost.

Transfer of power supply between essential buses shall be of a delayed nature, and a sustained undervoltage sensed by an undervoltage relay at the line side of the incoming breaker to the essential bus shall initiate it. This transfer is effected when the condition results in a voltage reduction for a minimum of 5.0 seconds and the bus voltage is less than 30 percent of normal after the standby AC plant is tripped.

Full relay or protective device coordination providing selective tripping shall be a prerequisite to protect against common mode failure due to single faults on either essential bus.

The delay requirement for transfer between buses (to allow time for shut-off of the telecommunication rectifiers) is approximately 5 seconds, but the exact time shall be determined for each location individually.

Paralleling of two live sources (i.e, between two energized buses or between a live bus and standby AC plant power supply) shall be supervised by a synchronism check relay.

4.03 Low-Voltage (480 V) Switchgear and Switchboards

This section defines additional requirements for low-voltage metal-enclosed switchgear and switchboards.

Metal Enclosed Low-Voltage Switchgear

Main bus and bus taps shall be made of high conductivity copper. Main bus joints and tap connections shall be silver plated.

Phase and neutral buses shall be copper. The neutral bus shall be sized for 100 percent of the switchgear rated load. The bus bars shall be mounted on supports of high impact, non-tracking insulating material.

Terminal blocks shall be suitable for use with closed crimp-type compression lugs.

Switchgear circuit breakers shall be power circuit breakers conforming to ANSI C37.13 and ANSI C37.16. They shall be three-pole, single-throw, air-break and have a self-aligning disconnecting device and disconnecting fingers mounted on the breaker. The drawout mechanism shall hold the circuit breaker in the connected, test, disconnected and fully withdrawn positions. Each position shall be clearly visible and identified by an indicator. The drawout mechanism shall operate externally by a removable handle. Each pole shall be equipped with a solid-state direct-rating overcurrent tripping device providing adjustable long-time delay (LTD), short-time delay (STD), high range instantaneous trip or ground-fault protection (GRD) as required. Delay settings shall conform to ANSI C37.17.

Each circuit breaker shall be 600 V class, 3 pole, drawout, stored-energy type. Breakers shall be capable of being withdrawn to test and disconnect positions with the door closed.

Static overcurrent trip devices with time delay features shall be furnished.

A mechanical indicator shall be provided to indicate the open and closed position of the breaker. It shall be visible without opening the door of the breaker compartment.

Low-Voltage Switchboards

Design criteria are provided for the use of either circuit breakers or fused disconnects in the switchboard. The preferred disconnecting means shall be circuit breakers. This design provides for ease of maintenance and testing without service interruption to the entire board. It provides automatic transfer capability and maximum security as well.

Circuit breakers shall be bus-mounted thermal-magnetic or true RMS-detecting microprocessor-based molded-case type, conforming to NEMA AB-1 and UL for insulated case types. They shall be quick-make, quick-break with a toggle-type handle switching mechanism that is trip-free from the handle so that contacts cannot be held closed against short circuits or abnormal currents. Tripping due to overloads or short circuit shall be clearly indicated by the handle assuming a marked position. All poles of multipole circuit breakers shall open and close simultaneously. Breakers shall be plug-in or drawout type to aid in testing and modifications.

The switchboard and overcurrent protective devices shall be designed and constructed to withstand mechanical and thermal stresses produced by specified external short circuits.

Phase and neutral buses shall be copper. The neutral bus shall be sized for 100 percent of the switchboard rated load. The bus bars shall be mounted on supports of high impact, non-tracking insulating material.

Fused switches shall be heavy-duty type, single or multipole, quick-make, quick-break, and capable of interrupting rated current. Main and branch fusible switches shall have an operating handle suitable for padlocking in the “OFF” position. An interlock shall be provided to prevent opening the cover when the switch is in the “ON” position unless the interlock release is operated.

Protection Philosophy

Low-Voltage Bus Tie Protection

A 480 V trip device with long and short-time characteristics with ground protection on both buses shall be provided for phase and ground-fault protection. The minimum pickup of the overcurrent trip devices shall be set at 1.2 times the total bus demand load.

The 1.2 multiplication factor is based on the following:

- 10 percent tolerance on the relay pickup
- Allowance for the loads to be maintained at 90 percent of rated voltage (approximately 110 percent of rated current).

The short-time delay setting shall allow the largest motor to accelerate when the bus is fully loaded. Both phase and ground-overcurrent trip devices shall coordinate with similar protection provided for the incoming supply breakers, feeder breakers, and feeders to the essential bus.

Main Bus Supply Protection

A 480 V trip device with long-time and short-time characteristics and ground protection shall provide overload and fault protection. The long-time phase trip device shall be set so that minimum pickup will be equal to or greater than 1.2 times the rating of the supply transformer rating and the short-time characteristic shall allow the largest motor to start with the bus fully loaded. Phase-overcurrent relays on the high-voltage side of the supply transformer and a ground-overcurrent relay in the neutral of the low-voltage side of the supply transformer shall back up these devices. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

Essential Bus Supply Protection

The 480 V trip device with long-time and short-time characteristics as well as ground-fault protection shall provide overload and fault protection for the essential bus during normal supply. This breaker shall be set to coordinate with the largest load feeder connected to this bus. The minimum pickup shall be set at 1.2 times the total bus demand load. The short-time delay setting shall allow the largest motor to accelerate when the bus is fully loaded. The ground-overcurrent trip device shall be set to coordinate with the ground-overcurrent trip devices at the feeders and the ground protection for the nonessential bus. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

When the standby generator is in the exercise mode and connected to the bus, the 480 V trip device with long-time and short-time characteristics shall trip the essential bus side breaker of the tie line for a fault occurring on the tie line or on the redundant main bus. These trip devices shall be lockable and set as follows:

- The pickup of these trip devices shall be sensitive enough to operate for the fault current supplied by the generator
- The minimum pickup shall be selected to be above the current contributed by the generator (in exercise mode) while the largest motor at the essential bus is starting.

Existing Facilities

First step-down distribution in most AT&T facilities is at 480/277 V level from the utility source. Ground-fault protection shall be provided at the entry of each utility source. Ideally, a power circuit breaker described above provides desirable selective tripping with downstream devices. For 208/120 V distribution and standby source, protection requirements are similar, except ground-fault protection may be eliminated. For 480/277 V standby sources, tripping from ground-fault protection can be eliminated, but an indication for such faults should be provided. Switchboards rated for three cycle duty are also used at the first level distribution in some facilities and instantaneous clearing becomes an issue.

A fault at the switchboard will most likely result in damage at the point of fault. Protection at the main incoming source may reduce the degree of damage but does not assure continued switchboard operation. However, a fault at any of the feeders off a switchboard should be protected by an instantaneous trip or a fuse to assure switchboard availability after the feeder fault is cleared.

Protection at the main incoming source to a switchboard or switchgear provides backup for downstream feeder faults and thus enhance the reliability of the distribution system. Existing facilities, which do not have any protection at the main incoming utility source should evaluate the implementation of this type of protection. Ground-fault protection at the transformer neutral, combined with phase-fault protection at the high side may be adequate when switching is not necessary. Typical arrangements and protection requirements for the existing buildings are outlined below:

Single Transformer

- When a single transformer feeds a main switchboard, a main incoming fuse can be used in series with a power circuit breaker having LTD, STD, and GRD trip functions providing switching convenience and ground-fault protection. A high-fixed instantaneous (INST) trip which trips at or below switchboard 3 cycle duty can also be used. Proper selection of fuse or instantaneous trip can provide full selectivity when the actual fault is below the instantaneous clearing of the fuse or breaker.

- When a single transformer feeds a main switchboard, insulated case circuit breaker at the main supply with LTD, STD, GRD, and high fixed INST override can be considered if space is limited. Large frame size breakers as well as specific manufacturer types should be considered to obtain higher instantaneous trip for optimum selectivity. Redundant bus design may be desirable if full selectivity can not be accomplished for worst faults.

Multiple Paralleled Transformers

- When commercial source is obtained from multiple paralleled transformers, fault current values are so high that fusing of breakers become necessary. Full selectivity from such high fault current source is possible if the main incoming fused breaker is furnished with LTD, STD, and GRD trip functions and downstream feeder breakers are also fused, maintaining a 2:1 ratio and when plotted on time/current coordination studies, there is a wide spread between these fuses. Downstream feeders protected with only a fuse can optimize phase-fault selectivity by limiting the current seen by the main breaker, though ground-fault selectivity can not be accomplished.
- Insulated case circuit breakers at the entry from the utility source can be considered if space is limited. Such breakers should be furnished with LTD, STD, GRD, and high-fixed-instantaneous override. Large frame size breakers as well as specific manufacturer types should be considered to obtain higher instantaneous trip for optimum selectivity. Downstream feeders protected with only a fuse can optimize phase fault selectivity by limiting the current seen by the main breaker, though ground-fault selectivity can not be accomplished. Redundant bus design may be desirable if full selectivity can not be accomplished for maximum calculated fault current values.

Main Bus Transfer Schemes

Whenever the utility supply source to a main bus is lost due to a fault in the main transformer or on its supply, a transfer shall be made to the redundant main bus (if provided) automatically by transfer switch. This occurs provided the bus voltage is below the undervoltage relay rating and the redundant bus has normal voltage and is not faulted.

Alternatively, whenever the utility power source to a main bus is lost due to a fault in the main transformer or on its supply, and no other utility source is available, a transfer shall be made by automatically starting the standby AC plant after an adequate time delay and closing the associated breaker. This action occurs provided the generators have reached appropriate speed and voltage, nonessential load has been shed and the bus to which the generators are connected has not faulted.

Transfer of power supply between main buses shall be of a delayed nature (a minimum of 5 seconds) and shall be initiated by a sustained undervoltage (at approximately 90% of rated voltage) or overvoltage (10% above rated voltage) sensed by voltage relays at the line side of the incoming main distribution supply breaker. This transfer is effected when the condition results in a voltage reduction or increase for a minimum of five seconds

The delay requirement for open transition transfer switches (to allow shut off of the telecommunication rectifiers) is approximately 5 seconds, but the exact time shall be determined for each location.

Essential Bus Transfer Schemes

Use manual operation to ensure that if all power is lost to an essential bus, connection to the power supply of the redundant essential bus is supervised. This will ensure that both sources of power loss are determined and that any adverse effects on the remainder of the AC distribution system are investigated and evaluated. Use extreme caution to ensure that unsynchronized power sources (either utility or standby AC plants) are not paralleled to the same bus simultaneously.

At unattended facilities, when loss of the utility source causes standby AC plants to supply the essential buses and the standby AC plant for one essential bus is lost, close the normally open breakers to make a transfer to the essential bus, unless a swing standby AC plant is available. If bus voltage is less than 30% normal after the standby AC plant is tripped and the redundant bus has normal voltage and is not faulted, transfer is successful.

Transfer of power supply between essential buses shall be of a delayed nature and shall be initiated by a sustained undervoltage (at approximately 90% of rated voltage) sensed by an undervoltage relay at the line side of the incoming breaker to the essential bus. This transfer is effected when the condition results in a voltage reduction for a minimum of 5.0 seconds and the bus voltage is less than 30 percent of normal after the standby AC plant is tripped.

It is emphasized that relay or protective device coordination providing selective tripping should be a prerequisite to protect against common mode failure due to single faults on either essential bus.

The delay requirement for open transition transfer switches (to allow shut off of the telecommunication rectifiers) is approximately 5 seconds, but the exact time shall be determined for each location individually.

Motor Feeder Protection

Individual motor feeders, except for fire pump motors, shall be protected in accordance with NFPA-70 (NEC), Article 430-32, and shall have overload, phase, and ground-fault protection provided by a low-voltage circuit breaker with a 3-phase trip device with adjustable long-time and instantaneous trip units with ground-fault protection. The pickup of the long-time unit shall be set at 115 percent of motor full load current, (not exceeding 130 percent) for motors with service factor of 1.0. The pickup of the long-time/short-time unit shall be set at 125 percent of motor full load current, (not exceeding 140 percent) for motors with service factor of 1.15.

Protection for the fire pump motor shall be provided in accordance with NFPA 20 and NFPA 70 (NEC) Article 695.

480V Multiple Motors, Heaters and Other Load Feeders

Multiple motors, heater loads and other feeders which have their own individual local protection or feeders which require downstream coordination and are fed by a single feeder from the 480 V bus shall be protected by a breaker which has adjustable long-time and short-time delay trip units with ground protection. The pickup of the long-time unit shall be set at a minimum of 120 percent of the sum of full load currents, but shall not exceed the cable ampacity. The short-time pickup shall be set at 1.2 times the total bus demand load. The short-time delay setting shall allow the largest motor to accelerate when the bus is fully loaded.

When the use of an adjustable breaker is not feasible, a 3-phase molded-case circuit breaker shall be used. This thermal magnetic breaker shall be selected by its continuous current rating to be above 120 percent of the circuit full-load current and below the feeder cable ampacity. The instantaneous trip shall be selected to accommodate the possibility of all the motors in the group starting simultaneously, unless such starting is definitely prevented.

Whenever the overload protection exceeds 15 amps, separate ground-fault protection shall be considered which shunt trips the breaker to achieve full coordination with the 480 V low-voltage power circuit breaker for the MCC feeder. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

480V Motor Control Center Feeders

Each 480 V MCC feeder shall be protected by a low-voltage power circuit breaker with adjustable LTD and STD trip units with ground-fault protection. The pickup setting of the long-time unit shall not exceed the capacity of the feeder cable. Also, the long-time unit shall be coordinated with the largest overload device in the MCC. The short-time delay shall be coordinated with the maximum instantaneous device clearing time in the MCC. For MCCs where the largest connected motor is less than 100 hp, assume that a 100 hp motor is present for coordination purposes. Ground-fault protection shall be set to coordinate with ground protection provided at the MCC loads. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

Each MCC shall have a fused 480-120 V control transformer which provides control power for all the ground-fault detection circuits used for shunt tripping.

480V Distribution Panels

Each 480 V distribution panel fed from a 480 V low-voltage switchgear or switchboard shall be protected by a low-voltage power circuit breaker with adjustable long-time and short-time delay trips with ground-fault protection. The pickup setting of the long-time unit shall not exceed the cable ampacity and shall coordinate with the largest overload device at this panel. The short-time delay unit shall be coordinated with the maximum instantaneous device clearing time in the panel. Consider eliminating the incoming feeder breaker or using a switch-only circuit breaker or an insulated molded-case circuit breaker with solid state trip having fixed high instantaneous to assist coordination. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

Existing Facilities

Ideal protection for MCC and distribution panels (PNL) is outlined above for 480/277 V as well as 208/120 V distribution. However, few existing facilities are furnished with such protection. Ground-fault protection for these feeds is unlikely to cause a major outage due to the lack of coordination with the downstream devices. For 480/277 V distribution such protection is necessary to achieve selectivity with the upstream incoming source ground protection, which in many cases may disable the entire utility source. For a building with 208/120 V building distribution, ground-fault protection should be implemented wherever possible. Protection at the existing facilities can be designed as outlined in the examples described below:

- When a power circuit breaker protects an MCC/PNL and the available fault current is very high, requiring a fuse in series with the breaker, LTD, STD, and GRD trip function should be used. Fuse size should be at least one-half of the upstream fuse size, and selectivity should be established through a time/current coordination study with upstream and downstream devices.
- When an insulated-case circuit breaker protects an MCC/PNL, LTD, STD, GRD, and high fixed INST override trip functions should be provided. Larger frame size breakers as well as specific manufacturer types should be considered to obtain higher instantaneous trip for optimum full selectivity.
- When a molded-case circuit breaker with a solid-state trip protects an MCC/PNL, LTD, STD, GRD, and INST trip function should be provided. Instantaneous trip should be set at the highest value. Redundant distribution should be considered when selectivity can not be assured for heavy faults.

- When an MCC/PNL is protected with fuse only, coordination should be established with the upstream device through coordination study, with adequate spread between these devices. Ground-fault coordination can not be achieved with the upstream ground protection and, therefore, redundant distribution should be considered.
- When a molded-case circuit breaker protects an MCC/PNL it is desirable to furnish the breaker with a ground-fault protection. Downstream coordination is difficult to achieve with downstream devices when provided with such protection and redundant distribution should be considered.
- Molded-case circuit breakers shall provide protection against overloads and faults for all panel feeders. The rating of the breakers shall be selected to provide cable protection.
- Feeders off an MCC/PNL should duplicate the existing protection. An attempt should be made to provide selective tripping in the overload region and instantaneous trips should be set at the highest setting to assist selectivity for large molded-case circuit breakers. Fuse sizing and selection can optimize selectivity when feeder is protected by a fuse.

4.04 Transfer Switches

Design

Transfer switches are the preferred method of transferring between utility and standby power sources for new designs.

The transfer switches shall have an adequate withstand, closing, interrupting and continuous current rating based on the ampacity and available fault current of the utility and standby power sources.

The withstand rating is the ability of the transfer switch to carry the design fault current until operation of the upstream protective device. The closing rating is the ability to close into the design fault current. The interrupting rating is the ability to interrupt the design fault current.

All transfer switches must meet the following criteria:

- The transfer switches shall be double throw and activated by two separate momentary energized electrical operators.
- The transfer switch shall be capable of automatically transferring from the utility source to the standby AC plant source.

- The time delay for retransfer shall be adjustable over a continuous range of 0 to 60 minutes. This setting shall be established by the OSWF. If the standby AC plant source fails during the time delay following the restoration of the utility power source, the switch shall automatically return to the utility power source.
- After restoration of normal power on all phases at 90 percent of rated voltage and 98 percent of rated frequency, the transfer switch shall retransfer to the normal source.
- The transfer switch shall be capable of being tested either at the equipment, or locally. The test will consist of a complete transfer of load from the utility source to the standby AC plant source.
- Loss of voltage for testing shall be simulated by utilizing a transfer switch “test” push button.

All transfer switches shall have a manual bypass switch for maintenance and emergency use. The manual bypass switch shall meet the following criteria:

- When the transfer switch is in the test mode or having corrective maintenance performed, electrical power shall be maintained to the essential loads, by a separate manual bypass (isolation) switch.
- The manual bypass switch operation shall match that of the transfer switch and shall be rated for the full load of the transfer switch. It shall be interlocked with the transfer switch so that manual operation to connect the standby AC source to the utility source is not possible.
- The manual bypass switch shall have be capable of bypassing to the normal source or the standby AC source, feeding the load directly around the transfer switch without interrupting power to the load.

Open Transition Switches

Open transition transfer switches shall be used in locations where interruption of AC power during routine testing of standby system is not considered a problem.

The transfer between sources shall occur after an intentional time delay. The delay is required for two reasons: one is to ensure that loss of voltage on the connected source is permanent and not transient; the second is to allow the telecommunication equipment rectifiers to shut off. The delay requirement for shut-off is approximately 5 seconds, but the exact time shall be determined for each location individually.

The operating mechanism shall employ the overcenter principle of operation to achieve a mechanically locked condition in both the normal and emergency positions without the use of latches, hooks, magnets, or similar devices. The normal and emergency contacts shall be mechanically and electrically interlocked to prevent simultaneous closing. Separate main contacts and arcing contacts with magnetic blowouts and enclosed arc chambers shall be provided. Contacts shall be silver-tungsten alloy.

Transfer switches shall be three-pole with an unswitched neutral and shall be mounted on a common operating shaft with the phase poles. Where the possibility exists for ground-fault sensing problems or the potential exists for the addition of ground-fault protection in the standby system, a four pole transfer switch shall be used.

Closed Transition Switches

When a transfer between two live sources is needed, a closed transition (make before break) transfer switch shall be used. The switch contacts for this application shall be overlapped to break last and make first in a closed transition transfer. Choice of location for closed-transition application shall be based on the criticality of the location as determined by the Building Engineer, business units and OSWF. The use of closed transition transfer switches shall be coordinated with the local utility company prior to design.

Protection Philosophy

Where the standby AC plant will be operated in parallel with the utility source, using a closed transition transfer, the utility may require additional protection for the utility source.

Instrumentation and Control

Each transfer switch shall be provided with local instrumentation and controls, suitable for manual starting, automatic starting and disconnecting electrical energy from the supplied equipment.

Local instrumentation shall be provided to indicate source availability, transfer switch position and switch operating mode.

Electrical Protective Systems

Grounding

Transfer switches shall be grounded in accordance with AT&T 802-001-198, General Equipment Ground Requirements for AC service Distribution Systems in Buildings Housing Communications Systems, and the manufacturer's instructions.

Seismic and Structural

Transfer switches shall be mounted and supported in accordance with the manufacturer's recommendation.

Transfer switches determined to be hazardous to adjacent essential equipment due to potential movement during a seismic event, shall have seismically designed supports and attachments to conform with the seismic zone in which they are located. Refer to AT&T 760-200-023, Earthquake Design Loads.

Codes and Standards

Transfer switches shall conform to the requirements of and be suitable for application in accordance with:

- UL 1008 - Automatic Transfer Switches
- NFPA-110 - Emergency and Stand-by Power Systems
- NFPA-70 - National Electrical Code
- AT&T 760-200-023, Earthquake Design Loads.

4.05 Switchgear Battery Plants

The preferred energy source for AC switchgear recharging and control circuits is the -48V central office battery using two redundant feeds. When this is not possible, a stand alone switchgear battery plant is recommended. The rectifier should be a constant voltage current-limited, solid-state type, capable of simultaneously float charging nickel cadmium (NICAD) or lead-acid type batteries while supplying the DC load. Under no circumstances shall a converter be used to support the AC switchgear recharging and control circuits.

Batteries

The preferred battery for switchgear battery plants is the nickel cadmium storage battery, although lead-acid batteries are acceptable in larger plants. Under no circumstances shall valve-regulated (VR) batteries be used. All batteries shall be equipped with explosion proof vents. The battery plant shall be sized to provide sufficient energy to recharge all switchgear components a minimum of three times. A detailed load study shall be performed to determine what the peak load (and subsequent battery size) should be. Additional capacity shall be provided to allow for 10-20% growth.

Battery Plant Chargers

The number and type of battery plant chargers utilized should be dependent on the type of load being served. For a plant serving only switchgear control and recharging loads, a single plant as described above will suffice, providing it is of recent vintage and adequately supported by the manufacturer. A spare parts kit should be maintained on site by AT&T against the possibility of rectifier failure. Charger capacity should be rated at 120% of calculated full-load current.

For plants supporting other loads in addition to switchgear control and charging (i.e.: emergency lighting or a DC compressor, etc.) redundant chargers should be considered. The size of each charger should be a function of the battery plant ampere capacity and the expected load on the plant. Each charger should be capable of recharging the batteries to full capacity within eight hours after a full discharge.

The charger unit shall have the following equipment options as a minimum:

1. DC Ammeter
2. DC Voltmeter
3. DC output failure contacts for alarms
4. Indicating lamps showing unit operation (AC on, High DC Voltage, and Low DC Voltage)
5. Fused AC input and DC output.

Alarms

Refer to ACP 154-103-101, Alarms Standards Manual for additional information concerning local and remote alarm standards for switchgear recharging and control battery plants.

The following remote alarm shall be provided:

— Switchgear Battery Plant Charger Fail

Cable and Connectors

Battery cable connections shall be made using two-hole circumferential-crimp type bolted connectors. All cables shall be flexible, multistranded, and sized per the ampere capacity of the battery plant.

Grounding and Anchoring

Battery stands, equipment frames, and battery chargers shall be grounded and anchored per AT&T 800-610-155, Earthquake and Disaster Bracing for Central Office Equipment General Equipment Requirements, 803-500-150, Grounding Practices - Telecommunication Systems Grounding in New Buildings Housing Digital and/or Analog Telecommunication Equipment, General Equipment Requirements, and Engineering Information, and the National Electric Code.

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5.01 Bus Duct

Bus duct should be used for applications above 1,000 amps or where taps or circuit rearrangements are required. However bus duct should not be used when accessibility requirements and other constraints related to bus duct installations are present. Do not install bus duct in foundations or concrete walls. Do not use bus duct for service entrance or standby AC plant service where site environmental conditions are not suitable due to moisture, dirt, or other contaminants.

Design

The bus duct shall be a rigid structure consisting of bus bars housed in a galvanized or bonderized sheet steel or extruded aluminum enclosure with all necessary fittings and accessories.

The maximum hot-spot temperature rise at any point in the bus duct at continuous rated load shall not exceed 55° C above an ambient temperature of 40° C.

A fire-resistant divider shall be furnished at all points where the bus duct extends through building interior floors or walls.

Outdoor bus shall have bus bars enclosed in a weatherproof housing.

Bus duct housing for outdoor bus shall be fabricated of heavy gauge hot-dipped galvanized sheet steel or extruded aluminum.

A weather and fire-resistant divider and wall plate shall be furnished at all points where the bus duct enters an exterior building wall.

Main bus and bus taps shall be made of copper. Bus bars shall be rectangular type with full rounded edges.

The neutral bus shall be sized for 100 percent of the bus duct rated load.

All bus joints shall be silver or tin plated.

The bus shall be braced to withstand the rms symmetrical short-circuit current and have a specified continuous-current rating.

Straight joints as well as connections to switchgear or transformer components shall be covered by vinyl covered boots for 15kV or 4,160 V applications. The 480 V bus bars shall be taped or otherwise covered with Class A insulation.

The 600 V bus bars for low-voltage bus shall be supported by polyester material. The 15kV and 5 kV bus supports for medium-voltage bus shall be polyester glass material. All of these materials shall completely isolate current carrying members from ground.

The bus duct shall be installed in such a manner that it can be easily maintained (i.e., bolts shall be accessible).

Plug-in bus duct shall connect to the feeder sections without special adapters. The plug-in bus duct shall have provisions for locking and wire sealing.

Plug-in units shall have a grounding blade to ensure a positive ground connection to the ground bus.

Plug-in units shall be labeled with engraved, laminated nameplate identifying feeder or circuit.

Fire Protection

Where bus duct is routed through fire-rated walls and floors, the manufacturer shall provide the fire stop design. The fire stop shall be UL listed for a fire exposure rating not less than the design rating of the floor or wall being penetrated.

Separation and Redundancy

Separation criteria for bus duct are addressed in Section 2.04.

Environmental

The bus duct shall be capable of operating at its design capacity under the ambient conditions of temperature, humidity, harmonics and altitude. Refer to Section 2.05.

Grounding

Bus duct shall be provided with an internal copper ground bar having ground straps between bus duct enclosure sections to maintain a continuous grounding system.

Seismic and Structural

Bus duct shall be supported in accordance with the manufacturer's recommendations with vertical bus duct being installed with spring isolators.

Bus duct which supplies essential loads shall be adequately designed to perform satisfactorily after an earthquake. Bus duct determined to be hazardous to adjacent essential equipment due to potential movement during a seismic event, shall have seismically designed supports and attachments to conform with the seismic zone in which it is located. Refer to AT&T 760-200-023, Earthquake Design Loads.

Codes and Standards

The bus duct shall conform to the requirements of and be suitable for application in accordance with:

- ANSI C37.20.1 - Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
- ANSI C37.20.2 - Metal-Clad and Station-Type Cubicle Switchgear
- ANSI C37.20.3 - Metal-Enclosed Interruption Switchgear
- ANSI Z55.1 - Grey Finishes for Industrial Apparatus and Equipment
- ANSI/ASTM B236 -Specification for Aluminum Bar for Electrical Purposes (Bus Bar)

- ANSI/ASTM B317 - Specification for Aluminum Alloy Extruded Bar, Rod, Pipe and Structural Shapes for Electrical Purposes
- ANSI/ASTM B187 - Specification for Copper Bus, Rod and Shapes
- AT&T Practice 760-200-023, Earthquake Design Loads.

5.02 Cables

Design

Power and Control Cables

All power cables shall be properly sized for ampacity and voltage drop.

The following are general design criteria. Specific applications may require alternate measures such as 125° C wiring for high temperature connections.

Cable ampacity shall be based on 90° C conductor temperatures using NFPA-70 (NEC) ampacities except for cables terminating on molded-case breakers, insulated-case breakers, and low-voltage starters where device temperature limit rating may be limited to 60°C or 75° C. The temperature rating of wire used shall be based on the temperature rating of the terminating device or equipment it serves. Cable ampacity shall be equal to the larger of 1.25 times rated full-load current of the load or the breaker setting for non-motor circuits. Motor circuit ampacities shall be based on 1.25 times rated full-load current. If the cable is protected with a breaker with an adjustable breaker setting and the setting device is unprotected as indicated in NFPA-70 (NEC) Section 240-6, then ampacity shall be based on 1.0 set-point of the breaker sensor rating regardless of the actual setting. For determining the ampacity of fire pump motor cables, refer to NFPA-70 (NEC) Article 230-90(a), and Article 695.

Cables shall be sized to ensure that adequate voltage is available at the load equipment terminals. Refer to ANSI Std. C84.1, Voltage Ratings for Electrical Power Systems and Equipment (60 Hz) and NEC Articles 210 and 215.

Cables shall be sized to withstand, without exceeding 250° C, a 3-phase bolted fault at the load side of the cable. Equations from ICEA P-32-382 shall be used.

The shield on medium-voltage power cable shall be selected to safely carry maximum line-to-ground fault current for the clearing time of the fault.

In general, minimum conductor size for control cable shall be 14 AWG; however, current transformer leads shall be 10 AWG copper, and minimum conductor size for distributed control systems shall be No. 16 AWG. Minimum conductor size for power circuits shall be 12 AWG.

A grounding wire sized per NEC Table 250-95 shall be scheduled with the cable, or included in the cable for multiple conductor cable. Refer to Section 2.07, Grounding.

The neutral conductor shall be sized in accordance with NFPA-70 (NEC), Article 220. Where there are significant harmonic loads with a harmonic factor exceeding 0.05 per unit (i.e., from computers), the neutral shall consist of two conductors each with the same size phase conductors. Refer to ANSI C57.12.80, Terminology for Power and Distribution Transformers and ANSI C57.110, Recommended Practice for Establishing Transformer Compatibility when Supplying Non-Sinusoidal Current.

All power and control cable for circuits operating at 480 V and below shall be rated 600 V. Cable insulation shall be XHHW-2, THWN-2, RHW-2, or THHN rated 90° C wet or dry and THHN rated 90° C dry for No. 6 AWG and above. Insulation for cables smaller than 6AWG shall be THHN. Cables installed in trays shall be listed by NEC for tray use with either a CT or TC cable.

Conductor material shall be Class B stranded concentric round copper. Lighting and receptacle circuits shall use solid copper conductor.

Voltage rating, manufacturer, type and conductor AWG size indication shall be continuously factory-applied the entire length of each conductor. Minimally, the cable shall be marked in accordance with the NEC and any other local codes.

Conductor insulation should be color coded by phase, consistent for each voltage, throughout the building.

Medium-voltage power cable shall be designed for 133 percent insulation level. The conductor and insulation semiconducting screen shall be extruded. The insulation shall be shielded with either a copper tape or copper wire shield; cable shall meet AEIC and ICEA standards.

Lighting and branch circuit feeders may be installed as Type AC armored or Type MC in lieu of metallic raceways for a distance of no more than 15 feet when permitted by local codes. Cable shall only be used in concealed areas such as walls and hung ceilings.

All instrument cable shall consist of twisted shielded pair or triads. The shield shall be aluminum mylar with a stranded copper drain wire. If installed in a tray, the cable shall be UL listed for tray installation. Cable insulation shall be XHHW or THHN.

Protection Philosophy

Cable shall be protected against short circuits and overloads. Protective device pickup shall not exceed the calculated ampacity of the protected cable. Clearing time of overcurrent devices shall ensure that the thermal rating of the cable during load-end short-circuit conditions is not exceeded. Long-time pickup of overcurrent devices shall be equal or less than the cable ampacity for continuously adjustable protective devices. For nonadjustable protective devices, the next higher standard device rating shall be permitted when this rating does not exceed 800 amperes. Refer to NFPA-70 (NEC) Article 240-3.

Electrical Protective Systems

Neutral conductors shall not be used for equipment grounding. A separate grounding conductor shall be provided for all circuits to ensure an adequate ground-fault return path. General electrical protective systems criteria are addressed in Section 2.07.

Codes and Standards

The cables shall conform to the requirements of and be suitable for application in accordance with:

- NFPA-70 - National Electrical Code
- ICEA P-32-382 - Short-Circuit Characteristics of Insulated Cable
- ICEA S-19-81 - Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (Applies to rubber and rubberlike cable assemblies and their testing)
- ICEA S-66-524 - Standard for Cross-Linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (Applies to cross-linked polyethylene cable assemblies and their testing)
- ICEA S-68-516 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy (Applies to ethylene-propylene-rubber insulation and testing)
- ANSI C57.12.80, Terminology for Power and Distribution Transformer
- ANSI C57.110, Recommended Practice for Establishing Transformer Compatibility when Supplying Non-Sinusoidal Loads

5.03 Distribution Transformers

Design

The transformers shall be delta-wye connected (if 3-phase) and shall be capable of operating at no-load KVA output at 10 percent above rated secondary voltage and at 100 percent rated KVA output at 5 percent above rated secondary voltage without exceeding limiting temperatures. The transformers shall be equipped with two 2 1/2 percent full-capability primary taps above and four below rated voltage unless otherwise required, based on the results of the voltage profile calculation.

Unless otherwise indicated, the transformer load current will have a harmonic factor not exceeding 0.05 per unit. Harmonic factor is defined in ANSI C57.12.80 and ANSI C57.110.

The transformers shall be constructed using a 220° C insulation system and shall not exceed 115° C average winding rise above standard ambient.

Transformers shall incorporate a rubber vibration isolation system between the transformer enclosure and the core and the coil assembly and vibration isolation between the frame and ground.

The maximum noise level of the distribution transformers shall not exceed the following:

50 kVA and below	45 db
51 to 150 kVA	50 db
151 to 300 kVA	55 db
301 to 500 kVA	60 db

Isolation transformers used for transient and noise suppression shall incorporate copper or aluminum electrostatic shielding between the primary and secondary coils. The attenuation of common mode noise and transverse mode noise shall be within the guidelines of a K rating of 13.

Transformers shall be in a heavy gauge, sheet steel, ventilated enclosure.

The core of the transformer shall be visibly grounded to the enclosure by means of a flexible copper grounding conductor sized in accordance with applicable NFPA-70 standards (National Electric Code, Article 384).

Floor space allocation should consider the addition of future transformers and comply with NEC space requirements.

Fire Protection

Fire protection criteria for distribution transformers are given in NFPA-70 (NEC), Article 450, Sections 21 and 22.

Grounding

Distribution transformers shall be grounded in accordance with AT&T 802-001-198, AC Grounding.

Seismic and Structural

Transformers shall be mounted on concrete pads with vibration isolators installed between transformer and pad, secured to the pad in accordance with seismic requirements for the zone in which the installation is located as well as manufacturer's recommendations. The pad shall be secured to the floor in accordance with the same standards. Wall mounted transformers (i.e.: smaller than 45kVA) shall be mounted amounted and braced in accordance with manufacturer's requirements and seismic requirements for the applicable zone.

Distribution transformers which supply essential loads shall be adequately designed to perform satisfactorily after an earthquake. Distribution transformers determined to be hazardous to adjacent essential equipment due to potential movement during a seismic event, shall have seismically designed supports and attachments to conform with the seismic zone in which they are located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads.

Codes and Standards

Transformers shall conform to the requirements of and be suitable for application in accordance with:

- IEEE C57.12.01 - Standard General Requirements for Dry-Type Distribution and Power Transformers Including those with Solid Cast and/or Resin Encapsulated Windings
- ANSI C57.12.50 - Requirements for Ventilated Dry-Type Distribution Transformers, 1 to 500 kVA, Single-Phase and 15 to 500 kVA, Three-Phase, with High Voltage 601 to 34,500 V, Low-Voltage 120 to 600 V

- ANSI C57.110 - Recommended Practice for Establishing Transformer Capability when Supplying Non-Sinusoidal Load Currents
- IEEE C57.12.91 - Guide for Loading Mineral-Oil-Immersed Overhead and Pad Mounted Distribution Transformers Rated 500 kVA and Less with 65 C or 55 C Average Winding Rise
- IEEE C57.94 - Recommended Practice for Installation, Application, Operation and Maintenance of Dry-Type General Purpose Distribution and Power Transformers
- IEEE C57.96 - Guide for Loading Dry-Type Distribution and Power Transformers
- NEMA ST-20 - Dry-Type Transformers for General Application
- AT&T Practice 700-200-023, Earthquake Design Loads
- AT&T Practice 802-001-180 Protective Grounding Systems, General Grounding Requirements for Communication Systems in Central Offices, Radio Stations and Other Structure Power Systems
- AT&T Practice 760-400-310 Building Electrical Systems, Transformers
- AT&T Practice 802-001-198 Protective Grounding Systems
- NEC Article 450.

5.04 Distribution Panels, Panelboards and Disconnect Devices

Distribution Panels and Panelboards

Design

Lighting panelboards, low-voltage distribution panels, and panelboards for operation on 120/240, 208 Y/120, or 480 Y/277 V shall be of the dead front, safety type with a door-in-door hinge. Panelboards shall have a fully-rated, isolated neutral bus and shall also have an equipment ground bus. When panelboards are serving many nonlinear loads, the neutral bus shall be sized at 200%. An individual terminal shall be provided for each neutral wire.

Panel and panelboard main bus ampere ratings shall be equal to or greater than the ampere rating of the feeder breaker or disconnect switch supplying that panel or panelboard.

Panels, panelboards and breakers shall have short-circuit current (AIC) ratings equal to or greater than available fault current at input to panel. Test in accordance with UL 67.

Feed-through lugs (one set of lugs on each end of main vertical bus) are not acceptable.

Two and three-pole breakers shall have internal common trip so that all poles trip simultaneously. All circuit breakers with frame sizes rated 100 Amps and larger shall have interchangeable trips.

Ground-Fault Interrupter (GFI) circuit breakers shall have frequency suppression circuitry to prevent false tripping and a separate neutral-to-load neutral conductor.

Circuit breakers shall have bolted bus connections. Plug-in circuit breakers shall not be used.

All overcurrent devices in Panels and Panelboards shall have the capability of being locked-out in compliance with OSHA Standard 1910.147.

Main bus shall be copper bars with two bolt compression lugs used to terminate feeders.

All wire connectors except screw terminals shall be of the anti-turn solderless type and shall be suitable for copper wire.

Each breaker shall supply only one circuit.

Unless the breaker is designed for multiple conductors, only one conductor shall be connected to each circuit breaker.

Each breaker shall be numbered sequentially from left to right and top to bottom with permanent tags.

The loads supplied by the panel shall be balanced in accordance with NEC Article 220.

Floor/wall space allocation should consider the addition of future panels and comply with NEC space requirements.

Protection Philosophy

120/240 V AC 120/208 V AC Distribution Systems

The power supply for these distribution panels is from a 480 V, distribution panel through a single-phase 480-120/240 V or a 3-phase, 480-208Y/120 V transformer with protection for the feeder cable and the transformer provided by a molded-case circuit breaker with an adjustable instantaneous element at the 480 V panel. Consider elimination of the incoming feeder breaker at the panel to assist coordination.

Molded-case circuit breakers shall provide protection against overloads and faults for all the panel feeders. The rating of these breakers shall be selected within the cable ampacity to provide cable protection.

If fuses are used at this distribution level, selection of fuses shall be based on coordination requirements outlined under the coordination section.

Disconnect Devices

Where disconnect devices are required by the NEC, only heavy duty safety switches, adjustable magnetic trip-only molded-case circuit breakers, or fractional horsepower manual starters shall be used. Application shall be as follows:

- **Fractional HP single-phase motors** (1 or 2 pole): Manual Starters
- **Motors 1/2 hp and up**: Heavy duty safety switch or adjustable magnetic trip-only molded-case circuit breaker

Large switches from 1200 to 6000 amperes shall be either bolted pressure contact switches or high pressure contact switches. When used as service entrance disconnects, these shall be provided with electric trip coils for remote operation and ground-fault protection.

All disconnects shall be enclosed in the appropriate NEMA rated cabinet based on location and environment with provisions for locking with padlock. Dry indoor locations NEMA 1, raintight/weatherproof NEMA 3R, etc.

Disconnects shall be mounted to the building structure with clearances complying with the NEC Article 384. In locations where the surface is not suited for mounting, Unistrut P-1000 shall be used for rack mounting.

Identification

All panels shall have permanently attached nameplates and circuit numbers. Each nameplate shall show panel name, voltage, phase, and feeder origin.

Each breaker shall be numbered sequentially from left to right and top to bottom with permanent tags.

All Panels and Panelboards shall have typewritten circuit directories describing the service of each circuit.

Main Distribution type panelboards shall have laminated plastic nameplate circuit identification.

Each disconnect shall have a laminated plastic nameplate showing name, voltage and feeder origin.

Plastic nameplates shall be black with white letters, and shall be attached using at least two cadmium-plated screws.

Feeder origin identification shall include switchgear/switchboard designation, Floor number, and Floor location ID or nearest column number.

Electrical Protective Systems

Grounding

A continuous copper ground bus with terminals shall be furnished in the distribution panels and panelboards. The ground bus shall be capable of carrying the required short-circuit current.

An individual terminal shall be provided for each ground wire.

Seismic and Structural

Distribution panels, panelboards and disconnects shall be mounted and supported in accordance with the manufacturer's recommendation. Floor mounted distribution panels shall be mounted on a 4 inch concrete pad, secured to the pad in accordance with seismic requirements for the zone in which the installation is located. The pad shall be secured to the floor in accordance with the same standards.

Distribution panels and panelboards which supply essential loads shall be adequately designed to perform satisfactorily after an earthquake. Distribution panels and panelboards which are determined to be hazardous to essential equipment due to potential movement during a seismic event, shall have seismically designed supports and attachments to conform with requirements for the seismic zone in which they are located. Refer to AT&T 760-200-023, Earthquake Design Loads.

Codes and Standards

The distribution panelboards shall conform to the requirements of and be suitable for application in accordance with the following standards:

- NEMA PB-1 - Panelboards
- UL67 - Panelboards
- AT&T Practice 760-200-023, Earthquake Design Loads
- NEC Article 384.

5.05 Conduit and Raceways

Design

Conduit

The following types of conduit shall be used in accordance with local building codes:

Rigid Metal Conduit

Rigid galvanized steel conduit (threaded only) shall be used for all “exposed” (subject to physical damage) indoor and outdoor runs of power, instrumentation and control cables. In areas that have a highly corrosive atmosphere, rigid aluminum conduit shall be used. Aluminum conduit shall not be encased in concrete, masonry walls, masonry floors, or buried in earth. Rigid galvanized steel conduit shall be used for motor circuits, hazardous areas and applications that require concrete encasement. Minimum size shall be 1/2 inch.

All motor leads shall be installed in rigid steel conduit.

Warning tape shall be installed over direct buried conduit.

Where conduits are installed underground, the threaded joints shall be sealed with a joint sealing compound.

Intermediate Metal Conduit

Galvanized intermediate metal conduit (IMC) may be used in all areas in place of galvanized rigid steel conduit only if allowed by local building codes. Minimum size shall be 1/2 inch.

Electrical Metallic Tubing

Electrical metallic tubing (EMT) may be used to enclose feeders, branch circuits, alarm and signal circuits in non-hazardous, non-corrosive and dry locations. It shall not be used for service feeders from power company equipment to main switchboards or from standby AC plants to generator distribution equipment. It shall also not be installed where subject to physical damage during installation or while in service. EMT shall not be installed underground and shall not be encased in concrete.

EMT sizes shall be 1/2 to 4 inches in diameter.

Liquid-tight Flexible Metal Conduit

Liquid-tight flexible metal conduit consisting of an inner flexible metal core with an outer liquid-tight, nonmetallic, sunlight-resistant PVC jacket shall be used between rigid metal conduit and equipment conduit boxes on all motors, connections to thermocouples, or in any situation where vibration or moisture is anticipated.

Non-Metallic Conduit

Nonmetallic conduit shall only be used where allowed by local codes.

Nonmetallic conduit may be buried or encased in concrete for special grounding requirements.

Rigid nonmetallic conduit sizes from 1 to 5 inches shall be used.

Rigid nonmetallic conduit shall not be used with cables whose temperature ratings exceed that of the conduit.

Conduit Fittings

All conduit fittings shall be compatible with the conduit and in accordance with the National Electrical Code. Where aluminum conduit is used, conduit threaded connections shall be coated with aluminum joint compound. Threaded fittings are required except for EMT conduit.

Where electrical metallic tubing is used, all fittings shall be compression fittings.

Expansion joints shall be provided where required to compensate for thermal expansion and contraction.

Sleeves

Sleeves shall be used for all raceways penetrating wall, floor and structural members. Sleeves shall consist of rigid galvanized steel conduit set in forms. Schedule 40 PVC shall be used for individual ground conductors.

Sleeves shall be sized to have 1/2-inch clearance around raceway. Space between raceway and sleeve shall be sealed with fireproof material after raceway is installed. Firestop material is to have a rating matching that of the material the sleeve is penetrating.

Cable Tray

A cable tray system may be used instead of conduit in cases where large concentrations of cable are routed together, such as local distribution feeders in an administrative area or temporary connection of a portable engine.

Cable Tray

All metal cable trays shall be ladder type, galvanized steel or aluminum. In areas that have a highly corrosive atmosphere, aluminum trays shall be used.

Cable Tray Fittings

Tray covers, when used to protect cables from damage and debris (i.e., under gratings) shall be solid-top, side-ventilated, requiring no derating of power cable through the use of accessories raising the cover above the side rail.

Underground Duct System

The underground duct system shall consist of rigid nonmetallic or metallic conduit resistant to moisture and corrosive agents and suitable for concrete or earth encasement. Concrete enclosing medium-voltage cables shall be color coded red as a warning.

Ducts in duct banks encased in concrete shall be PVC light-wall type. In sizes over 4 inches, duct shall be PVC heavy-wall type. The minimum concrete cover shall be 3 inches.

Ducts containing telephone circuits shall be separated from all other circuits by a minimum of 12 inches.

Ducts in single runs for direct burial may be rigid steel conduit painted with asphaltum or with a plastic covering or PVC heavy-wall Schedule 80 type.

Location of the ducts shall be marked by a warning tape 6 inches below grade.

Environmental

All penetrations entering an electrical area from above shall be sealed watertight. General environmental criteria are addressed in Section 2.05.

Electrical Protective Systems

Grounding

The metallic raceway system, whether exposed or concealed, shall be electrically continuous and grounded, and shall comply with all requirements of the NFPA-70 (NEC), Article 250, and AT&T 802-001-180, Protective Grounding Systems - General Grounding Requirements and 802-001-198, Protective Grounding Systems - General Equipment Ground Requirements. Refer to Section 2.07 for further requirements.

In addition, an equipment ground conductor shall be provided in the metallic raceway, bonded to equipment enclosures so as to provide continuity between enclosures independent of raceway continuity.

Where conduits are required to be grounded, they shall be furnished with a ground bushing.

Identification

All exposed conduits 2 inches and larger shall be identified with markers 20 feet on center. Markers shall be permanent, plastic-sheet conduit markers extending 360 degrees around conduit. Marker shall identify voltage and function of conductors in conduit and be a minimum length of 8 inches.

Seismic and Structural

Raceway shall be mounted and supported in a secure and workmanlike manner in accordance with NFPA-70 (NEC), Articles 318 and 345 through 351.

Raceway which contains cables supplying essential loads shall be adequately designed to perform satisfactorily after an earthquake. Raceway determined to be hazardous to adjacent essential equipment due to potential movement during a seismic event, shall have seismically designed supports and attachments to conform with the seismic zone in which it is located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads.

Codes and Standards

The raceway shall conform to the requirements of and be suitable for application in accordance with:

- NEMA VE-1 - Metallic Cable Tray Systems
- UL 6 - Rigid Metal Electrical Conduit
- UL 360 - Liquid Tight Flexible Steel Conduit
- UL 797 - Electrical Metallic Tubing
- UL 651 - Schedules 40 and 80 Rigid PVC Conduit
- UL 1242 - Intermediate Metal Conduit
- AT&T Practice 760-200-023, Earthquake Design Loads.

Motor Control Centers

6

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Motor Control Centers

6

6.01 Low Voltage Motor Control Centers

The preferred motor control center (MCC) shall use circuit breaker combination magnetic starters. This design provides protection from single phasing and minimizes spare part requirements.

Design

Motor control centers (MCCs) shall conform to the requirements of NEMA ICS 1, NEMA ICS 2, NEMA ICS 4 and NEMA ICS 6.

Each motor control center shall consist of one or more vertical sections and shall be designed to permit future additions, changes, or regrouping. Floor space allocation shall consider the addition of future sections and comply with NEC space requirements.

The enclosure shall be NEMA Type 1A Gasketed - General Purpose - Indoor, for indoor locations as determined in NEMA ICS 6.

Main and vertical buses shall be made of electrical-conductor grade hard-drawn copper and shall be electroplated. Insulated bus supports shall be made from mechanically strong, high dielectric strength, low power factor, non-hygroscopic, flame-retardant, track-resistant insulating material.

Motor control centers shall be designed and constructed to withstand the mechanical and thermal stresses produced by specified external short circuits, based on the results of a detailed fault-current study.

The main horizontal bus and vertical bus rating shall, in general, be minimum 600 amp and 300 amp rms continuous, respectively.

The neutral bus shall be sized at 100 percent of the rated load.

Motor control center internal component arrangements and wiring shall be Class 1, Type B, in accordance with NEMA ICS 2.

Terminal blocks for load connections shall not be furnished inside the compartment. Wiring between front unit compartments and rear-mounted equipment shall be provided by the manufacturer.

All control wiring shall be tinned, stranded copper, 90° C, Types SIS, XHHW and VW-1 flame-retardant construction.

A combination control unit for motors shall consist of an externally operable circuit disconnect (either a fusible interrupter switch or a molded-case circuit breaker) and a magnetic starter in accordance with NEMA ICS 2. Molded-case circuit breakers are the preferred design.

Starter units shall have 120 volt pilot lamps to indicate “run” and “stop”.

Molded-case circuit breakers or fused interrupter switches without magnetic starters shall be used principally for non-motor loads. They shall have an interrupting or short-circuit rating which equals or exceeds the available short-circuit current at the horizontal main bus.

Circuit breakers shall be of the bolted type. Circuit breakers shall be trip-free under all operating conditions.

Molded case circuit breakers shall comply with requirements of NEMA AB 1. Circuit breakers shall have a frame size of 100 amps, minimum, and shall be physically interchangeable for the same frame size.

Fuses, when used, shall be nonrenewable one-time dual-element, current- limiting fuses in accordance with NEMA FU 1.

All overcurrent devices in motor control centers shall have the capability of being locked-out in compliance with OSHA Standard 1910.147.

All circuits shall be identified with permanent tags.

The status of all control fuses shall be indicated on the front panel and status indicators shall have contacts for remote indication.

Auxiliary contacts shall be supplied for each starter as required by individual control schemes. Two normally open (N.O.) and two normally closed (N.C.) auxiliary contacts shall be provided with each starter as a minimum.

Switches shall be externally operated, quick-make, quick- break, with an on/off indicating operating handle.

The switch shall be able to carry safely whatever current values the fuse will let through before the fuse blows, including peak currents passed by the fuse when it is interrupting a maximum available short-circuit current. The switch shall be capable of safely closing-in on available fault currents up to the interrupting rating of the fuse/switch combination. Switch contacts must be capable of opening all normal load currents as well as any overcurrents on which the switch can be closed.

Loads that are not redundant but are considered critical for operation of the location, such as HVAC loads, shall be supplied from a double-ended MCC. The MCC shall be supplied from distribution system “A” and distribution system “B” with a bus-tie breaker.

Protection Philosophy

Single Motor Feeders

Motors fed from the MCCs are normally 100 hp or less. Overload and phase fault protection for each motor feeder shall be provided in accordance with NFPA-70 (NEC), Article 430-32, by individual phase overload heaters and a magnetic-only circuit breaker (or fuse) in a combination starter. The heaters shall be selected to 115 percent of motor full-load current (not exceeding 130 percent) for service factor of 1.0, or 125 percent of motor full-load current (not exceeding 140 percent) for a motor service factor of 1.15. The breaker setting or fuse selection shall clear a fault at a minimum of 1.73 times locked-rotor current. Whenever the trip rating of the overload heater exceeds 15 amps, separate ground-fault protection shall be considered. This protection should shunt trip the breaker to achieve optimum coordination with the ground-fault protection provided at the 480 V low-voltage power circuit breaker for the MCC feed. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

Group Motors

The feeder to a remote starter, a group of motors, or a group of heaters shall be protected by a 3-phase, molded-case circuit breaker. This thermal magnetic breaker shall be selected by its continuous current rating to be above 120 percent of the circuit full-load current and below the feeder cable ampacity. The instantaneous trip shall be selected to accommodate the possibility of all the motors in the group starting simultaneously, unless such starting is definitely prevented.

Whenever the overload protection exceeds 15 amps, separate ground-fault protection shall be considered which shunt trips the breaker to achieve full coordination with the 480 V low-voltage power circuit breaker for the MCC feeder. Refer to IEEE Std. 242, Chapter 7, Ground-Fault Protection.

Instrumentation and Control

Control switches shall be of the hand-off-automatic type.

Electrical Protective Systems

Grounding

A continuous copper ground bus shall be furnished over the full length of the structure which shall be capable of carrying the required short-circuit current.

Seismic and Structural

MCCs shall be mounted on 4” concrete pads, secured to the pads in accordance with seismic requirements for the zone in which the installation is located as well as manufacturer’s recommendations. The pad shall be secured to the floor in accordance with the same standards.

Distribution transformers which supply essential loads shall be adequately designed to perform satisfactorily after an earthquake. Distribution transformers determined to be hazardous to adjacent essential equipment due to potential movement during a seismic event, shall have seismically designed supports and attachments to conform with the seismic zone in which they are located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads.

MCCs which supply essential loads shall be adequately designed to perform satisfactorily after an earthquake. MCCs determined to be hazardous to adjacent essential equipment due to potential movement during a seismic event, shall have seismically designed supports and attachments to conform with the seismic zone in which they are located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads.

Codes and Standards

The MCCs shall conform to the requirements of and be suitable for application in accordance with the following:

- NEMA ICS-1 - General Standards for Industrial Control and Systems
- NEMA ICS-2 - Industrial Control Devices, Controllers and Assemblies
- NEMA ICS-4 - Terminal Blocks for Industrial Use
- NEMA ICS-6 - Enclosures for Industrial Control and Systems
- NEMA AB-1 - Molded Case Circuit Breakers
- AT&T Practice 760-200-023, Earthquake Design Loads
- NEC Article 430.

Programmable Logic Controllers

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Programmable Logic Controllers

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7.01 Programmable Logic Controllers (PLCs)

Design

The Programmable Logic Controller (PLC) shall be used when the accumulation of information for AC control operations is too complex or not feasible for the use of relays. PLCs may be used for specified controls, timing, peak shaving, monitoring functions, paralleling and change over for AC standby plant systems as well as control operations for AC distribution boards.

The PLC system shall consist of one or more central processing units (CPU), multiplexers, interface, input, output, memory, power supply, required remote devices, and all power and interface cables.

The PLC shall be capable of receiving discrete (digital) and analog inputs. By using relay ladder logic, it shall be able to control discrete and analog output functions, perform data handling operations and communicate with external devices.

Any use of PLCs for control of what is considered a critical operation shall have parallel redundant processors with each having its own power supply. Processors shall have dual I/O channels to accomplish redundant I/O connections to remote units. I/O racks shall be connected to prevent loss of communication on loss of any one control cable. Transfer to backup CPUs and power supplies shall occur in less than 50 milliseconds. The outputs in the remote I/O shall maintain its last state until it comes under control of the backup processor.

In the event of failure of all PLC processors, operation shall revert to manual control. Manual bypass switch shall also be provided.

The PLC shall be of modular construction, allowing I/O modules to be individually added or removed. The system shall have the capability of field upgrades without the loss of existing equipment. The system manufacturer shall guarantee evolutionary compatibility of the PLC system. All mature products shall be supported and available for 7 years after the particular product is declared obsolete or mature.

The PLC shall have at least 20 percent spare capacity at all levels.

The system shall be able to transmit alarms and interface with the Building Monitoring Alarm System (BMAS) by means of an RS232 cable connection.

CPU

The central processing unit (CPU) shall read the inputs, perform all system logic, conduct on-line diagnostics and control the outputs. Diagnostics shall include memory checks, scan time monitoring and I/O bus monitoring. In the event of a fault the processor will go to a fail-safe operation (last state). The fail-safe operation shall be applied to all PLC inputs, outputs, external controls and interlocks.

Indicating lights shall be furnished with the unit indicating the operating mode of the controller (run, stop, fault). Operating modes shall be sent to the BMAS system.

The full memory of the CPU shall be usable for program or data storage. The memory may be expanded either through the addition of RAM submodules or by direct replacement of the processor with a unit with larger memory. Should the processor be replaced by a unit with larger memory size, the replacement shall be accomplished simply by saving the PLC program, replacing the processor and downloading the saved program to the new system without having to make any program changes.

Program backup for the CPU shall be on nonvolatile Electronic Erasable Programmable Read-Only Memory cartridges.

Program functions shall include contacts, coils, timers, counters, math functions, shift registers, and bit and word operations.

There shall be four levels of passwords to provide different levels of access privilege for the PLC when the programmer is in on-line or monitor mode.

The CPU shall include an integral real-time clock which can be accessed from the control program. The clock shall include functions for time of day (year, month, day, hour, minute, seconds), alarm and operation hours counter, or be capable of providing this information by means of programming.

All diagnostic information shall be accessible at the programming workstation (personal computer). A diagnostic CRT page shall provide information which identifies the nature of the fault, the absolute memory or I/O address of the fault and the date and time of occurrence of the fault, or be capable of providing this information by means of programming.

The CPU shall permit modifications to ladder program or data values while running.

The programming software shall allow testing of edited rungs before they become a permanent part of the current program.

The capability shall exist to make program edits to rung without deleting and regenerating the entire rung. It shall be possible to insert relay ladder diagram rungs anywhere in the program, even between existing rungs, where sufficient memory exists.

On the relay ladder rung display, it shall be possible to show the on-line running open/closed status of contacts and energized/de-energized status of coils.

Input power shall be 48V DC. Each processor shall receive its own DC feed from separate DC power plants (“A” and “B” plants) within the building, if possible. Concurrence of the AT&T Power Engineer shall be obtained prior to obtaining power from the DC power plants.

Inputs/Outputs

Inputs and outputs shall be modular, with each module having status LEDs. Input LEDs shall be powered from the field-side; output LEDs shall be powered from the logic side.

All modules shall be enclosed in rugged plastic or metal housings. There shall be no user access to the circuit board components.

Each rack position shall have a mechanical interlock, unique for each type of I/O module to prevent insertion of an incorrect module.

Discrete input modules shall include non-isolated AC input modules for devices which operate at 120 VAC, and isolated AC input modules which provide isolation of 120 VAC input signals.

Discrete output modules shall include non-isolated AC output for devices which operate at 120 VAC, and isolated AC output which provides isolation of 120 VAC output signals. Digital (discrete) output modules shall be provided with short-circuit protection built into the output module. Load protection shall be provided by terminal strips with built-in, pullout fuses.

During normal operation, a malfunction in any remote input/output channel shall affect the operation of only that channel and not the operation of the CPU or any other channel.

All communications on the input/output channels between the remote input and output units and the CPU shall be digital in nature. Digital input and output modules shall be 48V DC powered.

The PLC system shall permit location of I/O modules up to 5000 feet from the CPU. Connection between the CPU and the remote I/O racks shall be by shielded twisted pair cable as specified by the PLC manufacturer.

General

The programming unit shall be a Personal Computer loaded with appropriate software package and required communication cable. The software package shall be capable of on-line and off-line programming, on-line monitoring, storage of programs on disk, output of programs to printer and connection to a modem for remote access capability. Communication shall be through the standard serial ports of the Personal Computer. No special boards shall be required in the computer.

Programming software shall be capable of symbolic addressing of I/O and data table addresses, rung comments, instruction comments and address comments.

The manufacturer used shall provide training on the PLC used. The training shall consist of a minimum of 8 hours on-site training.

The manufacturer shall also be required to have a service contractor or product line distributor within the local area of the AT&T building in which the PLC is being installed. The local representative shall be capable of being on-site within two hours of an emergency call out. The service contractor shall be able to provide local parts, troubleshooting, and repair services within a predetermined time limit.

Spares

Each PLC shall have a spare CPU, at least one spare of each type of I/O module and a spare EPROM memory cartridge containing the control program stored at site.

Environmental

The PLCs shall be capable of operating in temperature ranges between 0 and 55° C and a relative humidity (noncondensing) between 5 and 95%.

Seismic and Structural

PLCs shall be mounted and supported in accordance with the manufacturer's recommendations. Where required, all PLCs shall have seismically designed supports and attachments to conform with the seismic zone in which they are located.

Codes and Standards

Programmable logic controllers shall conform to the requirements of and be suitable for application in accordance with:

- Vibration
  - IEC 68-2-6
  - JIS C 0911 standards for vibration
- Noise Immunity
  - NEMA ICS 1-109
  - ANSI C-37.90A-1974
- Radiated Noise
  - IEC CISPR 11
- General
  - IEC 68-2-6
  - IEC 68-2-27
  - UL 508
  - CSA C22.2 (No. 142)
  - ISO 9001.

In addition to guidelines in Section 2.08, the final program (as-built) shall be formatted with instructions in the comment section of the program outlining the operations of the PLC.

Acceptance

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Acceptance 8

8.01 Documentation

1. Verify that the following design documents are updated, included with each project, turned over upon completion, maintained and easily accessible to potential users:

    a. Electrical drawings, including single-line drawings, riser diagrams, panel directories and floor plans identifying locations of panels on the floor and routing of main feeders. All drawings are to be completed in AutoCAD® Release 12 format per the AT&T Computer Aided Drafting Specification

    b. Electrical load calculation or analysis

    c. Short-circuit calculation or analysis

    d. Voltage profile calculation defining voltage levels throughout the AC system

    e. Cable sizing calculations

    f. Protective device coordination calculations with graphic representation

    g. System description, including operation of the system

    h. Integrated wiring diagrams which include all wiring from termination point to termination point.

2. Verify that all operating and maintenance procedures and manufacturer's drawings are submitted to the location prior to final acceptance of system modifications
3. Verify that on-site or factory training has been provided if necessary
4. Verify that breaker labeling and mimic panels are properly designated, and agree with the electrical drawings
5. Verify that the PQRS database is properly updated to include all information related to the new or modified AC distribution equipment.

8.02 Equipment Acceptance Checklists

Overview

The purpose of this section is to provide design and operating criteria checklists for installation acceptance activities. These checklists are primarily designed for use by the AT&T OSWF during final acceptance, but may be used by AT&T Building Engineering, Local Contractors or others at any time during the installation process. Each checklist is designed to ensure total working condition in compliance with current AT&T Standards. Local conditions may warrant additional design requirements, therefore the following checklists should be considered minimum criteria for acceptance.

General Design Criteria

Electrical Protection

1. Verify, using a current building short-circuit study, that electrical protection devices are designed and installed to isolate any short-circuit or overload condition
2. Verify, using a current building coordination study, that all breakers and fuses are closely coordinated with upstream and downstream trip devices without overlapping
3. Verify, using a current building coordination study, that fuse clearing characteristics are coordinated with upstream devices, and fuse melting characteristics are coordinated with downstream devices
4. Verify that all appropriate studies and calculations have been performed and are in compliance with guidelines set forth in Section 2.08
5. Verify that all power and grounding cable terminations are made using two-hole bolted circumferential-crimp type connectors

6. Refer to specific equipment acceptance criteria for individual electrical protection requirements.

Fire Protection

1. Verify that all areas are accessible for fire fighting with manual suppression systems including standpipe and hose. Verify that all standpipe and hose configurations are in compliance with AT&T 760-640-310, or as required by local codes.
2. Verify that all electrical areas are furnished with CO_2 or approved substitute portable fire extinguishers. Refer to AT&T 760-640-105 for distribution and selection of portable fire extinguishers.
3. Verify that automatic suppression systems are provided if required. Refer to individual acceptance checklists for requirements of specific equipment.
4. Verify that fire detection devices are provided for all areas of the telephone equipment building. Early warning fire detectors (smoke, heat and UV) should be installed in compliance with AT&T 760-650-100.
5. Verify that fire detection devices are compatible with any automatic suppression systems protecting the area.
6. Verify that all fire-rated assemblies are sealed with a qualified fire penetration and smoke seal in compliance with AT&T 760-630-410AC, Fire Stopping Consideration for Floor and Wall Penetration and Protection of Cable Runs.
7. Verify that fire protection systems and equipment are sufficient to meet any local code requirements.

Separation and Redundancy

1. Verify that redundant equipment and feeders are both physically separate and electrically isolated where feasible.
2. Verify that the minimum separation for electrical equipment is provided as set forth in NEC Sections 110 and 384.
3. Verify that the hazard to essential redundant circuits is minimized by cable routing restrictions, or special physical separation requirements.
4. Verify that minimum internal switchboard separation between redundant circuits in common switchgear, panels, or cabinets is at least:
    a. One foot between redundant power equipment including cables greater than No. 10 AWG
    b. Six inches between redundant power, control and instrumentation equipment including cables equal to or smaller than No. 10 AWG

c. One inch between redundant equipment and cable where a barrier exists.

Environmental

1. Verify that heating and ventilation systems maintain the ambient temperature within the operating limits of the equipment.
2. Verify that HVAC control systems include the provision for monitoring and alarming ambient equipment room temperatures, and the operating status of all cooling and ventilation equipment.
3. Verify that transformer and utility service entrance vault venting meets the following criteria (where required):
   a. Vaults are located to allow ventilation to the outside without the use of flues or ducts
   b. Vault ventilation is adequate for the removal of generated heat via natural or mechanical means
   c. Explosion vents should be a minimum of 1 square foot per cubic foot of the transformer vault volume
   d. Refer to AT&T 760-620-200, Considerations during Central Office Equipment Installation and Removal, AT&T 760-630-400, Compartmentation, and local utilities for additional requirements.
4. Verify that the following internal flood control measures are provided for electrical equipment areas subject to flooding from adjacent areas:
   a. An adequate floor drain system. Floor drains for transformer vaults and standby generator rooms must be provided with oil separators
   b. All floor mounted electrical equipment is mounted on 6 inch concrete pads.
5. Verify that pipe routing of fluid systems (potable water, chilled water, condenser water, etc.) meets the following requirements:
   a. Electrical equipment is protected from pipe leakage primarily by routing piping outside of electrical equipment areas
   b. Where existing piping is routed over existing electrical equipment, every effort should be made to relocate and isolate the equipment. If this is not feasible, then the equipment should be protected with drip pans or other means to prevent leakage directly onto electrical equipment
   c. Leak detection systems shall be provided for all raised floor areas whenever piping is routed through the area.

Instrumentation and Control

1. Verify that all electrical equipment is provided with local instrumentation, alarm and control systems suitable for operation. Refer to Chapter 3 for specific criteria associated with individual equipment.
2. Verify that sufficient instrumentation and control circuitry is provided for indication, alarms, and controls necessary to operate and control selected equipment.

Electrical Protective Systems

1. Verify that equipment grounding meets the following criteria:
   a. Equipment grounding is installed with the purpose of limiting the potential difference between noncurrent carrying metal parts and ground
   b. Equipment grounding provides a low impedance path for ground-fault current flow
   c. Equipment grounds are resistant to or protected from corrosion
   d. Equipment grounding resists deterioration and fusing under the most adverse combination of fault current magnitude and duration
   e. All noncurrent carrying metallic parts which might accidentally become energized (i.e., transformer tanks, motor frames, raceways and switching assemblies) are connected to the equipment ground system
   f. Neutral conductors are not used for equipment grounds
   g. All equipment grounds are connected to the central office grounding system
   h. All grounding conductors should use green insulation or be taped for identification with green tape
   i. Equipment grounding system complies with all requirements of the National Electric Code (NEC), Article 250, and with AT&T 802-001-180, Protective Grounding Systems - General Grounding Requirements, and AT&T 802-001-198, Protective Grounding Systems - General Equipment Ground Requirements.
2. Verify that the main distribution system is solidly grounded per IEEE Std. 142, Recommended Practice for Grounding of Industrial and Commercial Power Systems.
3. Verify that both ends of all office ground cables are tagged and designated to show opposite end terminating location.
4. Verify that all office grounding equipment is installed in accordance with the office record drawings and engineer's instructions.

5. Verify that all power and grounding cable connections are made using two-hole bolted circumferential-crimp type connectors.
6. Verify that all AC circuits have the ability to be locked out and tagged out by maintenance personnel in compliance with OSHA 1910.147, and ACP 010-160-212, Procedures for the Control of Hazardous Energy.

Equipment Design Criteria

Utility Service Entrance

1. Verify that all utility power sources and AT&T owned power transformers comply to fire protection requirements given in Section 2.03.
2. Verify that all utility owned power sources and transformers meet utility company mandated fire protection requirements as a minimum.
3. Verify that feeder cable separation is maintained when multiple (2 or more) utility power sources are provided. Where separation is not possible, verify that a 3 hour fire rated barrier is between cables.
4. Verify that all incoming utility power sources (overhead or underground) are protected by surge protective arresters per Section 3.03 of this document, AT&T 876-200-100, Electrical Protection - Central Offices, and 876-101-100, Electrical Protective Devices.
5. Verify that all circuits and circuit breakers are properly designated, and agree with electrical drawings.
6. Verify that all power and grounding cable terminations are made using two-hole bolted circumferential crimp type connectors.
7. Verify that main neutral/ground bond can be removed for testing of building ground electrode.

Power Transformers

1. Verify transformer type. Transformers located indoors should be ventilated dry-type.
2. Verify that all transformers are tested and calibrated according to manufacturer's guidelines before energizing. A “high potential” test should be performed on each transformer.
3. Verify that the oil in oil-filled transformers is tested for contamination such as water or PCB's.
4. Verify that transformers (> 3000kVA) are provided with three high-speed, harmonic- restrained, percentage-differential relays for protection against internal 3-phase, phase-to-phase, and phase-to-ground faults in each transformer.

5. Verify that a “rate-of-rise” gas pressure relay is provided to supply sudden pressure protection for each main power supply transformer. The relay should alarm and energize the transformer lockout relay.
6. Verify that a thermal detector is provided to sense temperature rise and initiate an alarm at 105^{o} C and energize an auxiliary relay which energizes the transformer lockout relay at 125^{o} C.
7. Verify that backup overcurrent phase protection is provided on the high-voltage side of each transformer.
8. Verify that two ground-overcurrent relays are provided at the low side wye neutral.
9. Verify that additional fire protection criteria for oil-cooled transformers are provided as follows:
    a. For transformers rated less than 75 kVA, portable extinguishers should be provided
    b. For transformers rated between 75 kVA and 50,000 kVA, 1-1/2 inch fire hose and portable extinguishers should be provided.
10. Verify that any transformer requiring a fire-rated enclosure is separated from switchgear by a 3 hour, fire-rated barrier.
11. Verify that transformer venting and floor drains are in accordance with Section 2.05.

Switchgear and Switchboards

1. Verify that all switchgear and switchboards are tested at the factory after fabrication and before shipment, including simulation of all control and relay functions and complete operation of breakers, including electric operation.
2. Verify that the following procedures are performed at the site before the bus is energized:
    a. All switches, circuit breakers and other operating mechanisms are manually exercised
    b. An electrical insulation resistance test is performed both phase-to-ground and phase-to-phase with the switches or circuit breakers in the opened and closed positions
    c. All breakers (greater that 100 amps) are tested by a NETA certified testing contractor, employed by AT&T, after delivery to site and before acceptance
    d. All electrical relay, meters and instrumentation are checked to determine that connections are made properly
    e. All electrically operated circuit breakers and other mechanisms are electrically exercised (not under load) to determine proper function

f. The ground-fault protection system is tested per manufacture's recommendations

g. Adjustable current and voltage trip mechanisms have been set to their proper values in accordance with the site coordination study

h. All field wiring is clear of any live bus and physically secured to withstand the effects of fault currents

i. All grounding is checked for proper connections

j. All scrap wire, boxes, spare parts, and other debris is removed from the switchgear interior

k. All bus connections and control wiring connections are verified to be tight and properly torqued, if required.

3. Verify that all switchgear or switchboards are mounted and secured to concrete pads per manufacturer's recommendations.
4. Verify that all switchgear or switchboards carrying essential loads are designed to adequately withstand and perform after an earthquake. Verify that supports and attachments conform to requirements for the seismic zone in which the office is located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads, for more information.
5. Verify that all power and grounding cables are connected using two-hole circumferential-crimp type lug connectors.
6. Verify that all electrical and mechanical interlocks are exercised and in working order before acceptance.
7. Verify that electrically operated breakers are capable of being operated remotely (by an electrical control signal) or locally (manually, indicating a manual latch release).
8. Verify that all breakers (electrical and manual) can be manually opened or closed without opening the door to the breaker compartment.
9. Verify that all breakers visibly indicate open, closed, and tripped positions without opening the door to the breaker compartment.
10. Verify that all overcurrent devices have the capability of being locked-out in compliance with OSHA Standard 1910.147.
11. Verify that a key interlock system is used where manual tie breaker operation is required.
12. Verify that the status of all control fuses is indicated on the front panel, and contacts are present for remote indication.
13. Verify that all circuits are identified with permanent tags.
14. Verify that each cable bundle is limited to 12 cables (maximum).

15. Verify that all medium and low-voltage tie connections (between buses) contain high speed differential relays sensitive to both phase and ground faults.

Bus Duct

1. Verify that bus duct is only used for applications above 1,000 amps, or where taps or circuit rearrangements are required. Bus duct should not be used when accessibility requirements or environmental conditions (moisture, dirt, etc.) are unsuitable.
2. Verify that all bus ducts are tested with a megger before energizing. Resistance should be above one megohm per 100 feet of busway.
3. Verify that the bus has been tested for 15 minutes (readings at one minute intervals) with a 1000 VDC insulation tester.
4. Verify that all joints are torqued according to manufacturer's recommendations and that all bolts are accessible for retorquing.
5. Verify that all switches, circuit breakers, and other operating mechanisms mounted on plug-in busways are manually exercised prior to acceptance.
6. Verify that all breakers 100 amps and larger are tested by a NETA certified testing contractor employed by AT&T after delivery to site and before acceptance.
7. Verify that bus duct is supported in accordance with manufacturer's recommendations.
8. Verify that all bus duct carrying essential loads is designed to adequately withstand and perform after an earthquake. Verify that supports and attachments conform to requirements for the seismic zone in which the office is located. Refer to AT&T 760-200-023, Earthquake Design Loads, for more information.
9. Verify that warning labels are placed at all access openings and end sections of AC bus duct as required.
10. Verify that bus duct in not installed in foundation or concrete walls.
11. Verify that plug-in bus duct can connect to the feeder sections without special adapters. The plug-in bus duct should have provisions for locking and wire sealing.
12. Verify that all plug-in units have a grounding blade to the ground bus.
13. Verify that all plug-in units are labeled with engraved, laminated nameplate identifying feeder or circuit.

Transfer Switches

1. Verify that the following tests were performed at the factory, and repeated at the site after completion of installation:
    a. Simulation of all control and relay functions
    b. Transitions demonstrating complete change between energized sources. Energized sources must be within specified limits before the transition occurs
    c. Simulation of voltage loss for testing should be conducted without interrupting AC service.
2. Verify that all transfer switches are mounted and secured per manufacturer's recommendations
3. Verify that all transfer switches carrying essential loads are designed to adequately withstand and perform after an earthquake. Verify that supports and attachments conform to requirements for the seismic zone in which the office is located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads for more information
4. Verify from manufacturer's data that transfer switches have adequate withstand, closing, interrupting, and continuous current ratings
5. Verify that transfer switches have hard manual bypass with posted step-by-step procedures
6. Verify that open transition transfer switches are mechanically or electrically interlocked to prevent simultaneous closing between the normal and emergency contacts
7. Verify that an intentional time delay is provided for open transition switches (to allow the telecommunication equipment rectifiers to shut-off) before transfer between sources. The delay requirement for shut-off is approximately 5 seconds, but the exact time should be determined for each location
8. Verify that loss of voltage can be tested without the pulling of fuses or breakers. Testing should be performed using a “test” push-button or switch position provided with the transfer switch controls
9. Verify that all power and grounding cable terminations are made using two-hole bolted circumferential-crimp type connectors.

Low-Voltage Motor Control Centers

1. Verify that all motor control center (MCC) controls, relay functions, and breaker operation (including electrical operation) are tested at the factory after fabrication and before shipment
2. Verify that the following procedures are performed at the site before the bus is energized:
   a. All switches, circuit breakers and other operating mechanisms are manually exercised
   b. All breakers 100 amps and higher are tested by a NETA certified testing contractor employed by AT&T after delivery to site and before acceptance
   c. All electrical relay, meters and instrumentation are checked to determine that connections are made properly
   d. All electrically operated circuit breakers and other mechanisms are electrically exercised (not under load) to determine proper function
   e. The ground-fault protection system is tested per manufacturer's recommendations (if applicable)
   f. Adjustable current and voltage trip mechanisms have been set to their proper values in accordance with the site coordination study
   g. All field wiring is clear of live bus and physically secured to withstand the effects of fault currents
   h. All grounding is checked for proper connections
   i. All scrap wire, boxes, spare parts, and other debris are removed from the Motor Control Center interior.
3. Verify that all motor control centers are mounted and secured (using 3/8" bolts) to concrete pads per manufacturer's recommendations
4. Verify that all motor control centers carrying essential loads are designed to adequately withstand and perform after an earthquake. Verify that supports and attachments conform to requirements for the seismic zone in which the office is located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads, for more information
5. Verify that the Motor Control Center is properly designated, and that it agrees with the electrical drawings
6. Verify that all breakers, fuses, and disconnects are properly designated as to what equipment is being fed, and that this information agrees with the electrical drawings

7. Verify that combination control units for motors consist of an externally operable circuit disconnect (either a fusible interrupter switch or a molded-case circuit breaker) and a magnetic starter in accordance with NEMA ICS 2. Molded-case circuit breakers are preferred
8. Verify that all circuit breakers are of the bolted type, and trip-free under all operating conditions
9. Verify that all overcurrent devices in the Motor Control Center have the capability of being locked-out in compliance with OSHA Standard 1910.147
10. Verify that all circuits are identified with permanent tags
11. Verify that all cable bundles are limited to a maximum of 12 cables
12. Verify that two normally open (NO) and two normally closed (NC) contacts are provided for individual control schemes (minimum)
13. Verify that the status of all control fuses is indicated on the front of the panel, and have contacts for remote indication
14. Verify that all power and grounding cable terminations are made using two-hole bolted circumferential-crimp type connectors.

Distribution Transformers

1. Verify that the following procedures are performed at the site before the distribution transformer is energized:
    a. All switches, circuit breakers and other operating mechanisms are manually exercised
    b. An electrical insulation resistance test is performed both phase-to-ground and phase-to-phase with the switches or circuit breakers in the opened and closed positions
    c. All grounding is checked for proper connections.
2. Verify that all distribution transformers are mounted and secured using vibration isolators to concrete pads per manufacturer's recommendations and according to requirements for the applicable seismic zone
3. Verify that all distribution transformers carrying essential loads are designed to adequately withstand and perform after an earthquake. Verify that supports and attachments conform to requirements for the seismic zone in which the office is located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads, for more information
4. Verify that the distribution transformer is properly designated, and agrees with the electrical drawings
5. Verify that all distribution transformers are tested and calibrated per manufacturer's guidelines before energizing. Voltage taps should be set in accordance with the voltage study prepared for the AC distribution system of the building.

Distribution Panels, Panelboards and Disconnect Devices

1. Verify that the following procedures are performed at the site before the panel is energized:
   a. All switches, circuit breakers and other operating mechanisms are manually exercised
   b. All breakers (100 amps or larger) are tested by a NETA certified testing contractor employed by AT&T before acceptance
   c. All grounding is checked for proper connections
   d. All debris, scrap wire, boxes, spare parts, etc., are removed from the panel interior.
2. Verify that all distribution panels, panelboards, and disconnects are mounted and secured to concrete pads per manufacturer's recommendations and requirements for the applicable seismic zone
3. Verify that all distribution panels, panelboards, and disconnects carrying essential loads are designed to adequately withstand and perform after an earthquake. Verify that supports and attachments conform to requirements for the seismic zone in which the office is located. Refer to AT&T Practice 760-200-023, Earthquake Design Loads, for more information
4. Verify that AC equipment is properly bonded to the panel frame
5. Verify that the neutral connection is terminated on an isolated neutral bar
6. Verify that the panel board, and the panel board legend is properly designated, and that they agree with the electrical drawings
7. Verify that the AC input source is designated on the front of the panel
8. Verify that all overcurrent devices in the panels and panelboards have the capability of being locked-out in compliance with OSHA Standard 1910.147
9. Verify that all circuit breakers have bolted bus connections. Plug-in circuit breakers are not allowed
10. Verify that each breaker is numbered sequentially from top to bottom and left to right with permanent tags
11. Verify that all power and grounding cable terminations are made using two-hole bolted circumferential crimp type connectors.

Cables

1. Verify that all cables are examined for physical damage and tested using a 1000 VDC insulation tester. Branch circuits should be tested for one minute. Feeder circuits should be tested for 15 minutes with readings at one minute intervals

2. Verify that cables are sized:
    a. To ensure that adequate voltage is available at the load equipment
    b. To withstand (without exceeding 250^{o} C) a 3-phase bolted fault at the load.
3. Verify that all power cables are routed in accordance with office record drawing layout
4. Verify that adequate insulating protection is provided on cable rack straps, stringers, threaded rods, auxiliary framing braces, and other metallic objects where power cable makes contact with sharp surfaces
5. Verify that all terminating wires and cables are properly tagged and designated at both ends of conductors when required
6. Verify that all cables listed on power cable running list are installed with correct type and size cable as specified or otherwise calculated
7. Verify that neutral conductors are not used for equipment grounding
8. Verify that all power and grounding cable connections are made using two-hole bolted circumferential-crimp type connectors.

Raceways

1. Verify that all bus duct, conduit, and raceways are installed in accordance with office record drawing layout and the manufacturer's specifications
2. Verify that proper size and type fuses or circuit breakers are installed in AC plug-in units
3. Verify that rigid metal conduit is used for all “exposed” indoor (subject to hazardous conditions or physical damage) and outdoor runs of power, instrumentation and control cables. Aluminum conduit should be used in areas that have a highly corrosive atmosphere. Galvanized steel conduit should be used for motor circuits, hazardous areas, and application that require concrete encasement
4. Verify that warning tape is installed over buried conduit
5. Verify that electrical metallic tubing (EMT) is not used for AC service feeders to main switchboards or generator distribution equipment, where it is subject to damage during installation or service, installed underground, or encased in concrete
6. Verify that liquid-tight flexible metal conduit is used in any situation where vibration or moisture is anticipated
7. Verify that sleeves are used for all raceways penetrating wall, floor and structural members
8. Verify that all power and grounding cable terminations are made using two-hole bolted circumferential-crimp type connectors.

Surge Protective Devices

1. Verify that all devices are tested with a breakdown tester, according to manufacturer's recommendation, before acceptance
2. Verify that distribution-class surge protective arrestors are connected to each overhead or underground primary distribution feeder or service entrance conductor on the utility side
3. Verify that all surge arrester current carrying leads are laced together and run as straight as possible (3 foot length, maximum) with a minimum bending radius of 8 inches
4. Verify that all surge arresters contain provisions for testing without disconnecting the incoming power supply
5. Verify that each surge arrester has audible and visible alarms (connected to the local and remote alarm systems) indicating if the arrester is open. Surge arrester devices that are installed inside switchgear cabinets must be equipped with a remote visual alarm unit
6. Verify that surge arresters are properly designated, and that they agree with the electrical drawings.

Programmable Logic Controllers (PLC)

1. Verify that all PLC control and relay functions are tested at the factory
2. Verify that the site test (performed in the presence of an AT&T representative) is consistent with the procedures listed below:
   a. Upon completion of equipment installation, verify that field equipment has been calibrated and transmission media is operational before the system is placed on-line
   b. A detailed cross-check should be performed on each transmitter within the system by making a comparison between the reading at the transmitter and the PLC
   c. A cross-check of each control point within the system should be performed by making a comparison between the control command at the system and field controlled device
   d. The results of functional and diagnostic tests and calibrations should be submitted in accordance with approved test plans and procedures
   e. Proper automatic, manual, and fail-safe operation during power failure simulations shall be demonstrated to the satisfaction of the AT&T representative
   f. Part of the final acceptance test should consist of the contractor demonstrating programming and operational compliance of the system with the contract documents

g. Verify that a detailed description of the PLC operation in all modes (manual, automatic, and fail-safe) is provided to the AT&T representative before acceptance testing

h. Verify that adequate documentation and training are available to ensure proper operation and maintenance of the PLC after acceptance.

References

A

1. AT&T Practice 760-620-200, Considerations During Central Office Equipment Installation and Removal.
2. AT&T Practice 760-630-105, General Requirements for Fire Alarm Systems.
3. AT&T Practice 760-630-305, Smoke Detection.
4. AT&T Practice 760-630-306, Smoke Detection Systems for Control Offices.
5. AT&T Practice 760-630-307, Air Sampling Detection Systems.
6. AT&T Practice 760-630-400, Compartmentation.
7. AT&T Practice 760-630-410A/C, Fire Stopping Considerations for Floor and Wall Penetrations and Protection of Cable Runs.
8. AT&T Practice 760-400-102, Stand-by AC Plant Design, Installation and Acceptance Criteria.
9. AT&T Practice 802-001-180, General Grounding Requirements for Communication Systems in Central Offices, Radio Stations, and Other Structures.
10. AT&T Practice 802-001-198, Protective Grounding Systems, General Equipment Ground Requirements for AC Service Distribution Systems, Buildings Housing Communication Systems.
11. AT&T Practice 876-100-100, Principles of Electrical Protection, Engineering Considerations.
12. NFPA-20 -Centrifugal Fire Pumps.
13. NFPA-70 - National Electrical Code.

14. UL-96 - Lightning Protection Components.
15. UL-96A - Installation Requirements for Lightning Protection Systems.
16. ANSI C84-1, Voltage Ratings for Electrical Power Systems and Equipment (60 Hz).
17. IEEE Standard 100, IEEE Standard Dictionary of Electrical and Electronic Terms.
18. IEEE Standard 242, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
19. NFPA 780 - Lightning Protection Systems.
20. AT&T Practice 876-200-100 Electrical Protection - Central Office.
21. AT&T Practice 876-101-100 Electrical Protective Devices.
22. ANS/IEEE C37.91.
23. NEMA Std-20.
24. NFPA-10 Fire Extinguishers - Portable.
25. NFPA-14 Installation of Standpipe and Hose Systems.
26. AT&T Practice 800-200-100 Electrodes.
27. AT&T Practice 760-200-023 Earthquake Design Loads.

Glossary

B

Building Command Center (BCC)

That location in the building containing the control, monitoring, alarm and indicating equipment required for operating and controlling selected equipment in the ACEDS from a central location.

C

Combustible Material

Material that is capable of undergoing a chemical process that involves oxidation sufficient to produce heat and light.

D

Distribution Transformers

Dry-type indoor transformers rated 500 kVA and below, three-phase, or 167 kVA and below, single-phase, with secondary voltage of 600 V or less. These transformers serve lighting and general loads and are in series with the main power transformer which is the interface between the electric utility system and the facilities electrical system.

Diverse Loads

Multiple, similar loads which may or may not be redundant.

E

Electrical Protective Systems

Those systems furnishing protection for equipment and personnel which are considered to be the grounding, lightning protection and surge protective device systems.

Essential Bus

The electrical buses (switchgear and switchboards) which supply the essential loads.

Essential Loads

Electrical loads which can have commercial AC power interrupted but, because of their criticality to operation of telecommunications equipment, require a backup source of power (usually connected to standby AC plant power supply).

Exposure Fire

A fire in a given area that involves either *in situ* or transient combustibles and is external to any structures, systems, or components located in or adjacent to that same area.

F

Fault-Current

The maximum current flow for all AC sources that would be available under the worst short-circuit conditions.

L

Low-Resistance Grounding

Grounded through a low value of resistance to limit equipment damage during ground-fault conditions.

Low Voltage

Voltage classes up to 1000 V. Refer to ANSI Std. C84.1, Voltage Ratings for Electrical Power Systems and Equipment (60 Hz).

M

Main Bus

The electrical buses (switchgear and/or switchboards) which supply the nonessential loads as well as the essential buses. Also may be called nonessential bus.

Medium Voltage

Voltage classes from 1,001 V to 69,000 V. Refer to ANSI Std. C84.1, Voltage Rating for Electrical Power Systems and Equipment (60 Hz).

N

Non-Combustible

A material which, in the form in which it is used and under conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat.

Non-Essential Bus

The electrical buses (switchgear and/or switchboards) which supply nonessential loads and may feed the commercial side of the essential buses. Also may be called main bus.

Non-Essential Loads

Electrical loads which, because of their lack of criticality, do not require a stand-by AC plant power supply.

P

Power Transformer

Transformers with their primary windings connected to the electric utility system or to the on-site distribution system at a voltage of 2,400 V or higher. These transformers may be liquid-filled or dry-type and indoor or outdoor construction. They customarily supply power to the facilities electrical system or specific loads.

Primary Distribution Feeder

The cable between the utility substation or point of supply and the primary distribution transformer.

Primary Distribution Transformer

The power transformer that steps voltage down from primary feeder voltage to AT&T utilization voltage.

Protected Loads

Special loads which cannot be interrupted during a commercial power failure or during testing. These loads are fed from an Uninterruptible Power System or an inverter system.

R

Redundant Equipment

Equipment that duplicates the essential function of another item of equipment so that either may perform the required function.

S

Service Entrance Conductors

The supply conductors that extend from the primary distribution transformer to the service equipment of the building supplied.

Service Equipment

The necessary equipment, usually consisting of a circuit breaker or switch and fuses and their accessories, located near the point of entrance of supply conductors to a building. This equipment constitutes the main control and means of cutoff of the commercial AC supply.

Stand-by AC Plant

A generator set driven by a prime mover, either a diesel engine or a combustion gas turbine.

T

Telecommunication Equipment

That equipment required to provide telephone services.

Telecommunication Network

The name given to the telephone equipment and supporting systems.

U

Uninterruptible Power Source

A source of power which is continuous, supplied from a battery backup and not appreciably affected by electrical distribution system perturbations.

Utility Distribution Substation

The utility facility, external to the telecommunications building, which supplies power to the primary distribution transformer at the primary feeder voltage. The primary distribution transformers and equipment may also be referred to as a distribution substation by the utility.