DENVER INTERNATIONAL AIRPORT

DESIGN STANDARDS MANUAL

Communication & Electronic Systems

Design, Engineering and Construction

Revised: Q4 2023

Included Technical Specification Requirements	Manual
Division 02: Existing Conditions	Architecture
Division 03: Concrete	Civil
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Summary of Revisions

The following tables list the revisions made to the Communications and Electronic Systems DSM.

2023 Revisions

Fourth Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes.
13.2.1 General Network Requirements	Updated information

Second Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes.
13.2.1 General Network Requirements	Added HVAC Control Network requirements.
13.4.2 Metasys UI Graphics	Revised graphic development information.

2022 Revisions

Fourth Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes.
1.1.12 Conduit/Cable Tray Riser Diagrams	Revised degree of bend between pull locations for communications dedicated conduit. Clarified documentation requirements for cable tray and conduit systems.
1.1.17 Drawing Delineation Types	Added security system and data outlets drawing delineation types.
2.1.1 Telecommunications Outlet	Clarified location of the telecommunications cable tray design requirements. Removed incorrect conduit size reference.
3.1.2.2 Emergency Communications System	Clarified ECS purpose at DEN and ECS speaker installation requirements.
3.2.4.1 Elevator Telephones	Clarified responsible installer.

Fourth Quarter

Reference	Revision Description
3.2.4.5 Emergency Telephones (Two-Way Communication)	Revised the section to include the new part numbers, installation options, and signage requirements.
3.2.4.7 Nursing Mother Room Telephones	This section was removed.
5.0.2 Criteria	Revised language concerning television drops.
6.0.1.2 Secured Area	Fixed incorrect area reference.
6.0.5.2 Security Doorframe Details	Added clarification on rough-in details and SSI information.
6.0.5.5 External Systems Interconnecting Conduits	Clarified responsibilities for designer and commissioning agent.
7.0 System Overview	Removed references to coax cable and analog systems. Clarified designer's responsibilities. Clarified requirements for CAT6A cables feeding camera sites. Added Field of Views test requirement to the CCTV/VMS system test.

Second Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes
1.0.1 Systems Information and Requirements	Revised description
1.1 Drawing Requirements	Revised description
1.1.7 Floor, Roof, and Reflected Ceiling Plans	Revised title to include roof
1.1.8 Equipment Room Layouts and Elevations (Den and Tenant)	New table added for reference
3.2.4.4 Blue Light Telephones	Revised description
5.1.3 Tenant Drops	Revised description
10.0 System Review	Revised description
11.3.12.1.4 and 5 GHz Unlicensed Band Channel Plan	Revised description
12.1 Requirements	Revised description
Table 13-1: EMCS Definitions	Added DDC definition
13.2.1 General Network Requirements	New section
Table 13-4: Metering EMCS Integration Points	Added new column for Point Name

Second Quarter (Continued)

Reference	Revision Description
13.4.2 Metasys UI Graphics	New section
Section 283111: Digital, Addressable Fire Alarm System	New section in Part 3 for definitions of NFPA 72 17.7 TRADE CLEANUP

Revision Notation: Revisions made to this Manual during this revision cycle are annotated as shown in the example below:

A vertical line in the left-hand margin is used to annotate paragraphs that have been added or revised in the current publication. Revisions may include items such as new requirements, clarification of existing requirements, or removal of requirements that no longer apply to projects. Revision annotation is applied to each publication individually; revisions made in past publications are not annotated in subsequent publications.

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Purpose of Design Standards Manuals

The DEN Design Standards have been developed to ensure a unified and consistent approach to the thematic and technical design for DEN. These standards are for use and strict implementation by all consultants under contract to DEN, to tenants, and all other consultants under contract to any other entity for the design of projects at DEN.

The Standards Manuals are working documents, which will be revised and updated, as required, to address the general, conceptual, design, and technical standards for all areas of design for DEN.

This Design Standards Manuals (DSM) for DEN has been prepared for use by competent, professionally licensed architectural and engineering consultants under the direction of DEN Maintenance and Engineering or tenants of DEN.

The Design Standards shall not be quoted, copied, or referenced in any bidding or construction contract documents. Content contained in this Manual shall not be copied in any bidding or construction documents, except where specifically instructed to do so. All information contained in these standards must be fully explained and shown in all bidding and contract documents.

The Design Standards Manuals are intended to be used as a whole, as each manual is complimentary to the other DSMs. To understand the overall thematic and design standards for DEN, the applicable manuals must be utilized together and not separated from the Design Standards Manuals.

The Consultant shall not reproduce, duplicate in any manner, transmit to other consultants or other entities, or use in conjunction with other projects without the express written consent of DEN.

NOTE: This document is optimized for duplex (double-sided) printing.

VARIANCE FROM DEN DESIGN STANDARDS MANUALS

Requests for non-conformance or variance from DEN Design Standards manuals, for any DEN or Tenant Projects, must be formally submitted using the online DSM Variance Request form at the following website:

DEN DSM Variance Request Form

Variance requests may or may not be approved by DEN and response will be communicated to the requestor.

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Chapter 1 - General System Information

1.0 Communication and Electronic System Information

1.0.1 Systems Information and Requirements

This chapter provides engineers and designers performing design work for DEN with systems overviews, configurations, and specific design requirements. Communications and Electronic Systems addressed in this Design Standards Manual include:

A. Premise Wiring Communication System (PWCS)
B. Telecommunication, Local Area networks (LAN), and Networking Systems
C. Time Synchronization
D. DEN Television
E. Physical Access Control System (PACS)
F. Closed Circuit Television System (CCTV) / Video Management System (VMS)
G. Voice Paging System (VPS) - ECS
H. Parking/Ground Transportation Revenue Control System (PGTS)
I. Flight and Baggage Information Display System (FIDS/BIDS/MUFIDS)
J. Radio Frequency (RF) Systems
K. Public Safety Distributed Antenna System
L. Energy Management and Control Systems
M. Multilateration (MLAT)
N. 2-Way Communications
O. Wireless Local Area Networks (WLAN) and Wi-Fi
P. Wireless Communication Systems

1.1 Drawing Requirements

1.1.1 Drawings

The communications and electronic systems described in this chapter shall be designed and drawings shall be prepared as applicable, based upon the characteristics, and complexity of the projects involved and as determined by each system narrative contained in these design standards. Drawings shall be provided when essential in the planning, procurement, construction, evaluation, recording, and use of the projects. All drawings shall indicate the complete design.

1.1.2 Definition

Facility communications and electronic systems drawings are graphic representations of the facility's design requirements.

1.1.3 Completeness

Facility communications and electronic systems drawings, when interpreted in association with the construction specifications, shall:

A. Furnish sufficient information for the contractor to facilitate permit drawings installation of manufactured equipment that satisfies the design requirements.
B. Furnish sufficient information to manufacture equipment that is of special design, made exclusively to meet the requirement of the project. Components, assemblies, and systems shall be UL listed.

C. Describe items so that they may be procured. If PMT is on the project, PMT is to procure a responsibility matrix and asset schedule.
D. Furnish sufficient information to permit planning, construction, evaluation, recording, repair, and maintenance of facilities.

1.1.4 Drawing Sequence

Construction documents are divided into specific groups per NCS. The group number shall always remain the same, no matter how large the project is. Refer to the DFI DSM.

Numbered sheets for areas for plan views shall remain consistent across disciplines. For example, sheets A2.01, S2.01, M2.01, P2.01, F2.01, E2.01, and T2.01 shall all show work in the same area.

1.1.5 General Notes, Drawing Index, Symbols, and Abbreviations

These sheets shall contain Notes that are applicable (or general) to all sheets in the set of drawings and, in addition, contain the drawing symbology as required in 1.1.14 Communications and Electronic Systems. These sheets shall also contain a complete drawing index for the document set.

1.1.6 Site Plan

The site plan shall identify, where applicable, all site facilities required in support of the specified communications and electronic systems, including conduits and their interconnection to existing conduits (duct banks), resources, and cabling systems. In addition, the site plan shall indicate all existing utilities and all communications and electronic systems devices and conduits that are located external to the building and indicate connections (penetrations methods) to internal systems. Where applicable, external devices and equipment, e.g., towers, antennas, etc., shall be shown, including all internal and external connections. Keyed symbology shall be shown, which directs the contractor to specific installation, provisioning, and configuration details that shall be included in the detail sheets. All required connections to the grounding system shall be indicated.

1.1.7 Floor, Roof, and Reflected Ceiling Plans

Plan drawings shall be provided which indicate all communications and electronic systems devices and equipment locations and include conduit interconnection between devices. All device locations shall be coordinated with all disciplines, including architectural finishes and features. Keyed symbology shall be shown, which directs the contractor to specific installation, provisioning, and configuration details which shall be included in the detail sheets.

When more than one system is shown on a plan, each shall be made clearly discernible by the system. Conduits indicated on the plans shall either be shown as routed to their specific termination location (Equipment or Terminal cabinet) or be indicated by a schedule for the termination location. All conduits shall be coordinated with the requirements of the conduit riser diagram. Devices indicated on plans shall be coordinated with the requirements as indicated in point-to-point diagrams.

1.1.8 Equipment Room Layouts and Elevations (DEN and Tenant)

Coordinated equipment room layouts, rack elevations, and wall elevations shall be provided, which indicate the scaled layout of the equipment room and all Communications and Electronic Systems and facilities co-located within the equipment room. Equipment rooms and layouts shall provide sufficient detail that permits coordinated construction and include the following elements:

A. Interconnection between equipment
B. Conduit terminations
C. Grounding and bonding connections
D. Electrical connections, bonding bus bars, and grounding bars
E. Floor-mounted and wall-hung equipment placement, including equipment racks

F. Cable tray configurations
G. All penetration and fire sealant/safing details
H. Clearance zones for servicing equipment
I. Locations and sizing of cooling equipment required and shall be coordinated with the mechanical designer
J. Coordinate electrical requirements with the electrical designer

Where new equipment and/or facilities are specified/required for installation in an existing equipment room, layouts shall be provided that coordinate the placement of new equipment with existing equipment. The detail provided shall be as indicated above. New equipment shall be delineated by a different line type from existing equipment so that positive identification between new and existing equipment is assured.

1.1.9 Functional Block Interconnection Diagrams

A block diagram describes the concepts and/or organization of equipment or facility using rectangular blocks, representing functions or groups of functions. Interconnecting lines establish the relationships between blocks and indicate the direction of information flow. A block diagram is used to give a quick overall picture of a system and the general interrelationships between components of that system. It may be used for general arrangement studies, functional explanations, systematization of facilities, or for design discussion purposes.

1.1.9.1 Diagrams

A. A block diagram shall be presented in as simple a form as possible. Rectangular blocks shall be used to represent functional electrical systems or parts thereof and/or major elements of an electrical system or circuit. Various other symbols may be used as supplementary information to increase the utility of the diagram.
B. Identifying nomenclature shall be included within the blocks.
C. Block diagrams may be made for any level of project activity. For example, a block diagram at the highest level may be made for a complete project or any lower-order stage.
D. Related mechanical, electro-mechanical, or optional apparatus may be included on block diagrams in rectangular form.
E. Mechanical connections between such elements shall be illustrated with dashed lines connecting the applicable blocks.
F. If the form of the circuit involves multiple sources and common or similar circuits, or variations thereof, tabulations may be used.
G. If a block diagram must be divided and placed on more than one drawing, the division of the circuit should be made in a logical manner that will eliminate confusion and at a point of minimum information transfer.
H. When abbreviations or symbols are used on any drawing, provide that same drawing keynote, abbreviation, and symbol legend.

1.1.9.2 Connecting Lines

A. Lines connecting blocks shall indicate the relationships, direction of flow of the system, the sequence of operation, etc. The arrangement of lines and blocks shall show action or energy flow in functional sequence from top to bottom and/or left to right of the diagram, starting at the top left or top center and ending at the bottom right of the diagram.
B. Connection lines shall be labeled, where necessary, to make the meaning clear and unmistakable. When dashed lines are used for more than one purpose on a block diagram, these purposes shall be made clear by label, legend, or note.
C. Connecting lines shall include arrows to further define the circuit flow.

1.1.10 Point-to Point Wiring Diagrams

Point-to-point wiring diagrams describe the detailed wiring configuration and arrangement of the specific system utilizing lines connected to specific equipment terminals and equipment pieces. Point-to-point wiring diagrams indicate the required system color-coded interconnection details at the component level. Point-to-point wiring diagrams shall be required at the design level only for those electronic and communications systems where interconnection to existing equipment is required. Point-to-point shall be provided only for the specific interface location and configuration. In the cases where new systems are designed and do not require interconnection to existing systems, system concepts and intent shall be conveyed through the functional block diagram, riser diagrams, floor plans, elevations, and project specifications. When required, point-to-point wiring diagrams shall contain the following detail.

A. All wiring by type and size required between all system components
B. Indicate wire color coding
C. Indicate terminal strip numbers and positions
D. Indicate current, signal, and data flow

1.1.11 Systems Riser Diagrams

Communications and electronic systems riser diagrams indicate the distribution of major systems components, wiring systems, and their interconnection requirements. Riser diagrams shall always be provided for cabling systems and indicate the following:

A. Equipment rooms
B. Cable quantities
C. Cable types
D. Termination locations
E. Keyed reference to related details
F. In multi-floor facilities, riser diagrams shall be organized by level

For simpler designs not containing cabling distribution systems, specific riser diagram information (e.g., major component location information may be incorporated into the Functional Block Diagram).

1.1.12 Conduit/Cable Tray Riser Diagrams

Conduit riser diagrams are provided to indicate the configuration, location, quantity, and size of the conduit/cable tray infrastructure required in support of the specified communications or electronic system. In multi-level facilities, conduit riser diagrams shall be organized by level. All conduit riser diagrams shall indicate the following information:

A. Equipment rooms (or conduit termination locations)
B. Conduit quantities
C. Conduit sizes
D. Conduit identification schemes
E. Interfaces to cable trays
F. Grounding and bonding requirements
G. Cable tray systems

Conduits that are specified or scheduled for installation of fiber optic cables shall be a minimum of 1" in size and configured with appropriate bending radii and bend requirements. All conduit shall have not more than 180 degrees of bend between pull locations. All conduits and cable tray systems shall be installed in compliance with applicable codes and DEN Standards. Review sizing and bends with Project Manager at Design Development Phase.

Terminal cabinets, equipment backboards, and other conduit termination facilities and locations are considered part of an integrated conduit riser diagram and shall be shown on the conduit riser diagram. Branch conduits installed in support of devices need not be shown on the conduit riser diagram.

The conduit riser diagram shall be coordinated with the system riser diagram, such that cross-reference between systems cables and conduit/tray infrastructure are achievable. Minimum height requirements of the cable tray and conduit systems will be included in the Architectural section so the building may be built to accommodate them. All conduit and cable tray systems shall be configured and suitably sized to permit the segregation of cables by conduit/tray segment by signal level as follows:

A. Less than 10V
B. 10V - 70.7V
C. Greater than 70.7 volts
D. Telecommunications cabling (voice and data) cables shall never be mixed with dissimilar resources.

1.1.13 System Details

Systems details are provided to indicate specific installation techniques and systems configurations. System details shall be provided in support of the design and installation intent indicated on other sheets and call attention to the specific conditions and requirements necessary to ensure that the installed system configuration is compliant with the design intent and requirements. Details shall be provided for all conditions where specific direction cannot be properly conveyed or is indicated on other sheets.

1.1.14 Communications and Electronic Systems

Communications and Electronic Systems and electronic symbols, when used, shall be in accordance with ANSI standards in accordance with this section. Other symbols, if devised by the consultant, shall be shown in the **ITEM** column and explained in the **DESCRIPTION** column of the **LEGEND** with an indication **FOR THIS PROJECT ONLY**.

1.1.15 Symbols for Other Functional Disciplines

Symbols for functional disciplines other than Communications and Electronic Systems shall be as specified in the respective sub-sections of this manual.

1.1.16 Functional Designations

Functional designations, when used, shall be in accordance with the appropriate functional designations.

1.1.17 Drawing Delineation Types

Communications and Electronic Systems drawings shall generally include the following types of delineations:

A. Block diagrams
B. One-line diagrams
C. Schematic diagrams
D. Connection diagrams
E. Facility communications and electronic systems power requirements plans
F. Facility communications plans and risers
G. Facility grounding plans and risers
H. Facility security plans and risers
I. Facility lightning protection plans
J. Fire alarm plans and risers
K. Panel, circuit, security system, data outlets, and other schedules
L. Detail drawings

The number of delineation drawings for a project shall be adequate to describe the entire system, including existing system and device locations, demolition of systems, reuse of systems or devices, and new work.

1.1.18 Delineation Drawings

Subject to the Project Manager's acceptance, the drawings for projects need not contain all delineation types. For example, projects consisting only of a single building and relatively simple communications and electronic systems may not need block diagrams or single-line diagrams if the information normally found in them is effectively conveyed by other delineation types. Each delineation shall be identified by its type below the area where it is displayed, e.g., SCHEMATIC DIAGRAM. These delineations shall not be included in architectural, structural, civil, mechanical, or electrical drawings. If delineation drawings are different from those outlined herein, then the Drawing Index shall clearly show a combination of delineation.

1.1.19 Specification Relationship

Specifications that are a portion of a contract package shall include communications and electronic systems technical specifications sections. Each communication or electronic system section shall have its own General Requirements section, which is specifically tailored to the requirements of the electronic and communications system requirements. The communications and electronic systems drawings, together with the specifications, shall describe specifically and adequately all the communications and electronic systems design requirements of the project. Vendor information drawings may be included as reference drawings subject to written approval from the manufacturer. Communications and electronic systems drawings that may form a part of a purchase specification drawing may be included as reference drawings. Prior written acceptance is required for any design-build component.

Communication and Electronic System Designers shall contact individual DEN Subject Matter Experts prior to final designs to make sure all manufactures and latest model numbers and part numbers are used for the given system and to confer that the individual division specifications are up to date or tailored correctly to meet the project needs along with DEN standards. This includes designs for systems called out in this DSM as well as those systems that are not covered herein.

Design/build efforts should also discuss with the DEN Project Manager and DEN Subject Matter Experts in regard to a sparing plan for a new or expanded system that is installed in the scope of the project. In general, design/build projects, unless specified differently in the associated Division Specification, should plan on providing a 10% level (or as directed by the DEN Project Manager) of equipment components on all communications and electronic systems installed in the project. A sparing plan shall exist for Division Specifications that do not make mention of a sparing plan requirement. In addition, warranty transfer should occur from the design/build entity to DEN at the end of the project (if required).

This Design Standards Manual will be the governing and order of precedent document where discrepancies exist between the relevant Division Specification and this DSM. Designers are encouraged to identify and resolve any discovered discrepancies with the DEN Project Manager, with input from the DEN Subject Matter Experts, as they undertake their design efforts on a given project.

End of Chapter

Chapter 2 - Premise Wire and Communications

2.0 System Overview

2.0.1 Description

The Premise Wire and Communications System (PWCS) at DEN is a universal structured wiring system consisting of multiple cable types that are service location oriented and transmission electronics, including Optical and 802.3 compliant networks. For new or remodeled installations, the PWCS predominantly utilizes Category 6 and Category 6A Unshielded Twisted Pair (UTP), Category 6 Shielded Twisted Pairs (STP), single and multimode fiber optic strands, composite Category 6 STP/UTP copper and fiber optic cable construction types, and coaxial cable for broadband video applications. Services that cannot be extended on the copper facility may be injected into the DEN Optical transport solution for delivery over fiber-based solutions between endpoints.

All cables are extended to their end locations via conduit and/or cable trays. All structured wiring system cables are terminated on universal wall plates (Panduit) that support modular connectivity of all cable types identified above.

All cabling additions (provisioning, configuration, and installation) to the existing infrastructure to satisfy local, site, and inter-building connectivity requirements must be performed by the DEN PWCS Technicians or their Inside/ Outside Plant Maintenance contractor. A tenant requiring cable installation is directed to contact the DEN Service Desk to order services for any cabling needs outside of their leasehold space.

Tenants are not permitted to install their own copper or fiber cabling between leasehold locations or utilize DEN-managed PWCS pathways for their own cabling. Tenants should coordinate copper and fiber cabling requirements for their leasehold space and connectivity between spaces with DEN Business Technologies at the time of design and throughout the term of their contract. Only DEN PWCS copper and fiber cabling is allowed to be installed in DEN pathways and spaces. Airlines that require their own Communications Room shall utilize a unique pathway when traversing other leasehold spaces and pass horizontal cabling through the DEN communications room such that horizontal cabling could be re-terminated in the DEN communications room if the space is reconfigured for different tenants.

2.0.2 Addition of Telecommunications Facilities

When a consultant's scope requires the addition of telecommunications outlets as part of a design, the consultant's scope shall include the following elements.

A. Location and specification of the outlet locations and quantities.
B. Specification of conduit and outlet box size with pull string.
C. Extension of outlet conduit to the nearest communications room or cable tray providing access to the nearest communications room.
   NOTE: This room may vary depending on the available resources within the nearest communications room. The consultant is required to coordinate with DEN Planning and Development to establish the proper conduit termination location.
D. Proper sealing of all openings (penetrations) created or resulting from the installation of telecommunications conduits.
E. Use of approved products as reviewed by subject matter expert prior to design completion.

2.1 Conduit Requirements

The following text includes the minimum requirements for conduit sizing and configuration to be utilized in the installation of telecommunications facilities.

2.1.1 Telecommunications Outlet

A telecommunications outlet is defined as a voice, data, fiber, or television outlet. The telecommunications outlet is wall mounted, typically at the same height as an electrical outlet, and serves desktop devices.

A. Conduit size: 1" minimum
B. Outlet box size: 4-11/16" x 2-1/2" deep equipped with a 2-gang device ring. This conduit shall be extended to the nearest telecommunications cable tray. Where a tray is not present, the addition of a tray shall be required, or an extension of the conduit to the nearest Intermediate Distribution Frame (IDF) (Communications Room).
C. Junction boxes in a conduit run shall be a minimum of 6" square.
D. Looping between telecommunications outlets shall not be permitted.
E. Gathering of telecommunications conduits to an intermediate (Large) box and extending a single larger conduit to the nearest communications room shall not be permitted unless submitted to and approved by DEN telecommunications.
F. When a conduit is extended to an existing cable tray, it shall be secured (clamped) and properly bonded (grounded) to the tray system.
G. All conduit ends shall be equipped with a plastic bushing.
H. Where a new cable tray is specified in a consultant's design, its type, size, and configuration shall comply with the requirements as indicated in the electrical specification telecommunications subsection for cable trays.
I. The DEN cable tray system, which is utilized for telecommunications, is subdivided into segments, where services are subdivided by service type and signal level. In those cases where telecommunications facilities include a cable tray segment between the outlet and the serving telecommunications room, the consultant shall be mindful of and coordinate the conduit termination requirements into the proper cable tray segment to ensure code, signal level, and service type compliance.
J. Installation of a conduit to the cable tray system shall be made so as not to interfere with the future installation of cabling systems.
K. All conduit installation shall comply with applicable requirements in this and other Manuals, as well as the National Electric Code (NEC) for the number of bends (in degrees) between pull boxes and distances between pull boxes.
L. Telecommunications conduits may contain fiber optic cable; therefore, the specified bending radius of a telecommunications conduit shall be 2" ID minimum.
M. Any deviation from these requirements is not acceptable without the written approval of the DEN telecommunication department.

2.1.2 Telecommunications Outlet – Wall-Mounted Telephones

A. Wall-mounted telephone outlets typically serve above-counter single-line sets and courtesy phones and serve as the rough-in for pay stations. Typical mounting height is 54" AFF. In all cases, the final height must be coordinated with the architect based on function.
B. Outlet box size: Single-gang x 1-7/8 D with a single-gang device ring. This conduit shall be extended to the nearest telecommunications cable tray. Where a tray is not present, the addition of a tray or an extension of the conduit to the nearest Intermediate Distribution Frame (IFD) (Communications Room) may be required.
C. Junction boxes in a conduit run shall be a minimum of 4" square.
D. All the requirements as indicated in items D – K above in Telecommunications Outlet shall apply to wall-mounted telephone outlets.
E. Wall-mounted telephone outlets will not receive fiber optic cable; therefore, the minimum bending radius required in item 1, l. above does not apply.

2.1.3 Modular Furniture

Because of the varying connection configurations of modular furniture and the quantities of units that may be fed from a single communications source point, a standard physical interface is not provided. The consultant, when

specifying/designing spaces that contain modular furniture, shall be required to initiate a coordination meeting with DEN Telecommunications to develop an interface that supports the connectivity requirements of the space.

2.1.4 Building Service Conduits

A. Conduit size: 4" minimum
B. Conduit quantity: The quantity is dependent on the size and functionality of the facility. The contractor shall be required to coordinate with DEN Telecommunications to establish the exact quantities of telecommunication service conduits required, including fiber and copper facilities.
C. Bending radius
D. Pull boxes
E. Distance between pull boxes
F. Burial depth

2.1.5 Duct Bank Systems

A. Conduit size: 4" minimum
B. Conduit quantity: The quantity is dependent on the size and functionality of the facility. The contractor shall be required to coordinate with DEN Telecommunications to establish the exact quantities of telecommunication service conduits required, including fiber and copper facilities.
C. Burial Depth
D. Marker tape
E. Ground
F. Conduit bending radius

2.1.6 System Color Coding

ECS conduits installed to serve systems specified in Section 275123, “Emergency Communications System,” shall have “GREEN” bands, 5' on centers for the entire length of a conduit run. All junction or pull boxes shall have the cover painted green with the associated zone number written neatly on the box cover with a permanent marker.

EMCS conduits serving temperature control, metering data cabling, lighting control BACnet cabling, and other EMCS integration cabling systems shall have “BROWN” bands, 5' on centers for the entire length. All junction or pull boxes shall have the cover painted brown.

2.2 As-builts

As-built documentation for all systems: All as-built documentation shall comply with the requirements identified in DFI DSM.

End of Chapter

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Chapter 3 - Telecommunication and Networking

3.0 System Overview

3.0.1 Scope

This chapter provides guidance to the Design Consultant in telecommunication and network systems design for specific DEN use.

3.0.2 Criteria

General criteria are set forth below, as well as drawing and design requirements. Options available to the Design Consultant are also indicated. In addition to the requirements set forth herein, all telecommunications designs shall meet the requirements of accepted industry standards, as well as the following reference standards:

A. IEEE
    a. C62.41: Recommended Practice on Surge Voltage in Low-Voltage AC Power Circuits
    b. 802.3: Information Technology – Local and Metropolitan Area Networks

B. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA)
    a. EIA-310-D: Cabinets, Racks, Panels, and Associated Equipment
    b. TIA/EIA-568-B: Commercial Building Telecommunications Cabling Standard

C. NFPA
    a. 70: NEC
    b. 70E: Standard for Electrical Safety in the Workplace

3.1 Networks and Services

3.1.1 Telecommunications Service

Basic telecommunications service is currently provided to the airport by the regulated provider CenturyLink. These services are delivered to the airport from multiple feeds. These services are extended over the airport Premise Wiring and Communications System (PWCS) to demarcations at airport locations and tenant leasehold spaces throughout the airport. These services range from basic 1FB business lines, frame relay, and data circuits to higher capacity DS-1 (T1) – DS-3 level services.

3.1.2 Local Area Networks

DEN operates three Local Area Networks (LANs).

3.1.2.1 Enterprise Network

This is the largest network, supporting services ranging from DEN-managed desktops, flight information displays, common-use departure control equipment, building automation systems, and in some cases, tenant networks. The enterprise network is a large, layer three network consisting of core switches, pairs of distribution switches in each major building, and access layer switches located in Intermediate Distribution Frame (IDF) rooms throughout DEN.

3.1.2.2 Emergency Communications System

The Emergency Communications System (ECS) is a standalone network that supports PA communications and audible emergency notification. It utilizes switches in a three-layer configuration (core, distribution, and access) that allows public address CobraNet audio to traverse locally in each network region while allowing client-server and audio communications to traverse between buildings to reach the system servers. The ECS network utilizes Realtime Transport Protocol (RTP) to allow inter-building audio to traverse between buildings, including the Hotel and Transit Center (HTC), Main Terminal, Airport Office Building (AOB), and Concourses.

The ECS loudspeakers serve as the audible portion of the Fire and Emergency Notification System. These loudspeakers must be installed in all tenant spaces. Coordinate with DEN Life Safety to obtain information on the ECS system and proposal submittals for any new equipment.

3.1.2.3 Security Access Control Network

This is also a separate network. Security Access Control Network (SACN) is dedicated exclusively to security access control, including communications to door controllers, door-related intercom, and door security cameras.

3.1.3 Wireless Networking

DEN operates a wireless 802.11a/b/g/n LAN system throughout all public areas of the airport for public use. The existing network is integrated with the DEN enterprise network and consists of a distributed system of Wi-Fi controllers, access points, and antennas.

DEN does not require or prohibit tenant Wi-Fi networks. However, any proposed private Wi-Fi networks to be installed in tenant spaces are subject to the review and approval of DEN Business Technologies.

3.2 Design Criteria

3.2.1 Telecommunications Service

Telecommunications shall be provided in each facility to serve the specific communications needs of that facility. This would include the special communications needs of the building or system function as well as the needs of tenants and users of the facility and may include voice, data, and/or video communications services. Space allocations and design, mechanical and electrical services, and premises wiring system shall all meet the requirements of the telecommunications system installed. Raceways to accommodate the required premises wiring shall be installed as part of the construction of the facility and shall meet the requirements called out here-in or within other Design Standards Manuals or Division Specifications. The power requirements of the system and power requirements of all pay telephone credit card readers shall be coordinated with the telephone supplier.

The DEN-managed PABX system provides telephony services to DEN offices and facilities across the entire DEN campus. It can provide both analog and Voice over IP service to endpoints. In addition, some tenants are served telephony service from this system under the DEN Business Technologies Tenant Services program.

Airlines and other tenants may elect to utilize a private PABX or key system to support telephone service within their leasehold space. Tenants with multiple leasehold spaces (such as airlines, who may have a presence at the terminal, concourses, and remote locations such as cargo) will be required to utilize PWCS circuits between these leasehold spaces.

Power requirements for all communications rooms at DEN are addressed in the Electrical DSM, Chapter 2.

3.2.2 Local Area Networks

In new construction areas, Intermediate Distribution Frame (IDF) rooms are normally constructed in directly adjacent pairs. One room is dedicated for DEN communications equipment. The second room is dedicated for tenant equipment. Horizontal cabling shall be routed through the DEN room to the tenant IDF room to allow cabling to be pulled back and re-terminated in the DEN room if the tenant vacates the tenant room.

Designers are required to meet with the DEN Business Technologies PWCS group to define copper and fiber backbone cabling requirements for any new IDF facility. DEN will provide pair and strand count information as well as tie points in the existing PWCS system for any new cabling.

3.2.3 Public Wi-Fi Network

Designers shall coordinate the specific location and configuration of Wi-Fi access points and pods with the DEN Business Technologies Wi-Fi group during the design development phase of each project. Contact the DEN Project Manager to coordinate a meeting after a preliminary layout is selected.

All public areas shall be fully covered by the public Wi-Fi network. In addition, Wi-Fi is provided on the roof or side of buildings for the working side of aircraft. Back office spaces on all building levels shall also have Wi-Fi coverage. Each access point requires two (2) CAT 6A-rated cables to be extended from the nearest DEN communications room when within a 90-meter distance. Single-mode fiber and 120VAC power shall be available at Access Point locations that are beyond a 90-meter distance from the nearest DEN communications room. External antennas may be utilized to keep the install clean aesthetically. Extensions to the existing airport public wireless LAN system shall be physically complete and fully functional. All new equipment shall fully integrate with the DEN Enterprise Network and the existing Wi-Fi controllers.

3.2.4 Telephones

Elevator telephones, courtesy telephones, garage blue light telephones, hands-free telephones at gated parking locations, and utility metering phone lines are generally connected as analog lines on the DEN-managed PABX system. Airline and tenant telephones will generally connect to the airline or tenant PABX.

3.2.4.1 Elevator Telephones

Elevator telephones at DEN are Talk-A-Phone ETP-103V OEM analog units that are installed behind the stainless control panel in each elevator cab. These telephones connect to the PABX as analog telephones on circuits that ring down when the telephone is in an off-hook condition. The telephones utilize a microphone, loudspeaker, and call-placed LED indicator. A braille placard is affixed to the control panel. Phone dialing is triggered by an auxiliary normally open contact on the alarm bell button in each car. Elevator phones are polled at least once a day using Viking PB-500 polling software. Phone connections are made at the elevator machine rooms. Installation of an elevator phone is generally performed by the DEN elevator support contractor.

3.2.4.2 Loading Bridge Telephones

Telephone cables within loading bridges shall be protected from damage. For telephone cables to run externally, Aan SO-type cord must be used between the building and rotunda/aircraft end telephone junction boxes. The cord must be a four-strand #14 wire with water-tight / strain-relief fittings on both ends as they terminate into the junction boxes. Additionally, the cable must be 600V rated and be cold, sunlight, and petroleum resistant. The intent is to minimize telephone cable failures and let it share a common path with adjacent power cables in the “pantograph” or scissor arm, which is external to the bridge.

3.2.4.3 Courtesy Telephones

Courtesy telephones used at DEN are flush mount Ceeco model SSP-361F units with a DTMF stainless steel dial pad and hearing aid compatible handset. All courtesy phones shall be provided with an armored cord and a white handset to align with the standard *Please pick up a white courtesy phone* announcement.

3.2.4.4 Blue Light Telephones

Blue Light telephones used at DEN are Talk-a-Phone model ETP-500 dual button, hands-free phones. The red button on the phone is marked **Emergency** with an ADA-compliant braille label placard. This button is programmed to call the Denver Police position in the airport communications center. The black button on the phones is marked **Info** with an ADA-compliant braille placard. This button is programmed to call the parking operator operations office. Phones connect to a standard analog PABX circuit. These telephones are polled at least once per day with DEN’s existing polling software.

Blue Light phones are located adjacent to each stairwell. On lower levels of the garage, Blue Light phones are installed in a Talk-a-Phone ETP-WM wall-mount blue light enclosure. On the upper level of the garage, phones are mounted in a Talk-a-Phone ETP-MTE-72 tower enclosure. All phones will require both a telephone line connection and 120VAC power to power the blue light and strobe.

3.2.4.5 Emergency Telephones (Two-Way Communication)

Area of Refuge Telephones, or elevator vestibule telephones, where required by code, shall be Talk-a-Phone ETP-500 units with either a flush or surface-mounted MS-500 backbox. These phones shall be mounted with the top of the push-button at 48 inches above the finished floor, and the phone cord length should be at least 39 inches. Appropriate ADA-compliant and Denver Building Code Amendment signage shall be installed where applicable. These units connect to the DEN PABX as analog telephones and are programmed in the PABX for ring-down operation. These telephones are polled at least once per day with DEN's existing polling software.

3.2.4.6 Parking AVI Hands-Free Telephones

Hands-free telephones at gated parking and employee parking locations shall be Gaitronics model 393-001AD units. These telephones connect to the DEN PABX as analog stations and are programmed in the PABX to ring down to the parking operations office.

3.3 Design Requirements

3.3.1 Design Development Coordination

NOTE: All communications with DEN personnel shall be routed via the DEN Project Manager unless the Project Manager gives explicit permission to do otherwise.

During design development, consultants shall coordinate their designs with DEN Business Technologies.

Designers are required to produce a spreadsheet for each of the three networks that include the following information for each item of network-connected equipment:

A. Item number
B. System name
C. Device type
D. Device name, adhering to DEN Business Technologies naming standard
E. Room number
F. Outlet and jack number
G. Serving IDF room
H. Network (Enterprise, ECS, or SACN)
I. Power over Ethernet required in Watts

After the information above is compiled, designers are required to meet with the DEN Business Technologies network staff. The DEN staff will compile a detailed bill of materials (BOM) for inclusion in the project specifications based on the equipment that is currently being procured. Designers shall include this bill of material in the network specifications for each of the three networks.

DEN Business Technologies will also complete the network spreadsheet for each of the three networks, including the following for each item of network-connected equipment:

A. Circuit ID number
B. Switch name, adhering to DEN Business Technologies naming standard
C. Switch port assignment
D. VLAN ID
E. IP address
F. Subnet mask
G. Default gateway
H. Port speed and duplex
I. Circuit cut sheet

With this information, the Designer may then produce a completed BOM for the project to be included in the design drawings.

3.3.2 Design Analysis Report

The Design Consultant shall include in the design analysis report a high-level description of the network design, including the following:

A. A single-line diagram showing the proposed network topology, including points of connection to the existing networks.
B. A listing of existing networks affected by the project, as well as an analysis of the effects and required support equipment.
C. Bandwidth requirements for new equipment.

3.3.3 Design Drawings

The Design Consultant shall show all telecommunications system requirements in the contract documents. As a minimum, the drawing shall show the following:

A. A single-line diagram to depict the network switching equipment, telephone instruments, network outlets, terminal cabinets, premises wiring, and other system components.
B. Each system component shall be identified as to its type and location. Floor plan drawings shall include a unique numerical identifier adjacent to each outlet to associate drawings with PWCS equipment spreadsheets.
C. A completed, project-specific BOM, as coordinated with DEN Business Technologies.
D. Floor plan drawings shall show the location of each system component, outlet, instrument, and distribution wiring.

End of Chapter

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Chapter 4 - Time Synchronization

4.0 General Information

This chapter provides guidance to the Design Consultant in the area of master timekeeping system design. Adherence to this standard ensures that all DEN systems maintain time synchronization for the purposes of system log correlation or for the display of uniform time on systems that are public facing.

4.0.1 Criteria

A. DEN was constructed with a Simplex Time Recorder master clock system. Over the years slave clocks have subsequently been removed, due to the prevalence of time displayed on flight information monitors and passenger cell phones. Once the last of the slave clocks are removed the legacy master clock and subsequent architecture will be retired.

B. DEN operates two Stratum One GPS time servers which are both connected to the DEN networks for Network Time Protocol services. These servers synchronize time with the US GPS constellation.

C. DEN systems connecting to the DEN enterprise network, Emergency Communications System network, or Security Access Control Network shall obtain time synchronization by periodically forwarding a Network Time Protocol (NTP) request to the default gateway on their respective subnets. The networks have been configured to relay NTP requests and responses to and from the NTP servers.

D. Systems and Computers that are not network-connected may also receive time synchronization directly from the time servers. The primary and secondary time servers at DEN are equipped to provide an Inter-Range Instrumentation Group Protocol B (IRIG-B output). IRIG-B is a 1000 hertz modulated tone that can be amplified and extended to various locations in the airport over copper telephone pairs. IRIG-B interface cards are available from several manufacturers for various bus configurations and operating systems.

End of Chapter

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Chapter 5 - DEN Television

5.0 System Overview

5.0.1 Scope

This chapter provides guidance to the Design Consultant in the area of television system design for DEN.

5.0.2 Criteria

General criteria are set forth, as well as drawing and design requirements. Options available to the Design Consultant are also indicated. All communications with DEN personnel such as DEN Business Technologies shall be routed via the DEN Project Manager unless the Project Manager gives explicit permission to do otherwise.

During design development, DEN Business Technologies will provide specific guidance to designers relevant to each project. Depending on the scope of the project, designers may only be required to provide simple drop cable. On larger projects, designers shall request a coordination meeting with the DEN Project Manager, DEN Business Technologies, and relevant stakeholders to determine project requirements. Depending on the scope, designers may be required to specify new optical nodes, RF splitters, and optical dividing networks located in DEN comm rooms to provide support for DEN and tenants television drops.

Optical nodes may be required to be shunted in the event of an Emergency Communication System (ECS) announcement. Designers shall coordinate this feature with the subject matter expert of the ECS system at the time of design.

In addition to the requirements set forth herein, all television systems shall meet the requirements of accepted industry standards, as well as the following reference standards:

A. IEEE – C62.41: Recommended practice on Surge Voltage in Low-Voltage AC Power Circuits
B. TIA/EIA – EIA-310-D: Cabinets, Racks, Panels, and Associated Equipment
C. NFPA – 70: NEC

5.1 Television Service

5.1.1 Head End Service

The DEN Television System (DEN TV) utilizes a head-end system that connects the satellite signal origination, local over-the-air antenna signal, and local insertion channels to produce a composite signal which propagates throughout the campus via a fiber/coaxial hybrid transport system. The lower tier on this system contains approximately sixty (60) unencrypted, standard-definition television channels in the 54-450MHz spectrum. The upper tier on the system (from approximately 450-860MHz) contains encrypted Dish Network standard definition, high definition, and premium content that can only be viewed by tenants using Dish Network receivers.

5.1.2 Network Topology

Upper and lower-tier channels are combined into a single RF stream and fed to a Harmonic HLT optical transmitter. The transmitter provides two 1550nm optical outputs at +10.5dBm, which, in turn, feed two Harmonic HOA series Erbium Doped Fiber Amplifiers (EDFAs). Each EDFA provides eight optical outputs at +21dBm.

Outputs from the EDFA amplifiers are fed via single-strand, single-mode APC terminated fiber circuits to 1 x 16 optical dividing networks at the following locations:

A. Terminal East (1)
B. Terminal West (1)
C. Concourse A (1)
D. Concourse B (2)

E. Concourse C (1)
F. North Terminal/AOB (1)
G. North Hut (1)
H. South Hut (1)
I. Southeast Hut (1)
J. Miscellaneous Site (1)

Outputs from the dividing networks are patched over single-strand, single-mode APC terminated fiber circuits to ATX model QFHPN-D44 optical nodes located in various DEN IDF rooms throughout the buildings and campus. Optical inputs at the nodes are padded with SC/APC inline optical attenuators to a level of 0dBm. There is an LED bar graph on the face of each node that displays a green bar when a level of 0dBm is achieved, with red bars above and below 0dBm.

Gain and slope controls on each node are adjusted to provide a sloped RF output of +37dBmV at 54MHz and +45dBmV at 860MHz. This output shall be run through an 8dB RF pad into a 16-way splitter. At IDF rooms that support more than sixteen drops, the pad shall be removed and replaced with a four-way splitter (also 8dB loss) which in turn shall connect to up to four 16-way splitters.

The calculated output from the 16-way splitters is +13.5dBmV at 54MHz and +20.5dBmV at 860MHz. This allows for acceptable signal strength at television receivers while accounting for overall distance and losses in either RG-6 quad-shielded drops or RG-11 quad-shielded drops. Unused splitter outputs shall be equipped with Regal tamper-resistant 75-ohm terminators to guard against pirated drops.

The QFHPN-D44 optical nodes are bi-directional with a reverse path optical transmitter. However, reverse path transmission is not currently in use at DEN.

ATX QFHPN-D44 optical nodes that feed public spaces must be shunted to remove distraction from television service to occupants in an emergency initiated by the fire alarm system. Typically, this is performed through a shunting power module and interface to the Simplex Fire Alarm System.

5.1.3 Tenant Drops

Subscription-based television service is available to all tenants. Tenant locations include, but are not limited to, the following:

A. Bars and restaurants
B. Retail establishments
C. Any non-public tenant-leased locations
D. Airline-leased spaces such as break rooms and offices

Drops to all tenants shall be equipped with 450MHz high-pass filters at the DEN IDF rooms to block the unencrypted lower-tier service. The standard receiver required to view Dish Network content is the VIP222k or the Wally. Coordinate exact equipment requirements with DEN Business Technologies. (Dish Network may change the receiver model at any time.)

Termination locations and details of tenant drops are dependent on the number of drops required and facilities available in the area. For multiple drops, such as in bars and restaurants, additional equipment required to support the drops shall be included in the project. Coordinate the exact requirements for each project with the DEN Project Manager. Tenants are not allowed to insert splitters into the drops provided by the transport system. Drops are to be installed by a DEN PWCS-approved contractor.

Tenants may utilize mounts for their television receivers that accommodate a Dish VIP222k or Wally receiver behind each television receiver, or they may elect to centralize these receivers at a back-of-house location. In the latter case, HDMI video extenders will be required from the centralized receivers to the television receivers. The Dish VIP 222k receivers operate with either an infrared remote control or a UHF RF control, allowing remotes to be used with centralized receiver configurations.

5.1.4 DEN and Public Drops

Non-tenant drops include the following:

A. DEN offices
B. DEN break rooms
C. Non-public, DEN-owned locations
D. Hold room televisions (transport only - tuned to Airport Revenue concession channel – e.g., CNN Airport)

Non-tenant television drops are not provided with high pass filters, allowing the unencrypted lower-tier channels to be viewed. Non-tenant drops shall be run to the nearest DEN IDF room. During design development, designers shall coordinate with DEN Technologies to ensure that the serving IDF room is equipped with an optical node and adequate splitter ports to support the required number of DEN TV drops. These drops will not be provided with high pass filters allowing viewing of both unencrypted standard definition channels and over-the-air high definition channels.

5.2 Design Criteria

5.2.1 Cabling and Conduit

All horizontal television cabling shall be contained within an accepted raceway or cable tray.

Drop cables used for DEN TV service shall be quad-shielded RG-6 or RG-11 75-ohm cables. Cables enclosed in metallic raceways shall utilize an overall PVC jacket. Cables run in cable trays shall be plenum rated.

Coaxial cable connectors shall be compression-type and designed for the specific cable type being used. Crimp connectors shall not be permitted.

4-way and 16-way RF splitters shall provide a bandpass of 5-1000 MHz. Loss for four-way splitters shall not exceed 8dB, and sixteen-way splitters shall not exceed 16.5dB.

A. When a consultant’s design scope identifies a requirement for the addition of a television outlet, the consultant’s design shall include a conduit and pull string between the nearest equipment room containing a passive device and the outlets location. Wiring and outlet commissioning shall be arranged between the tenant/occupant and DEN.
B. All conduits specified for the installation of DEN TV facilities shall comply with the following requirements:
    a. Conduit size: 1" minimum
    b. Outlet box size: 4" square x 2-1/2" deep equipped with a 2-gang device ring
    c. Looping between DEN TV outlets shall not be permitted
    d. Gathering of DEN TV conduits to an intermediate (Large) box and extending a single larger conduit to the nearest communications room containing a passive device shall not be permitted.
    e. When a conduit is extended to an existing cable tray, it shall be secured (clamped) and properly bonded to the tray system.
    f. All conduit ends shall be equipped with a plastic bushing.
    g. Where a new cable tray is specified in a consultant’s design, its type, size, and configuration shall comply with the requirements as indicated in the electrical specification.
    h. Proper sealing of all openings (penetrations) created or resulting from the installation of DEN TV conduits.
    i. DEN’s cable tray system is subdivided into segments, where services are subdivided by service type and signal level. In those cases where extension DEN TV facilities include a cable tray segment between the outlet and the serving communications room, the consultant shall be mindful of and coordinate the conduit termination requirements into the proper cable tray segment to ensure code, signal level, and service type compliance.
    j. Installation of a conduit to the cable tray system shall be made so as not to interfere with the future installation of cabling systems.

5.2.2 Equipment

Where required, new optical nodes shall be ATX Networks QFHPN-D44 nodes. Optical input shall be padded with an SC/APC male-to-female optical attenuator to provide an input level of 0dBm to the node. Each node requires an ATX network #951 120VAC to 26VAC 50VA power transformer.

5.2.3 Fiber

DEN Technologies may assign the Designer ports on an existing optical dividing network. In the case of a new building with multiple nodes, the Designer may be required to provide a new Blonder Tongue model FOC116U-FA optical dividing network. These are one input/16-output dividing networks.

Fiber connectivity to new nodes will need to be coordinated with DEN Business Technologies. In the terminal, concourses, and most site locations, DEN has implemented a single-mode ring cable system where a high strand count, single-mode cable originates at one network distribution switch location and terminates at a second physically diverse distribution switch location. At each intermediate IDF location, a different 12-strand buffer is broken and terminated in each direction while other buffers express through. Strands 11 and 12 in each buffer are terminated with FC/APC connectors to support DEN TV service.

5.3 Drawing Requirements

The Design Consultant shall show all entertainment television system requirements in the contract documents. As a minimum, the drawings shall show the following:

A. A single-line diagram to depict the entertainment television system, including all optical and RF components with RF and optical level calculations. DEN Technologies will utilize this information to update the master DEN Television System diagrams.

B. Each system component shall be identified with its type and location.

C. Floor plan drawings to show the location of each system component, outlet, and the distribution raceways.

End of Chapter

Chapter 6 - Security Card Access

6.0 System Overview

6.0.1 Description

The security environment at DEN is FAA Regulation 107.14 compliant and is comprised of two (2) specific secure areas, Sterile and Secured.

6.0.1.1 Sterile Area

Sterile areas are those areas in the terminal, concourses, and other facilities where the occupants have been screened.

6.0.1.2 Secured Area

The secured area is comprised of the Airport Operating Area (AOA). Individuals with badged access to the secured area must enter or leave the AOA environment through an access control door.

Access control doors are required at all points that provide access from public or sterile locations to the AOA, regardless of building type or location.

6.0.2 Controlled Area Access

A third access control area is defined at DEN. Controlled areas are those areas where access control is required by DEN rather than by the FAA. These areas and requirements shall be defined by the Project Manager.

6.0.3 Security Card

The Security Card Physical Access Control system (PACS) at DEN interfaces two (2) external systems. These include the Closed Circuit Television System (CCTV) and an interface to an audio system that provides 2-way communications between certain door types and the DEN operation center.

6.0.4 PACS

The PACS at DEN is an airport-wide integrated system. All-access control doors and the systems-related functionality are maintained from a single system. The PACS utilizes multiple door-type configurations that require different conduit rough-in schemes and doorframe and door hardware configurations. DEN Planning and Development maintains a library of the various conduit rough-ins, doorframe types, and hardware configurations.

6.0.5 Consultant Design and Contract Document Requirements

Whenever a consultant's design scope meets the criteria for FAR 107.14, administrative requirements, or external system interface, and the addition of a security door is required, the consultant shall be required to initiate a meeting with the DEN Planning and Development Project Manager and DEN Access Services to review the specific access requirements. Design decisions with respect to access control door types, quantities, and interfaces will be made. In support of the consultants' design activities, DEN maintains a comprehensive set of as-built documentation, which upon request, will be made available to the consultant for review in the development of the design. The Design consultant shall be responsible for the coordination of, specifying, and drawing preparation of the following design elements, which will comprise a functional extension of the PACS.

6.0.5.1 Security Door Conduit Rough-In Details

The applicable details to be used shall be provided to the Design consultant once the specific details are identified. The appropriate CADD files of the details shall be given to the consultant for inclusion in the construction documents.

6.0.5.2 Security Doorframe Details

The applicable details to be used shall be provided to the Design consultant once the specific details are identified. The appropriate details shall be given to the consultant for inclusion in the construction documents. Security door rough-in details are not considered to be SSI information.

6.0.5.3 Door Hardware

The applicable hardware types and details to be used shall be provided to the Design consultant once the specific details are identified. An appropriate hardware list shall be given to the consultant for inclusion in the construction documents.

6.0.5.4 PACS Interconnecting Conduits

Conduits and raceways that tie the new access control doors or devices to the existing system shall be required. The Design consultant shall be required to conduct a building and site investigation to establish the exact inner/ inter-building and/or site conduit configuration. All conduit specifications provided by the Design consultant for PACS work shall be suitably sized for the cabling to be installed. Where the installation of fiber optic cables is indicated by DEN, the consultant's specifications shall be representative of those requirements.

6.0.5.5 External Systems Interconnecting Conduits

Where identified by DEN and tie-ins to external systems are required, the Design consultant shall be required to include in the design all necessary conduit systems and wires. These requirements shall be coordinated with the Project Manager.

All other PACS components, including electronic interfaces to external systems, wiring, and software, shall be installed by DEN Maintenance unless the Project Manager requires the consultant to design and specify this work. Verify with the Project Manager the scope requirements during the Programming Phase of Design. The design consultant shall require in the door hardware specifications that a coordinated commissioning test of all PACS doors installed as part of the work be jointly tested by the contractor supplying the door hardware system and DEN Maintenance. This will ensure proper hardware/electronic systems interface and operation. This testing shall be coordinated by the DEN Project Manager and the commissioning agent, if applicable.

End of Chapter

Chapter 7 - Closed Circuit Television/Video Management

7.0 System Overview

7.0.1 Description

The CCTV/VMS system is utilized for general surveillance throughout DEN and for PACS door monitoring. The system consists of IP-based cameras. All new installations shall be approved IP cameras as directed and reviewed by the DEN subject matter expert. New camera installations at DEN also need to be reviewed and approved by the Video Management (VMS) committee. IP cameras utilize the Enterprise Network for Ethernet transport, except Audio/Visual enclosure cameras located at some PACS doors, which utilize the Security Access Control Network for Ethernet transport. IP cameras are integrated with a Genetec Security Center Video Management system for remote viewing and archiving. A variety of camera configurations are utilized, including indoor and outdoor, fixed, pan/tilt/zoom, 180-degree, 360-degree, and remote controllable types. Designers shall coordinate specific type and model numbers with DEN Project Manager and subject matter expert as part of design efforts. Designers shall provide the initial layout per direction from the VMS Committee Design Guidelines provided by the Project Manager/SME.

7.0.2 Requirements

Quantity and general location of CCTV cameras shall be provided by the DEN Project Manager and subject matter experts on a project-by-project basis. All new camera installations shall be IP cameras from an approved manufacturer/model list. The Design consultant shall be required to review the requirements provided by the Project Manager to validate the functionality and direction provided by the Project Manager. The Design consultant shall be responsible for the design and specification of all CCTV system components, wiring systems (both fiber optic or CAT6A as applicable), and interfaces to the headend system. Each camera location shall be fed by two (2) CAT6A cables. For camera locations outside of the 90-meter range from the nearest communications room, single-mode fiber connections from the nearest communications room will be used with 120VAC power available at the camera site. All cabling shall reside in a conduit between the camera location and the nearest communications room. Final system connection and system software programming at the headend shall be completed by the DEN subject matter expert.

7.0.3 Infrastructure

DEN has in place an extensive site, intra-building, and inner-building copper and fiber optic infrastructure that is utilized in the transport of various signals (including CCTV) throughout DEN. This infrastructure is maintained by DEN Business Technologies. The consultant's design shall be coordinated with those resources and include all work required (including costs) by DEN Business Technologies to implement the transport of signals between CCTV cameras and the system headend. Network devices, digital storage, and software licensing for additional camera installations shall be assessed as part of new camera installations as part of the design effort. The project may be required to support the procurement of these items for new cameras in accordance with design specifications provided by DEN subject matter experts.

7.0.4 Installation Details and Parts

DEN maintains a library of CCTV installation details and parts lists that are utilized at DEN. The Design consultant shall be responsible for initiating a meeting with the Project Manager to obtain appropriate details to ensure that all designs provided are compliant and compatible with existing systems and components. In support of the consultant's design activities, DEN maintains a comprehensive set of as-built documentation, which upon request, will be made available to the consultant for review in the development of the design.

7.0.5 Specification

The design specifications shall require that an integrated CCTV/VMS system test be conducted by the installing contractor and the DEN subject matter experts. This test will be conducted to ensure proper operation and

approved Field of View of contractor-supplied and installed equipment and work performed by the DEN subject matter expert. Under no circumstances shall the consultant's specifications and project requirements allow the contractor to make connections to existing equipment without direct supervision by DEN subject matter experts.

End of Chapter

Chapter 8 - Voice Paging

8.0 System Overview

Refer to the Emergency Communication System chapter in the Life Safety DSM for the voice paging system description and requirements.

End of Chapter

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Chapter 9 - Parking & Ground Transportation Automatic Revenue Control

9.0 System Overview

9.0.1 Description

The Parking and Ground Transportation Automatic Revenue Control System (PGTS) consists of several individual elements, when integrated, comprise a fully functional system. The elements that make up this system include:

A. The public parking revenue control system
B. License Plate Inventory (LPI) system
C. Access control system for employee parking
D. Automatic Vehicle Identification System (AVI)

The public parking revenue control system is a distributed PC-based system. Review the requirements with the Project Manager and the DEN subject matter expert.

End of Chapter

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Chapter 10 - Flight & Baggage Information Display

10.0 System Overview

10.0.1 Description

The Flight, Baggage, and Gate Information Display System (FIDS/BIDS/GIDS), otherwise referred to as Multi-User Flight Information System (MUFIDS), at DEN, is a distributed server/client-based system that provides flight schedule and baggage location text information to video monitors throughout the terminal and concourses. The system signals are distributed throughout the facilities on the DEN PWCS and DEN Enterprise 802.3-compliant network. Signals are IP based between the system servers and the media players at the display devices. After conversion to a video format at the media player device, video cables are extended to the individual display monitors. The software supporting this system is based on the SITA-Dayton AirportVision software. Any hardware additions to the FIDS/BIDS/GIDS system shall be compliant with this software and approved by the DEN subject matter expert. Designers shall design to authorized video displays by manufacturer and model number as provided by the DEN subject matter expert. The design shall also account for required network components, PWCS cabling, Ethernet-enabled Power Distribution Units (ePDUs) at the FIDS/BIDS/GIDS location, and required power for the displays and media players. In addition, the project may need to procure software licenses as part of the project and support any required airline data integrations. Designers shall coordinate complete design with DEN subject matter experts to account for all system components and integrations and to validate all current manufacturer and model numbers as part of the design effort. Designers shall coordinate with the Project Architect for specific mounting and infrastructure requirements.

DEN has in place a service and maintenance agreement that is utilized in day-to-day system maintenance, implementation of system configuration changes, and system expansions. Therefore, when a consultant's scope includes the addition, deletion, or modification of the existing system, the consultant's scope is limited to the specification of the correct physical characteristics and facilities in support of the installation of equipment and facilities by others. The consultant shall be responsible for the correct specification and configuration of kiosks and millwork, communications conduit systems, electrical provisions, and cooling and ventilation requirements.

Because the FIDS/BIDS/GIDS system utilizes the Premise Wiring and Communications System (PWCS) and infrastructure as the transportation media for system signals, all conduit, cabling, and infrastructure components specified for the FIDS/BIDS system shall be typical of those requirements identified below for the PWCS system.

The FIDS/BIDS/GIDS system is also connected to the Emergency Communication System and will display emergency messages as controlled by the Simplex Grinnell Fire Alarm system. This integration happens at the SITA-Dayton AirportVision software level via physical integrations between the two systems. Visual paging is also integrated with this system at the software head end. Only DEN subject matter experts or their approved contractors are allowed to configure the software head end to account for any new FIDS/BIDS display locations.

Although displays can display emergency messaging, they do not require UPS backup.

End of Chapter

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Chapter 11 - Radio Frequency

11.0 General

These technical RF standards, as may be amended from time to time by the Manager of Aviation, are intended to apply to all cases where transmission of signals of any type are contemplated by a user. DEN reserves the right to review any and all proposed technologies and to reject any or all proposed installations if, in its own judgment, a proposed user's use or activity would limit, restrict, interfere with, prevent, or otherwise damage any present or proposed telecommunications use by DEN, other tenants' or users.

There is no intent whatsoever to limit the scope of application of these standards to radio technologies presently known or available. These standards are intended to include the entire electromagnetic radiation spectrum. Technologies not contemplated at the date of this instrument and including non-RF bands (e.g., lightwave, infra-red, laser, etc.) are all subject to DEN's approval and must be demonstrated to be free of all harmful interference and to pose no threat to people, or equipment or activities of DEN and its other users. DEN may, at its discretion, require testing of the user's equipment to determine compliance with these standards or to determine a source of interference.

11.0.1 RF Definitions

Table 11-1: RF Definitions

Term	Definition
Radio Interference	Any emission, radiation, or induction that endangers the function, degrades, obstructs, or repeatedly interrupts the telecommunications of Airport Operations, Public Safety, Federal Aviation Administration (FAA), Airline, or other users and users of RF communications. All wireless systems must operate in a shared environment with regard to the needs of other DEN communications and wireless operators.
Harmful Radio Interference	Interference causes circuit outages and/or message losses, as opposed to interference that is merely a nuisance or annoyance that can be overcome by appropriate measures. In order for radio interference to be considered harmful interference, it must degrade the performance of a communications system or other passive or active electronic systems.
Effective Radiated Power (ERP)	Antenna input power (in decibels referenced to a milliwatt (dBm) plus the gain of the transmitting antenna in decibels (dB) relative to a dipole (dBd).
User	Any tenant, person, or organization operating a wireless device(s) at DEN is a user. This includes all licensed or unlicensed frequency bands.
Unlicensed Devices	Unlicensed transmitters are typically low-power transmitters and are regulated by the Federal Communications Commission (FCC) Code of Federal Regulations 47 CFR §15. Unlicensed transmitters include but are not limited to; wireless headsets, WiFi access points, Family Radio Service (FRS) radios, low power broadcast, and Bluetooth devices. DEN reserves the right to restrict the use of these devices in all tenant agreements under section 40.20-2 -- Radio/Wireless Communications Systems of Rules and Regulations for The Management, Operation, Control, and Use of The Denver Municipal Airport System.

11.0.2 Transmitter Power Limit

11.0.2.1 Personnel Exposure

RF Transmitters shall NOT be allowed to exceed the maximum level for public exposure to non-ionizing RF radiation for any continuous interval, as set by the FCC's Office of Engineering and Technology, without specific prior written approval by the DEN Business Technologies Division and properly installed signs. See 11.5 RF Safety for proper signage and guidelines.

11.0.2.2 Aircraft Operation Area (AOA)

RF Transmitters are limited to 25 watts ERP without specific prior written approval by the DEN Business Technologies Division (special antenna or filtering may be required).

11.0.2.3 Indoors

RF Transmitters are limited to 5 watts ERP. Mobile radios used with a power supply for indoor operation must be limited to 5 watts or have an attenuator installed to effectively limit ERP to 5 watts.

11.1 Adding New and Modifying Existing RF Systems

11.1.1 Application for Proposed Wireless Systems at DEN

Users who propose to add channels to an existing radio system, change the configuration of an existing radio system, or construct new radio systems at DEN must submit a RF Application to the DEN Technologies Division – RF Systems Manager and receive written approval from the Business Technologies Division RF Manager before proceeding. Applications may be obtained from the DEN Business Technologies Division upon request. Such applications shall be reviewed, and a written response shall be given no later than thirty (30) business days from the date plans and specifications are submitted. If the applicant does not receive a written response within the time period set forth herein, such application is deemed denied. The RF Application shall, at a minimum, shall meet the requirements detailed in the following paragraphs:

Frequency Band and Specific Frequencies

The specific frequency band or bands within which the system will operate, as well as all the specific transmit and receive frequencies to be used.

11.1.1.1 Power

The actual transmitter output power, antenna gain, and ERP.

11.1.1.2 Transmission Line and Antenna Information

The specific type and length of the transmission line to be used and the specific type of connectors to be used. The transmission line can be listed as a specific manufacturer's type number or generically (e.g., 1/2-inch solid outer conductor foam dielectric line). Antenna type, manufacturer, model number, and gain relative to a dipole should be specified for both transmit and receive antennas. Directional antennas should include a diagram of the antenna's radiating pattern.

11.1.1.3 Modulation/Multiple Access Method

The specific type of modulation used in the system (e.g., AM, SSB, FM, ACSSB, CDMA, TDMA, etc.). For digital modulation techniques such as TDMA and CDMA, the channel bandwidth occupied by the system should be specified.

11.1.1.4 Coverage Requirements

Provide a general description of the area the system is designed to cover. Distinguish between systems that require wide area coverage over much of the airport and systems which require coverage only in limited areas, such as in the immediate vicinity of the Concourses or underground areas.

11.1.1.5 Underground Coverage

Specify the requirements for underground coverage so that the addition of the proposed system to the Radio Frequency Distribution System (RFDS) can be evaluated.

Other applications for existing sites where specific antenna mounting locations are available (e.g., on a tower at the antenna farm or rooftop of a building), the specific mounting location and methods shall be specified by DEN. This determination will be based on the results of the interference study performed on the proposed system per the user's RF Application. See 11.7 Antenna Plan Views, 11.8 NFPA-178 Example, and 11.9 RF Application.

FAA Form 7460 may be required by users constructing towers for antennas or other structures that infringe on the airspace regulations at DEN. It is up to the applicant to determine if an FAA Form 7460 is required and to provide a copy of the FAA Form 7460 with the RF Application.

The Business Technologies Division RF Manager and RF Engineer are the final approving authorities for all RF Applications and site approvals.

11.1.2 Modification and Existing Systems

Modifications to existing systems require an RF Application to be submitted as detailed in 11.1 Adding New and Modifying Existing RF Systems.

11.1.2.1 Modifications

Additional capacity at a proposed site is limited by potential interference considerations, physical space limitations, and/or RF radiation exposure limits. DEN reserves the right to evaluate different distributions of channel capacity among the various service providers operating at a site to ensure that physical capacity is distributed equitably.

11.1.2.2 Capacity

Limitations for each provider operating a transmitter/receiver shall be restricted by:

A. Non-Ionizing Electromagnetic Radiation limits
B. Physical space limitations for antennas or base station equipment
C. Potential for interference from additional users or from additional channels
D. Requirements for maintenance of space for future users

11.1.2.3 Previously Approved Frequencies

Previously approved frequencies can be turned on/off at any time.

11.2 RF Operational Requirements

11.2.1 Pre-Operational Standards

All users shall furnish the following to the DEN Site Project Manager prior to the installation of any equipment:

A. Executed Lease, License Agreement, Temporary Site Access Permit, or other approved permit/contract.
B. Copy of the current FCC license or pending application, and construction permit, as appropriate.
C. Accurate block diagrams showing all system interface components with (active or passive) gains and losses in dB, along with power levels.
D. Detailed construction drawings.

E. Antenna type and mounting arrangements. DEN shall coordinate the equipment location for all potential users.

An intermodulation (IM) study may be required at the discretion of the DEN Business Technologies Division's RF Engineer prior to the installation of any equipment. In such cases, the IM study shall be performed by DEN or its approved consultant. The results of the IM study shall determine whether a potential transmitter is permitted to operate on the site or whether additional interference protection devices are required. Payment of all costs associated with any IM study shall be the full responsibility of the applicant.

11.2.2 User Maintenance

User shall not make alterations, changes, or modifications to any installation in terms of the number of transmitters, type of equipment, antennas or antenna height, frequencies used, the power output of transmitters, or alter any other technical parameters without prior written approval by DEN, as detailed in 11.1 Adding New and Modifying Existing RF Systems.

User equipment approved for operation shall be properly maintained in accordance with the manufacturer's specifications to prevent it from becoming a source of interference or from becoming a safety hazard.

11.2.3 Disputes Between Users

The DEN Business Technologies Division, RF Manager, and the RF Engineer have final authority with respect to technical parameters, equipment placement, antenna location, as well as installation workmanship. Recommendations and decisions of the RF Manager and the RF Engineer shall be final and binding.

The DEN Business Technologies Division, RF Manager, and the RF Engineer shall be the final authority between users in the interpretation of these RF Technical Standards.

11.2.4 Facility Regulations

All areas in and around the user's equipment and work area shall always be kept clean and neat. Exterior areas on the Property, including roads and parking lots, shall be kept clean. User's trash and other unused materials shall be removed immediately from the property and not stored on the premises in any manner.

Tools, test equipment, and work materials shall be stored only in areas with prior approval by the DEN Business Technologies- RF Manager. It shall be the user's responsibility to secure stored materials against theft and vandalism. All stored materials other than small tools and parts are to be tagged with the owner's name.

Food and drink shall be permitted on the premises. However, all trash related to the same shall be removed. Care shall be taken not to spill or litter equipment on the premises with food or drink.

No alcoholic beverages shall be taken on the premises by the user, its agents, or employees.

Users shall not use or permit the use of the premises for lodging or sleeping.

Smoking, open flame, or welding shall not be permitted inside buildings.

Users shall not allow or authorize entry into the premises for any purpose whatsoever to any person performing maintenance work for the user without following DEN Security processes and procedures.

11.3 RF Site Technical Standards

11.3.1 Posting of Information

The following information must be posted by the user on or near equipment cabinets:

A. Copy of the current FCC station license and an Identifier Card with the following information:
    a. Name of the licensee and contact information
    b. Name and telephone number of the responsible technician or engineer
    c. FCC call sign

d. Transmit and receive frequencies
e. Authorized output power and ERP
f. Type of emission
g. Antenna type, gain, and location installed
h. Transmission line type

B. Unidentified equipment shall be considered unauthorized and may be shut- down or possibly removed from the site.

11.3.2 Changes

Changes are not permitted to any RF installation without submitting an RF Application to the DEN Business Technologies Division and receiving prior written approval by the DEN Business Technologies Division RF Manager and RF Engineer before proceeding. Unauthorized changes to frequencies, antennas, ERP, or approved configuration may be punishable as set forth in Section 7.01 (B) below.

11.3.3 Transmitters

As a minimum, each transmitter shall employ a dual-stage isolator followed by a single cavity bandpass filter. All transmitters must have external harmonic (low pass) filters. Low pass filters shall attenuate the second harmonic by at least 60 dB and the third harmonic by at least 50 dB. The following minimum specifications apply:

A. 30-76 MHz:
   a. Isolators- minimum of 60 dB
   b. TX cavity- minimum of 20 dB rejection at + 1 MHz

B. 118-174 MHz:
   a. Dual Stage Isolators- minimum of 60 dB
   b. TX cavity- minimum of 25 dB rejection at + 1 MHz

C. 406-512 MHz:
   a. Dual Stage Isolators- minimum of 60 dB
   b. TX cavity- minimum of 20 dB rejection at + 5 MHz

D. 851-940 MHz:
   a. Dual Stage Isolators- minimum of 60 dB
   b. TX cavity- minimum of 20 dB rejection at + 5 MHz

E. Cellular, PCS, and 220 MHz combiners: These systems require special consideration. Additional details and engineering specifications may be required.

Bandpass filters shall follow the isolator because ferrite isolators are nonlinear and can create harmonics. Please note that most bandpass cavity filters pass odd harmonics of the tuned frequency, so an external low pass filter is required. Transmitter combiners shall be considered on a case-by-case basis. Please submit all combiner technical information with the RF application to the DEN Business Technologies Division.

11.3.4 Additional Protective Devices

Additional protective devices may be required based upon an evaluation by the DEN Business Technologies RF Engineer. This evaluation is performed based on the following information derived from the submitted RF Application:

A. TX and RX IM products, particularly second and third-order mixes
B. Antenna location and type
C. Combiner/multicoupler configurations
D. Transmitter specifications
E. Receiver specifications
F. Historical problems

G. Transmitter-to-transmitter isolation
H. Transmitter-to-antenna isolation
I. Transmitter-to-receiver isolation
J. Calculated and measured the level of IM products
K. Transmitter output power
L. Transmit ERP
M. Spectrum analyzer measurements
N. Standing Wave Ratio (SWR) measurements
O. Existing cavity filter selectivity
P. Antenna-to-antenna proximity

11.3.5 Base Station Mobile Radio Receivers

DEN has high RF levels in all mobile radio bands. Receiver amplifiers must have good IM rejection, high compression points, and high third-order intercept. If interference is encountered and it is determined the receiver is not performing according to manufacture specifications, DEN will require receiver improvements before requesting changes to other user equipment or configurations.

Filters are required for base stations using mobile radio receivers. Single receivers must employ a minimum of a single cavity bandpass filter (use TX filter performance in 4.03 A 1 through 5 for RX filter performance). Additional filter isolation may be required in special cases. Receiver multi-couplers must use a bandpass filter prior to the multi-coupler amplifier. Duplexed systems should meet both the TX and RX filter specifications.

11.3.6 Antennas

Select antennas designed to minimize passive intermodulation generation. Unless the antenna is configured for simplex or duplex operation, transmit and receive antennas should be separated vertically on the tower or other support structure. Antenna locations shall be designated by the RF Engineer. All antennas must be DC grounded to the tower or supporting structure unless otherwise approved by the RF Engineer.

Antennas proposed for installation on DEN buildings shall provide an approved antenna mount per RF Technical Standards specifications. See 11.7 Antenna Plan Views. No ballast mount antenna or roof penetrations are permitted on the bonded membrane roofing system. If penetrations are unavoidable, penetrations shall be made by a DEN-approved roofing contractor in order to maintain the warranty on the roof.

DEN maintains a map of potential antenna locations on each major facility. Users proposing the installation of antennas and mounts shall obtain a copy of the map for the proposed facility. The user may indicate the preferred locations and submit this with the RF Application. See 11.1 Adding New and Modifying Existing RF Systems and 11.9 RF Application.

11.3.7 Transmission Lines

The coaxial cable should be grounded at the top and bottom of the cable run with an Andrew ground kit or approved equivalent. Ground conductors must run straight down with no sharp bends (bends increase the impedance of the line; low impedance is required for good lightning protection). DEN requires that the line be marked for identification purposes. Bands of colored electrical tape at the bottom, middle, and top of the run (similar to a resistor color code) are required. Installation of a coaxial surge arrestor at the bulkhead is also required. Transmit and receive lines should be separated by at least one foot from the cabinet to the antenna. All transmission lines must meet or exceed accepted industry standards.

Transmission lines must be labeled at the antenna with a stainless-steel stamped identification tag permanently affixed to the transmission line. The tag will contain the following minimum information:

A. Owner
B. Contact Number

C. Frequency or frequencies of operation
D. Date of installation
E. DEN permit number
F. FCC Call Sign (if applicable)

11.3.8 Connectors

Connectors are often sources of RF leakage and passive intermodulation. UHF connectors (PL259) are not allowed. 7/16 DIN connectors should be used at 800 MHz and above; N connectors are authorized at 800 MHz. Connectors using dissimilar metal contacts or ferrous materials (e.g., nickel plating) are not allowed. The preferred connector uses a silver-plated body with gold plated inner conductor. Any exception to the above must be approved by RF Manager or RF Engineer in writing.

11.3.9 Grounding - General

Equipment grounding and bonding shall be accomplished in accordance with National Electrical Codes, NFPA-178, and Lightning protection code. See 11.8 NFPA-178 Example Properly installed transmission line outer-conductor grounding kits and center-conductor surge- suppressors such as a polyphaser or equivalent are required at the building entry point (bulkhead). Coordinate with the DEN Site Project Manager for guidance on grounding and bonding at a particular facility. Note that DEN has specifications for grounding and bonding at the airport.

11.3.10 Shielding

RF interference can pass directly into the electronics of a receiver or transmitter. Cabinet doors and all stock RF shielding must be in place and maintained to the manufacturer's specifications. Transmitters determined to be emitting spurious emissions will be considered a violation. See 11.6.1 Compliance with DEN Technical Standards.

11.3.11 Power Limits

Cellular, ESMR, and PCS/PCN facilities operating on DEN property shall limit their ERP to 25 Watts (+ 44dBm) per RF channel at all locations, without specific prior written approval by the DEN RF Manager, except the West Antenna Farm, Old Toll Plaza Site, and Pena Blvd. sites. For wideband systems, this power limit applies to the equivalent power over the entire bandwidth occupied by the RF channel discussed in 4.11 B. below.

Due to frequency spreading with wideband systems, there is less power density in each piece of spectrum, equivalent to narrow-band analog use. For a wideband carrier bandwidth of 1.25 MHz or greater, the total channel power limit is 200 Watts (+53 dBm). These maximum ERP levels are to help reduce intermodulation and receiver desensitization in portable or mobile radios authorized for use at DEN. In some locations, additional transmitter filtering or lower power limits may be required of the user by DEN. This concept applies to broader bandwidth UMTS, LTE, and other broadband transmissions.

11.3.12 Unlicensed Devices

Unlicensed devices, as defined by FCC 47 CFR §15, shall be subject to the RF application process and all guidelines as noted above. No approved unlicensed device shall be modified to increase RF power output or modifications to the antenna radiating element. Any unlicensed device shall be maintained in good working order with no physical or electrical damage. In addition, unlicensed devices are subject to the following requirements:

A. Unintentional Transmitters: Unintentional transmitters such as personal computers or other computing devices shall be Class A devices.
B. Intentional Transmitters Broadcast Band: Intentional radiators in the broadcast band are discouraged for use on Airport property.
C. Intentional Transmitters All Other Bands: FCC Part 15, Intentional transmitters in all other bands, shall be subject to the RF application process and the requirements as noted above.

D. In-House Broadband Over Power Line: In-house broadband over a power line is not allowed in airport facilities.

11.3.12.1 2.4 and 5 GHz Unlicensed Band Channel Plan.

Wireless Fidelity (WiFi) is a growing wireless connection medium able to handle high data rates in relatively small areas, typically within a 300-foot radius. The FCC allocated two bands for this service, 2.4 GHz and 5 GHz. Because of the recent growth of devices utilizing WiFi technology, tenants are encouraged to use channel 1 in the 2.4 GHz band and channels 36, 40, 92, and 96 in the 5 GHz band. Coordinate new installations with the DEN WiFi group.

11.4 RF Installation and Construction Standards

All installations shall be completed in a professional manner by qualified technical personnel and are subject to approval by the RF Manager and the RF Engineer prior to rendering any system operational. All construction must follow practices described in the DEN Tenant Development Guidelines (TDGs) as provided by the Engineering Division and applicable standards.

11.4.1 Cabinets

A. All RF devices, including duplexers, isolators, cavities, switches, etc., shall be located inside grounded cabinets.
B. Properly shielded devices may be mounted on grounded relay racks with prior written approval by DEN.
C. All cabinets must be bonded together and to the ground system with at least #6 copper wire or 1" copper strap.
D. All doors must be on and closed.
E. All holes larger than 1" must be covered with copper screen or solid metal plates.
F. Cabinets shall be spaced with no less than three ft of front and back clearance for maintenance access.

11.4.2 Cabling

All cables exiting through a building bulkhead must use approved weatherproof seals and fasteners (NO tape). All antenna cables must be jacketed Heliax™ or equivalent. Kinked or cracked cable shall NOT be permitted and may be considered a violation.

Antenna cables must be tagged at building bulkhead entry/exit points in the same manner as at the antenna with weatherproof identification tags. See 11.6.1 Compliance with DEN Technical Standards. An additional tag is required in the equipment room if the building bulkhead entry/exit point is not in the equipment room.

Any unused cable must be terminated or removed. The unused cable includes RF cable that is no longer part of the transmitting/receiving system. Fiber optic, telephone, or network cables need not be removed.

All antenna transmission lines shall be grounded at the tower top (50 Ft. or above) and bottom and at the building entrance with approved grounding kits.

All coaxial cables shall be individually attached to the tower legs or wave-guide hangers. This location shall be assigned by DEN. Attachment of coaxial cable shall be by insulated stainless steel clamps and hangers or ultraviolet-stabilized nylon ties spaced a maximum of four (4) feet apart for both towers and rooftops.

All transmit interconnecting cables/jumpers must be a solid copper outer conductor (e.g., Superflex™ or equivalent) or double-braided silver (RG-214/U or equivalent).

All receiver cabling must be 100% shielded coaxial cable or double-shielded silver cable.

All rooftop cable must be run on the antenna mounting structure and/or cable trays.

All inside cable must be run in troughs or cable trays.

All AC line cords must be three conductor with grounding plugs.

Where no troughs or cable trays exist, all cable must be tied at least 3' intervals.

Power and phone line cables shall be protected by grommets where they enter cabinets. The cable shall not be wrapped with black tape.

Lightning protection must be provided for the antenna, power, and control lines.

The cable between an equipment cabinet and the building exit must be an uninterrupted, continuous length without splices or adapters.

11.4.2.1 Connectors

Connectors must be 50-ohm type, including chassis/bulkhead connectors. Connectors must comply with all manufacturers' instructions. Connectors must be properly fabricated (soldered if applicable) if field installed.

Connectors must be taped and coated with a sealing agent at least 4" onto the jacket if exposed to the weather.

Connectors must be pliers tight as opposed to hand-tight.

Connectors must be silver-plated or brass.

Connectors must be electrically and mechanically equivalent to OEM connectors.

11.4.3 Antennas and Mounts

No welding to any portion of the tower structures. All antenna mounts or supporting structures shall be stainless steel or hot-dipped galvanized steel. Any hot dipped galvanized pipes or brackets that have been field cut must be sprayed with a minimum of two coats of cold galvanizing paint or stainless steel paint.

All antennas should be fiberglass or ABS plastic enclosed. Exposed metal antennas shall not be permitted on the site unless treated by chromate conversion (irridite).

All antennas that become corroded or damaged must be replaced in a timely fashion.

No ballast mount antennas are permitted.

Applicant must comply with EIA-222G (or most recent revision) for a basic wind speed of 85 miles per hour dry (Uniform Building Code for Denver County) or 0.866 times 85 miles per hour with ½ inch radial solid ice (56 lbs/ cubic foot). This requirement is critical to applications at DEN antenna towers 1 through 4.

The applicant will provide the results of the study (5.04 (E) above), and will be at the applicant's expense. The study must be stamped by a licensed professional engineer in the State of Colorado. In some cases, a study may not be required if previous studies have identified antenna locations that are vacant but considered in the most recent studies as available or filled.

11.4.4 Prevention of Passive Intermodulation

To help prevent passive intermodulation, the following practices shall be followed at DEN sites:

A. 7/16 DIN connectors are required for new systems with a transmitter power of 100 watts or greater.
B. All connectors shall be non-ferrous (no nickel).
C. Do not use UHF connectors (PL259) at any frequency.
D. All coaxial cables shall be a solid shield (e.g., Heliax?, Flexwell?, or equivalent).
E. Transmission lines shall be grounded at the top and bottom of each run.
F. All bonds shall be clean, tight, free of corrosion, and have no dissimilar metals.
G. Transmit and receive lines will be physically separated.
H. Use antennas designed to prevent passive intermodulation.

11.4.5 RF Distribution System Interface

Users shall be responsible for all equipment necessary to interface with the RF Distribution System (RFDS). Input to the RFDS downlink (base-to-mobile) is a type N connection with a maximum input of +18 dBm per carrier. The output of the RFDS uplink (mobile-to-base) shall provide the base-station receiver with all in-band signals from portable and mobile radios in the distributed areas of coverage via the respective band (450, 460, 800, cellular, 900). The receive port connection is through a type N connector on the tower RFDS rack, assigned to the user by DEN upon RF Application/Installation approval.

User installations requiring RFDS connections to couple signals from antenna lines must provide adequate isolation between the RFDS and antennas. Coupling or summing devices must have 20 dB minimum port-to-port isolation.

11.5 RF Safety

11.5.1 RF Safety Standards and Guidelines

The engineering, design, configuration, installation, and maintenance of radio facilities on the site shall be accomplished in a manner that minimizes downward radiation. Changes to proposed systems may be directed by DEN to comply with this objective. The following guidelines are applicable:

A. All personnel entering the site must be authorized.
B. Obey all posted signs.
C. Assume all antennas are active unless proven otherwise.
D. Before working on an antenna, notify the owner and disable the transmitter. In collocated sites, all users and owners must be notified to disable all transmitters.
E. Use an RF personal monitor when working near antennas.
F. Never operate transmitters without shields.
G. Post a warning sign at the base of your tower. A warning sign shall contain the following information:
    - CAUTION – OVERHEAD WORK IN PROGRESS

Power densities on towers can be much higher than at ground level. For this reason, tower climbers shall request power reductions from high-power users and carry RF personal monitors when climbing towers. The Site Manager can tell you which transmitters should be turned down before climbing your tower.

Federal Government guidelines regarding environmental impacts from RF energy are found in the Code of Federal Regulations (CFR) Title 47, Parts 1.1307-1.1310.

Available sources for warning signage are TESSCO or

Radhaz

11.6 Section 7 - Compliance with RF Standards

11.6.1 Compliance with DEN Technical Standards

DEN reserves the right to inspect all systems to ensure compliance with installation and technical standards. Users must cooperate with DEN if requested to demonstrate proper operation of filters and other protective devices installed in the user's system.

A. Violation Notice:
User (system owner and/or operator) shall respond as directed to any notice by DEN that a suspected offense and violation of these RF Technical Standards herein exists. Per the revised DEN Rules and Regulations (Section 1.13.8, General Penalty), violations confirmed by DEN are subject to:

a. Possible fines (penalty) of up to $999 per day; each day an offense or violation continues shall constitute a separate offense or violation.
b. Possible revocation of any privilege shall be in addition to any penalty.
c. Possible disconnection and/or removal of systems.

B. Disconnection and/or removal of systems and/or equipment:
Any system or equipment installed or operating at DEN that does not have an approved RF Application associated on file approving the installation and operation will be considered in violation of these standards. Every attempt will be made to determine the user/owner of the system and/or equipment. If the RF Manager is unable to determine the user/owner, DEN reserves the right to disconnect and/or remove and may even dispose of the equipment at the discretion of the RF Manager.

11.7 Antenna Plan Views

For specific drawings at the desired location, contact DEN Business Technologies Division.

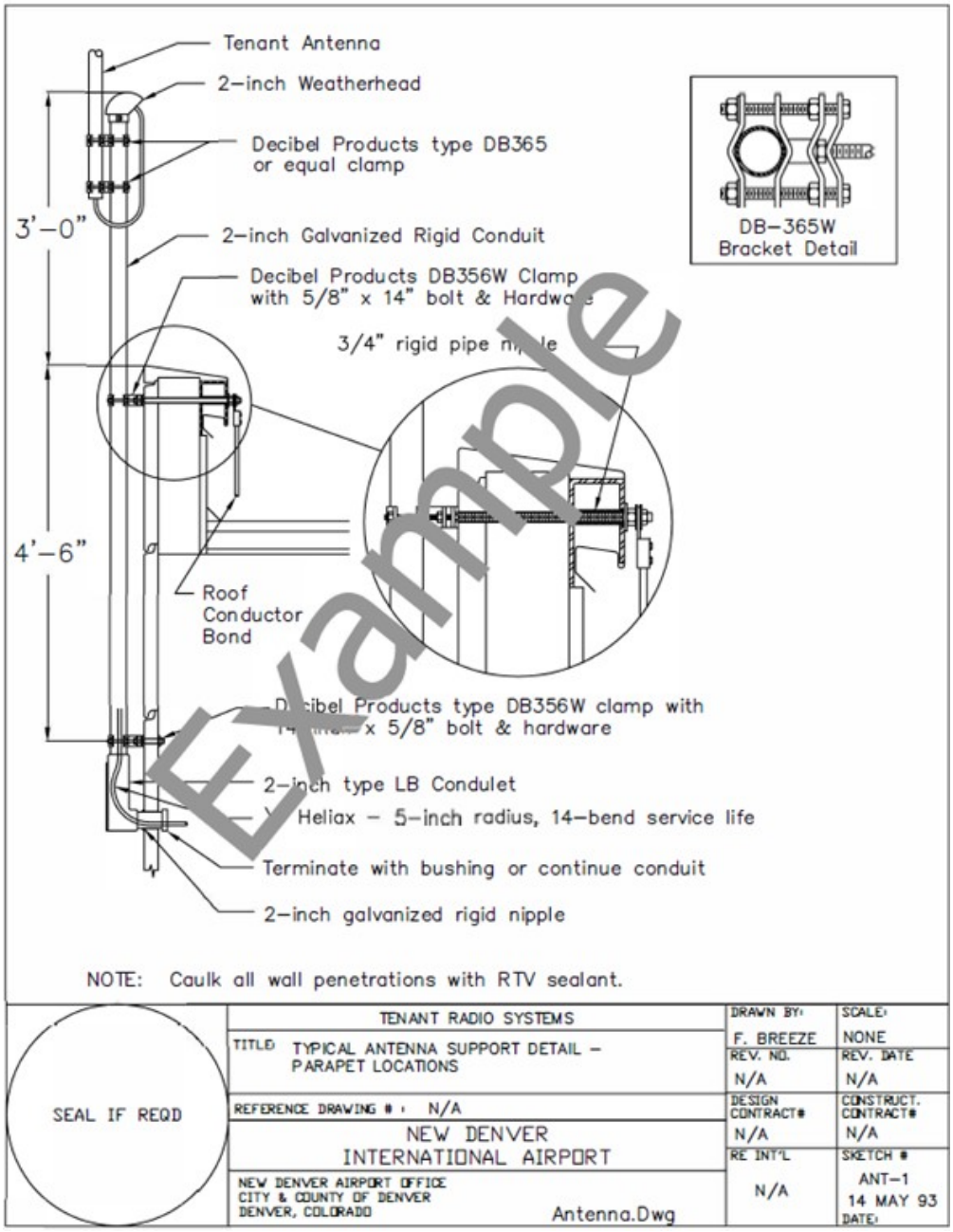

Figure 11-1: Antenna Plan View

11.8 NFPA-178 Example

An ordinary structure shall be any structure that is used for ordinary purposes, whether commercial, industrial, farm, institutional, or residential. Ordinary structures not exceeding 75 ft (23 m) in height shall be protected with Class I materials, as shown in Table 3-1.1(a). Ordinary structures greater than 75 ft (23 m) in height shall be protected with Class II materials, as shown in Table 3-1.1(b). If part of a structure is over 75 ft (23 m) in height (e.g., steeple) and the remaining portion does not exceed 75 ft (23 m) in height, the requirements for Class II air terminals and conductors shall apply only to that portion exceeding 75 ft (23 m) in height. Class II conductors from the higher portion shall be extended to the ground and shall be interconnected with the balance of the system.

Table 11-2: Minimum Class I Material Requirements

Type of Conductor		Copper		Aluminum	
		Std	Metric	Std	Metric
Air Terminal, Solid	Diameter	3/8 in	9.5 mm	1/2 in	12.7 mm
Air Terminal, Tubular	Diameter Wall thickness Size each strand	5/8 in 0.033 in 17 AWG	15.9 mm 0.8 mm	5/8 in 0/064 in 14 AWG	15.9 mm 1.6 mm
Main Conductor, Cable	Weight per length Cross Section Area	187 lb/1000 ft 57,400 CM	278 g/m 29 mm2	95 lb/1000 ft 98,600 CM	141 g/m 50 mm2
Main Conductor, Solid Strip	Thickness Width	0.051 in 1 in	1.30 mm 25.4 mm	0.064 in 1 in	1.63 mm 25.4
Bonding Conductor, Cable (solid or stranded)	Size each Strand Cross Section Area	17 AWG 26,240 CM		14 AWG 41,100 CM	
Bonding Conductor, Solid strip	Thickness Width	0.051 in 1/2 in	1.30 mm 12.7 mm	0.064 in 1/2 in	1.63 mm 12.7 mm

Table 11-3: Minimum Class II Material Requirements

Type of Conductor		Copper		Aluminum	
		Std	Metric	Std	Metric
Air Terminal, Solid	Diameter	1/2in	12.7 mm	5/8 in	15.9 mm
Main Conductor, Cable	Size each stand Wight per length Cross section area	15 AWG 375 lb/1000 ft 115,000 CM	558 g/m 58 mm2	13 AWG 190 lb / 1000 ft 192,000 CM	283 g/m 97 mm2
Bonding Conductor, Cable	Size each strand Cross section area	17 AWG 26,240 CM		14 AWG 41,100 CM	
Bonding Conductor, Cable	Thickness Width	0.051 in 1/2 in	1.30 mm 12.7 mm	0.064 in 1/2 in	1.63 mm 12.7 mm

11.8.1 Materials

Protection systems shall be made of materials that are resistant to corrosion or acceptably protected against corrosion. Combinations of materials that form electrolytic couples of such a nature that, in the presence of moisture, corrosion is accelerated shall not be used. One or more of the following materials shall be used:

11.8.1.1 Copper

Where copper is used, it shall be of the grade ordinarily required for commercial electrical work, generally designated as being of 95 percent conductivity when annealed. Copper lightning protection materials shall not be installed on aluminum roofing, siding, or other aluminum surfaces.

11.8.1.2 Copper Alloys

Where alloys of copper are used, they shall be as substantially resistant to corrosion as copper under similar conditions.

11.8.1.3 Aluminum

Where aluminum is used, care shall be taken not to use it where contact could be made with the earth, or anywhere it could rapidly deteriorate. Conductors shall be of electrical grade aluminum. Aluminum lightning protection materials shall not be installed on copper surfaces.

11.8.2 Corrosion Protection

Precautions shall be taken to provide the necessary protection against any potential deterioration of any lightning protection component due to local conditions. Copper components installed within 24 in. (600 mm) of the top of a chimney or vent emitting corrosive gases shall be protected by a hot-dipped lead coating or equivalent.

11.8.3 Mechanical Damage or Displacement

Any part of a lightning protection system that is subject to mechanical damage or displacement shall be protected with protective molding or covering. If metal pipe or tubing is used around the conductor, the conductor shall be electrically connected to the pipe or tubing at both ends.

11.8.4 Use of Aluminum

Aluminum systems shall be installed in accordance with other applicable sections and with the following:

A. Aluminum lightning protection equipment shall not be installed on copper roofing materials or other copper surfaces or where exposed to runoff from copper surfaces.
B. Aluminum materials shall not be used where they come into direct contact with the earth. Fittings used for the connection of aluminum-down conductors to copper or copper-clad grounding equipment shall be of the bimetallic type. Bimetallic connectors shall be installed not less than 18 in. (457 mm) above earth level.
C. Connectors and fittings shall be suitable for use with the conductor and the surfaces on which they are installed. Bimetallic connectors and fittings shall be used for splicing or bonding dissimilar metals.
D. An aluminum conductor shall not be attached to a surface coated with alkaline-base paint, embedded in concrete or masonry, or installed in a location subject to excessive moisture.

11.8.5 Strike Termination Devices

Strike termination devices shall be provided for all parts of a structure that are likely to be damaged by direct lightning flashes. Metal parts of a structure that are exposed to direct lightning flashes and that have a metal thickness of 3/16 in. (4.8 mm) or greater shall only require connection to the lightning protection system. Such connections shall provide a minimum of two paths to the ground. Strike termination devices shall not be required for those parts of a structure located within a zone of protection.

11.8.6 Conductor Bends

No bend of a conductor shall form an included angle of less than 90 degrees, nor shall it have a radius of bend less than 8 in. (203 mm). Refer to Figure 11-2: Conductor Bend.

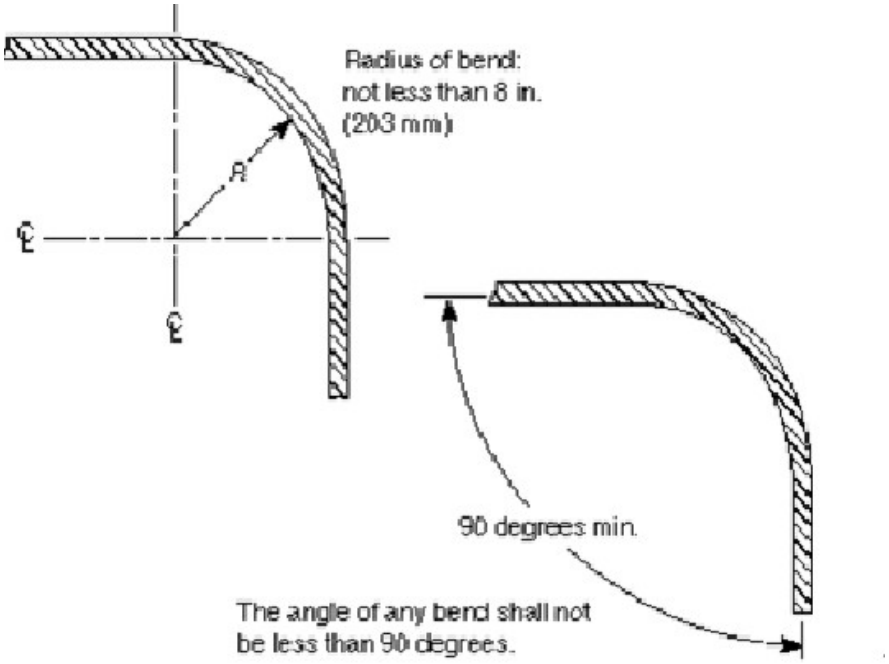

Figure 11-2: Conductor Bend

11.8.6.1 Conductor Supports

Conductors shall be permitted to be coursed through the air without support for a distance of 3 ft (0.9 m) or less. Conductors that must be coursed through the air for longer distances shall be provided with a positive means of support that will prevent damage or displacement of the conductor.

11.8.7 Conductor Fasteners

Conductors shall be securely fastened to the structure upon which they are placed at intervals not exceeding 3 ft (1 m). Attached by nails, screws, bolts, or adhesives as necessary, the fasteners shall not be subject to breakage and shall be of the same material as the conductor or of a material equally resistant to corrosion as that of the conductor. No combination of materials shall be used that will form an electrolytic couple of such a nature that, in the presence of moisture, corrosion will be accelerated.

11.8.8 Masonry Anchors

Masonry anchors used to secure lightning protection materials shall have a minimum outside diameter of 1/4 in. (6.4 mm) and shall be set with care. Holes made to receive the body of the anchor shall be of the correct size, made with the proper tools, and preferably made in the brick, stone, or other masonry unit rather than in mortar joints. When the anchors are installed, the fit shall be tight against moisture, thus reducing the possibility of damage due to freezing.

11.8.9 Connector Fittings

Connector fittings shall be used at all “end-to-end,” “tee,” or “Y” splices of lightning conductors. They shall be attached so as to withstand a pull test of 200 lb (890 N). Fittings used for required connections to metal bodies in or on a structure shall be secured to the metal body by bolting, brazing, welding, or using high-compression connectors listed for the purpose. Conductor connections shall be bolted, welded, high compression, or crimp-type.

Crimp-type connections shall not be used with Class II conductors.

11.8.10 Metal Antenna Masts and Supports

Metal antenna masts or supports located on a protected structure shall be connected to the lightning protection system using main-size conductors and listed fittings unless they are within a zone of protection.

11.9 RF Application

See Figure 11-3: RF Application (Page 1 of 2) and Figure 11-4: RF Application (Page 2 of 2) for an example of the RF application. Contact the DEN Project Manager for a fillable version of this application.

Administrative Information

	Proposing Agency or Organization (User)		
1	Name:	Req	
2	Phone:	Req	
3	Street Address:	Req	
4	City, State & ZIP:	Req	

	Administrative Contacts Information		Construction Administration	Project Manager
5	Agency or Organization Name:	Req		
6	Contact Individual & Title:	Req		
7	Phone:	Req		
8	Mobile:			
9	E-Mail:	Req		

	Technical, Construction or Field Contacts		Equipment Installer	RF Engineer Contact
10	Agency or Organization Name:	Req		
11	Contact Individual & Title:	Req		
12	Phone:	Req		
13	Mobile:			
14	E-Mail:	Req		

General System Information

1	Type of System (VHF, UHF, ETC):	Req		
2	Type of Action (Add, Modify or Remove):	Req		
3	Proposed Antenna Location at DIA:			
4	Structure or Site Name:	Req		
5	Geographic Coordinates (D-M-S NAD83):	Req	Latitude:	Longitude:
6	Ground Elevation (Feet AMSL):			
7	Number of Antenna Locations Needed	Req		
8	Floor Space Needed (L x W in feet)			
9	AC Power Needed (Volts, Amps, Phases)			
10	Coverage Requirement			
11	On RF Distribution System (Underground)?	Req		

Regulatory Information (See Notes 1 &2)

1	FCC Call Sign(s):			
2	FCC Radio Service(s):			
3	FCC Authorization Grant Date(s):			
4	FCC Authorization Expiration Date(s):			
5	FCC authorization or application attached?			
6	FAA Aeronautical Study Number (ASN): (See RF Standard Section 2.01G3)			

Applicant may be required to provide additional information before approval.
For questions, contact Leonard Spomer at: 303-342-2879. Return completed form via e-mail to leonard.spomer@flydenver.com

NOTES & COMMENTS:

1. This information is required for licensed services only.
2. Use the FAA OE/AAA website to see if an Air-space study is required. Attach a copy of the submitted study request (Form 7460-1) if one is.
3. Use FCC emission designator & modulation type for non-commercial services. (LMR, MW, etc.) Use technology for commercial (CDMA, UMTS, LTE).
4. Use the FCC frequency number, industry standard channel number, or user assigned channel number.)
5. Attach a scaled plan view of the platform or roof showing the location of each antenna by antenna number if the system uses more than one antenna.
6. Sort Antennas by Antenna Number from lowest to highest
7. Multiple channel labels and frequencies should be entered where they have the same emission designator, or use the same technology and bandwidth.
8. Where multiple signal formats use the same antenna, a separate antenna entry is needed for each format. The antenna number should not change.
9. If the same antenna is used for transmit and receive, enter the antenna number used for Tx. No further Rx antenna or transmission line data is needed.
10. Include All Antennna Patterns for all used Frequencies in MSI/Planet Format either in a separate excel or notepad file

Req = required field.

APPLICANT NOTES & COMMENT AREA

For Denver International Airport Use Only

Application Number:	
Application Received:	
Review Completed:	
Approved/Rejected:	
Planning & Engineering Submittals:	
Planning & Engineering Project Number:	
Engineering Approval:	
Response Sent To Applicant:	

Figure 11-3: RF Application (Page 1 of 2)

Frequencies 1-6								
RF Characteristics								
Transmit RF								
1	Transmit Antenna Number: (notes 5 & 6)	Req						
2	Action (Existing, New, Modify or Remove):	Req						
3	Transmit Carrier Label: (notes 4 & 7)	Req						
4	Transmit Carrier Center Freq. (MHz): (note 7)	Req						
5	Transmit Carrier Bandwidth (kHz):	Req						
6	Transmitter Output Power (Watts):	Req						
7	Transmitter Filter Loss (dB):							
8	Other Transmit Losses (dB):							
9	Transmit Line Loss (dB):	Req						
10	Transmit Antenna Gain (dBi):	Req						
11	Transmit Antenna Azimuth (°T):	Req						
12	Transmit Antenna HPBW (°):	Req						
13	Calculated EIRP (dBW):	Req						
14	FCC Emission Designator (note 3):							
15	Transmitter Modulation Type (note 3):	Req						
Receive RF								
16	Receive Antenna Number: (notes 5, 6 & 9)	Req						
17	Action (Existing, New, Modify or Remove):	Req						
18	Receive Carrier Label: (notes 4 & 7)	Req						
19	Receive Carrier Center Freq. (MHz): (note 7)	Req						
20	Receive Carrier Bandwidth (kHz):	Req						
21	Receiver Filter Loss (dB):							
22	Other Receive Losses (dB):							
23	Receiver Line Loss (dB):							
24	Receive Antenna Gain (dBi)							
25	Receive Antenna Azimuth (°T):							
26	Recieve Antenna HPBW (°):							
27	FCC Emission Designator (note 3):							
28	Receiver Modulation Type (note 3):	Req						
29	Receiver Sensitivity at threshold (dBm):	Req						
30	Receiver IM Signal Rejection (dB)	Req						
31	Receiver IM Signal Margin (dB)	Req						
Equipment Characteristics								
Transmitter Equipment								
32	Transmitter Make:	Req						
33	Transmitter Model:	Req						
34	Transmitter Output Isolator & Filter Types:							
35	Transmitter Output Isolator & Filter Make:							
36	Transmitter Output Isolator & Filter Model:							
37	Analysis Isolator Type (DIA Internal Use Only)							
38	Analysis Tx Filter Curve (DIA Internal Use Only)							
39	Transmit Antenna Type:	Req						
40	Transmit Antenna Make:	Req						
41	Transmit Antenna Model:	Req						
42	Transmit Antenna Horizontal Pattern Attached	Req						
43	Transmit Antenna Height (feet AGL)							
44	Transmit Antenna support structure hgt (AGL):							
45	Transmit Line Manufacturer:	Req						
46	Transmit Line Type:	Req						
47	Transmit Line Length (ft):	Req						
48	Transmit Line Connector Type:							
Receiver Equipment								
49	Receiver Make:	Req						
50	Receiver Model:	Req						
51	Receiver Selectivity or ACIPR:	Req						
52	Receiver IM Rejection (EIA SINAD, dB):	Req						
53	Receiver Spurious & Image Rejection (dB)	Req						
54	External Receiver Filter or Duplexer Type:	Req						
55	External Receiver Filter or Duplexer Make:	Req						
56	External Receiver Filter or Duplexer Model:	Req						
57	Analysis Rx Filter Curve (DIA Internal Use Only)							
58	Receive Antenna Type: (note 6)							
59	Receive Antenna Make: (note 6)							
60	Receive Antenna Model: (note 6)							
61	Receive Antenna Horizontal Pattern Attached							
62	Receive Antenna Height (feet AGL)							
63	Receive Antenna support structure hgt (AGL):							
64	Receive Line Manufacturer:							
65	Receive Line Type:							
66	Receive Line Length (ft):							
67	Receive Line Connector Type:							
68	Receiver Multicoupler Block Diagram Attached:							
(Attach block diagram of multicoupler with amps/splits)								

Figure 11-4: RF Application (Page 2 of 2)

11.9.1 Administrative

A. Proposing Agency
    a. Applicant Information
    b. Final RF Approval Letter will be sent to the address listed here
B. Administrative Contact Information
    a. Construction Administration
        • Manager or contractor responsible for equipment installation
    b. Project Manager
C. Construction Technical Contact Information
    c. Equipment Installer
    d. RF Engineer Contact

11.9.2 General System Information

A. Type of Systems requested to be installed
B. Type of action on proposed systems
C. General Antenna Location
D. Structure Name
E. Antenna Coordinates
F. Ground Elevation of Antenna
G. Number of Antenna Locations Needed
H. Floor Space Needed
    a. Generally, will be used if a new radio room is being constructed
I. AC Power Needed
J. Coverage Requirement
    a. Fill this in if RF Coverage Study is needed
K. RF Distribution
    a. Indicate if the system needs to be hooked into DEN's distributed antenna network.

11.9.3 Regulatory Information

A. Fill out the information in this section if a separate FCC License sheet is not available or included in the application.

11.9.4 Notes

A. Attach all FCC Licenses as a PDF or Image in a separate worksheet or Excel File.
B. Provide, at a minimum, an image of the vertical and horizontal radiation pattern of the proposed antennas at the operational frequencies. If data is available, please provide gain and azimuth data on a separate worksheet.
C. Provide Construction Diagrams indicating antenna location and antenna numbers that will correspond to the TX and RX antenna numbers used later in the RF Application.

11.9.5 RF Characteristics (Required)

A. Transmit Antenna Number
    a. Ensure this number corresponds with the indicated antenna on the CDs.
B. Action
    a. Indicate Add, New, Modify, or Remove for each antenna/frequency on application.

C. Transmit Carrier Label
    a. Use the FCC frequency number, industry-standard channel number, or user-assigned channel number.
    b. Multiple channel labels and frequencies should be entered where they have the same emission designator or use the same technology and bandwidth.
D. Transmit Carrier Center Frequency in MHz
E. Transmit Carrier Bandwidth in KHz
F. Transmitter output power in Watts
G. Transmit Filter Loss in dB
H. Other Transmit Losses
    a. Indicate any additional loss not covered by the TX line or Filter in dB.
I. Transmit Line Loss in dB
J. Transmit Antenna Gain in dBi
K. Transmit Antenna Azimuth
    a. Direction of the main lob of a directional antenna is referred to North as 0°.
L. Transmit Antenna HPBW
    a. Half Power beam width of main lobe of antenna
M. Calculated EIRP (Effective Isotropic Radiated Power
    a. EIRP = Power Transmitted – Loss + Gain of Antenna
N. FCC Emission Designator
    a. Use FCC emission designator and modulation type for non-commercial services. (LMR, MW, etc.) Use technology for commercial (CDMA, UMTS, LTE).
O. Transmitter Modulation Type
    a. Use FCC emission designator and modulation type for non-commercial services (LMR, MW, etc.) Use technology for commercial (CDMA, UMTS, LTE).
P. Receive Antenna Number
    a. Ensure this number corresponds with the indicated antenna on the CD's
Q. Action
    a. Existing, New, Modify, Remove
R. Receive Carrier Label
    a. Use FCC frequency number, industry standard channel number, or user assigned channel number.
    b. Multiple channel labels and frequencies should be entered where they have the same emission designator or use the same technology and bandwidth.
S. Receive Carrier Center Frequency in MHz
T. Receive Carrier Bandwidth in KHz
U. Receiver Filter Loss in dB
V. Other Receiver Losses in dB
W. Receiver Line Loss in dB
X. Receive Antenna Gain
Y. Receive Antenna Azimuth
Z. Receive Antenna HPBW
AA. FCC Emission Designator
    a. Use FCC emission designator and modulation type for non-commercial services. (LMR, MW, etc.) Use technology for commercial (CDMA, UMTS, LTE).
AB. Receiver Modulation Type

a. Use FCC emission designator and modulation type for non-commercial services. (LMR, MW, etc.) Use technology for commercial (CDMA, UMTS, LTE).

AC. Receiver Sensitivity

a. Receiver Equipment Sensitivity in dBm

AD. Receiver IM Signal Rejection

a. Intermodulation Signal Rejection in dB

AE. Receiver IM Signal margin

a. Desired safety margin away from equipment's IM Signal Rejection in dBs

11.9.6 Transmitter Equipment

A. Make
B. Model
C. Antenna Type
D. Antenna Model
E. Horizontal Pattern
F. TX Line MFG
G. TX Line Type
H. TX Line Length

11.9.7 Receiver Equipment

A. Make
B. Model
C. Selectivity
D. IM Rejection
E. Filters

11.10 DEN Rules and Regulations

All installations shall comply with the latest edition of DEN rules and regulations, including but not limited to the following:

A. Part 40: Conduct of Commercial Operators Using the Airport, which contains regulations regarding Alternations of Airport Facilities and Telecommunications regulations.
B. Part 120: Carrier Rates and Charges, which contains rates and charges for the use of the DEN antenna farm.

DEN Rules and Regulations

11.11 DEN RF Application Process Flowchart

The following application process flowchart is provided for reference purposes.

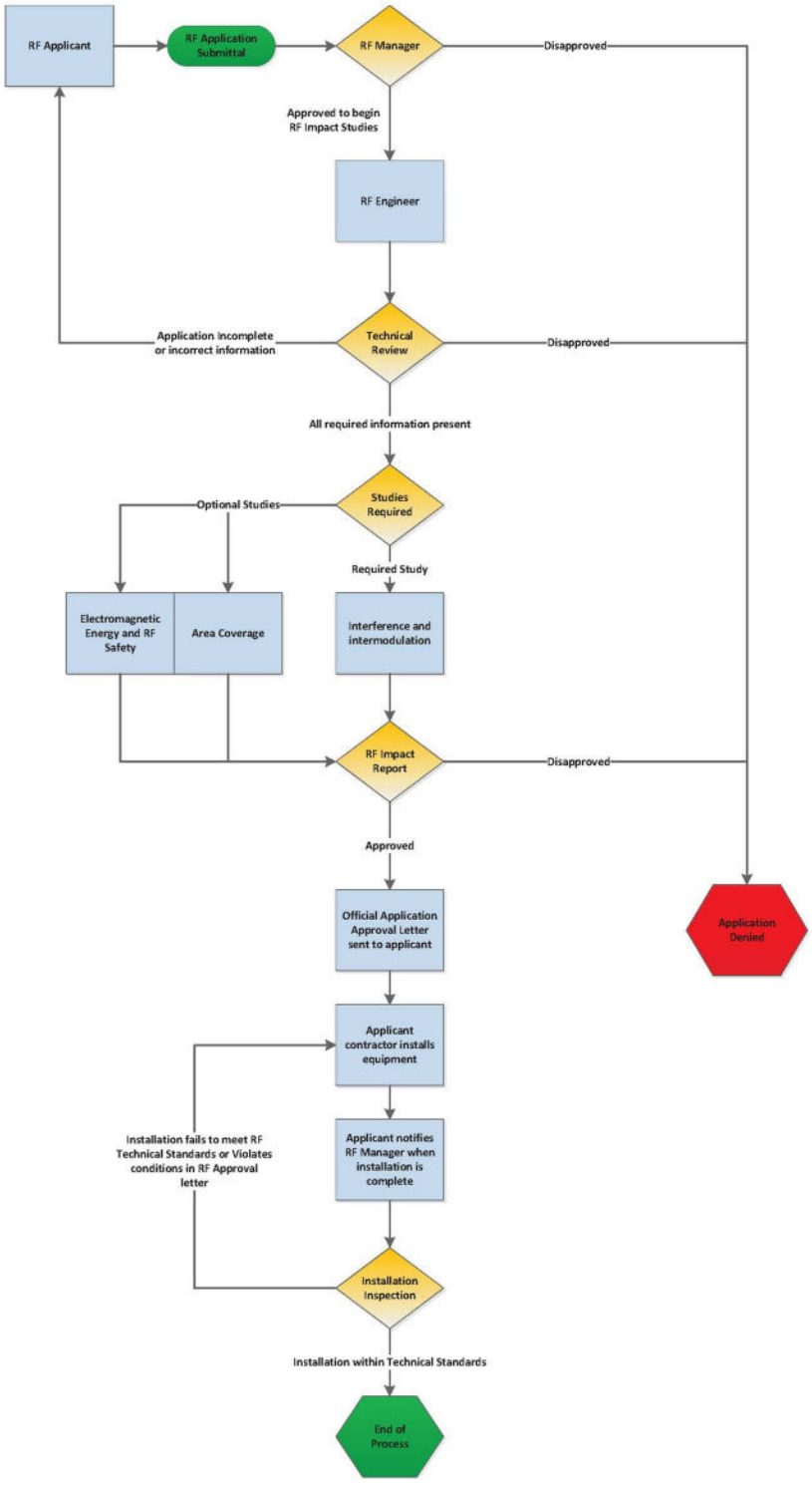

Figure 11-5: DEN RF Application Process Flowchart

End of Chapter

Chapter 12 - Public Safety Distributed Antenna System

12.0 System Overview

12.0.1 Description

The Public Safety Distributed Antenna System at DEN distributes the P25 Harris radio signal from outdoor primary or secondary transmission sites into interior buildings or underground tunnels. This system is critical to the First Responders (Fire/Police/Paramedics) that use it, as well as DEN Operations, Maintenance, and Airline tenants. This system is based on a Zinwave Unitivity system. This system contains primary hubs that are connected to the P25 radio system, which also connect via single-mode fiber to secondary hub sites and remotes units (RU) and antennas throughout the facility. Refer to the Life Safety DSM for additional requirements regarding two-way communication and other related life safety systems.

The DEN Public Safety Distributed Antenna System (DAS) is equivalent to Denver Fire Code Radio Enhancement System (RES). The term RES is also used in International Fire Codes.

12.1 Requirements

A. The system must be architected such that signal levels and overall compliance is maintained with the International Fire Code, as adopted and amended by the City and County of Denver.

B. All new or modified interior areas requiring indoor radio distribution will use Zinwave 5000 series equipment.

C. All electronic components in the system are served by a UPS in line with emergency power circuits with a 4-hour run time at full load. Refer to Electrical DSM for additional requirements regarding UPS and emergency power systems.

D. All Primary and secondary hubs must be located in rooms with a two (2) hour fire rating.

E. Cabling from primary to secondary hubs must be redundant and in a level 1 survivability pathway. The pathways have a minimum 20' separation between the redundant paths. The pathway from the secondary hub to RU must reside in a level 1 survivability pathway. Coax cable from RU to antennas do not require a level 1 survivability path.

F. The designer shall use RF modeling tools in new construction or remodeling efforts to demonstrate needed additions or changes to the Public Safety DAS system to DEN stakeholders prior to completing the design.

G. Systems engineers need to coordinate the positioning of equipment such that adequate space is provided in architectural locations (e.g., Remote Unit placement above ceilings, antenna locations, and cabling pathways) prior to design finalization.

H. New construction or remodel design processes will need to validate that these exceptions are still enforced/accepted by the authority having jurisdiction and validate the design with the DEN subject matter expert prior to the final design and permitting process.

I. Testing per Denver Fire Code is required for system acceptance.

J. Connection to operational systems must be coordinated in advance and requires DEN RF Systems Technicians' support.

K. Detailed specifications are contained in DEN Public Safety Distributed Antenna System, 27 Communications, Section 275319 technical specification.

End of Chapter

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Chapter 13 - Energy Management and Control

13.0 System Overview

13.0.1 Scope

This chapter provides guidance to the Design Consultant in the area of design of the Energy Management & Control System (EMCS) at DEN.

13.0.2 Criteria

General criteria are set forth below. Drawing and design requirements are contained in this chapter.

A. Applicable City and County of Denver building codes
B. NFPA 70: National Electrical Code
C. TIA/EIA – TIA-485 / RS-485: Recommended Standard for drivers and receivers used in serial communications systems.

13.0.3 Definitions

Table 13-1: EMCS Definitions

Term/Abbreviation	Definition
BACNet	A data communication protocol for building automation and control networks, as defined and maintained by AHSRAE Standing Standard Project Committee 135.
BBMD	BACNet/IP Broadcast Management Device
DDC	Direct Digital Controls in a centralized network-oriented approach to control systems that are integrated into the EMCS including HVAC, Electrical Metering, Lighting, and others.
EMCS	Energy Management and Control System
GUI	Graphical User Interface
HMI	Human-Machine Interface
IP	Internet Protocol
MSTP	Master-Slave, Token-Passing

13.1 Networks and Services

13.1.1 Basic EMCS Network Architecture

The DEN EMCS is a comprehensive network of electrical and mechanical systems and system components that shall provide the ability to monitor, control, and alarm equipment connected to the EMCS and is scoped to be available in all buildings on the DEN campus. The EMCS is primarily used for HVAC and lighting control, data analysis, utility metering, and billing.

The standard communication at the DEN Enterprise Network level is BACnet/IP. The standard communication at the field bus level is BACnet MSTP at a baud rate of 38.4. All addresses, including IP addresses, MSTP Network

numbers, BACnet instances, and MAC addresses, are managed and assigned by DEN, and assigned addressing must be strictly adhered to at all times.

Because of the size and complexity of the DEN EMCS network, each project must coordinate with the DEN EMCS administrator as early as possible to ensure network availability and expedite the process. DEN must be provided all tools to fully support, update, replace, or otherwise maintain any component on any type of control system and installed components. All Programming of all controlling equipment shall be done at the server level and pushed over the IT network to the controllers. Local Laptop interface or programming is considered a last resort in the event of server or network failure. Monitoring-only systems, such as Conveyance Monitoring, shall have a BACnet/IP interface for system integration and alarming. All Devices shall be uniquely discoverable using standard BACnet discovery tools and applications. Control System Groups shall be on separate and independent MSTP networks; for example, HVAC MSTP networks shall not have Tenant Electrical Panel Energy Metering devices or lighting control devices on the HVAC MSTP bus.

13.1.2 BACNet IP Networks

All DEN Enterprise Network-connected equipment is to be statically assigned from the DEN EMCS Administrator. BBMDs are installed and maintained by DEN- no device shall be installed and configured as a BBMD by any contractor, and care shall be taken to ensure devices that may have BBMD enabled by default are configured with this feature turned off.

13.1.3 BACNet MS/TP Networks

All MSTP networks shall follow BACnet architecture standards, and specific care must be taken to ensure common installation errors such as total length of MSTP runs, Starred networks, T-tapped networks, and incorrectly installed/ not installed End of Line (EOL) resistors are avoided. Network shop drawings shall indicate accurate architecture and include any and all EOL devices and resistors. Routers shall always be the first device of an MSTP BUS. MSTP networks shall be equipment group specific. DEN standard color and polarity shall be: Black Wire to BACnet MSTP (+) and White Wire to BACnet MSTP (-).

13.2 Design Criteria

13.2.1 General Network Requirements

Design each network of the DDC system to include at least 30 percent available spare bandwidth with the DDC system operating under normal and heavy load conditions. Calculate bandwidth usage and apply a safety factor to ensure that this requirement is satisfied when subjected to testing under worst-case conditions. Do not use an existing network controller that is at 80 percent capacity or greater. If DDC equipment is added to a piece of controls equipment (e.g. a FEC, NAE, SNE, etc.) which is below 80 percent capacity, it must not exceed 70 percent capacity once the equipment is installed.

Projects that add points and sequences to DEN Network Automation Engines (NAEs) or System Network Engines (SNEs) must add a new DEN NAE or SNE should the extra controls load cause the NAE to reach 80 percent capacity in hardware points, software points, memory, and/or processing capacity.

Additionally, any project or program that adds over 500 thousand (500,000) new building square feet to DEN shall require a new controls integration server to be installed. This server shall have at minimum, processing, memory, and network performance requirements capable of operating all mechanical, electrical, and plumbing controls and meters for the new space, as well as any white spaces, future tenant spaces, and/or office buildouts, plus extra hardware and software for an extra 25% performance (i.e., no newly installed controls integration server shall be loaded more than 80 percent in either hardware points, software points, memory, or processing capacity for a full build-out of said space).

Include spare processing memory for each new or replacement controller. RAM, PROM, or EEPROM will implement requirements indicated with the following spare memory:

A. Network Controllers: Not less than 30 percent spare capacity.

B. Programmable Application Controllers: Not less than 30 percent spare capacity.
C. Application-Specific Controllers: Not less than 30 percent spare capacity.
D. HVAC Controls Networks are to remain independent of all other networks. Tenant BACNet devices such as electrical, water, and BTU meters are to be on an IE dedicated Engine.

13.2.2 HVAC Controls Networks

The HVAC Control Network shall be comprised of any and all equipment attached to a DEN heating, cooling, or ventilation system. This shall include any tenant space with heating, cooling, or ventilation equipment supplied by a DEN-owned and maintained system. HVAC controls networks shall include all HVAC equipment such as Air Handlers, Temperature Control Panels (TCPs), Energy Meters (BTU meters), Variable Frequency Drives, Boilers, Chillers, or any other equipment that controls any aspect of Heating, Cooling, or Ventilation. The intent is 100% BACnet Native equipment to avoid the use of any protocol gateways.

Refer to the Mechanical DSM for detailed requirements regarding HVAC Controls.

13.2.3 Programmable Logic Controllers (PLC) located in Switchgear

All PLCs shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-2: Electrical Switchgear EMCS Integration Points.

Table 13-2: Electrical Switchgear EMCS Integration Points

Integration Point	Units	Status	Command	Trend
PLC Low Battery	True/False	Yes	No	Yes
System Error	True/False	Yes	No	Yes
Software Fault	True/False	Yes	No	Yes
Bad RAM	True/False	Yes	No	Yes
Application Fault	True/False	Yes	No	Yes
CPU Hardware Fault	True/False	Yes	No	Yes
I/O Module Loss	True/False	Yes	No	Yes
Main 1 Tripped	True/False	Yes	No	Yes
Main 2 Tripped	True/False	Yes	No	Yes
Fire Department Control Relay (86 Relay or LOR) Tripped	True/False	Yes	No	Yes

13.2.4 Automatic Transfer Switches (ATS)

All ATS shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-3: ATS EMCS Integration Points.

Table 13-3: ATS EMCS Integration Points

Integration Point	Units	Units	Status	Trend
Transfer to Secondary Power Source	True/False	Yes	No	Yes
Trouble Alarm	True/False	Yes	No	Yes

13.2.5 Electrical Metering Networks

All Electrical meters shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation. BACNet/MSTP meters shall be on a dedicated BACnet/MSTP trunk. All devices shall be Revenue Grade devices. All billable meters shall be integrated in both DEN GUI and DEN billing application. Refer to the Electrical DSM for electrical metering requirements. Integration points shall be as defined in Chapter 13-4: Metering EMCS Integration Points.

Table 13-4: Metering EMCS Integration Points

Integration Point	Point Name	Units	Status	Command	Trend
Total Energy Consumed (3 phases combined)	Total Energy	kWh	Yes	No	Yes
Total demand (3 phases combined)	Current Demand (3 phases)	kW	Yes	No	Yes
Total demand (per phase)	A Phase Current Demand	kW	Yes	No	Yes
Voltage (per phase)	A Phase Voltage	V	Yes	No	Yes
Current (per phase)	A Phase Current	A	Yes	No	Yes
Peak demand (3 phases combined)	Peak Demand (3 phases)	kW	Yes	No	Yes
Real time power factor	Power Factor	N/A	Yes	No	Yes

13.2.6 Lighting Controls

All lighting control systems shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP. Lighting Control Systems software shall be server-based, with programming and maintenance tools that can be run from the server.

Power consumption of lighting loads is required, either using the lighting control system or electrical submetering. The lighting control system is not required to meter energy on a zone level. Total power consumption from the lighting panel is acceptable.

Individual lighting fixtures will be controlled using either separate control-voltage wiring (e.g., 0-10-volt dimming), such that line-voltage power is not interrupted at the fixtures as part of the control sequence. Refer to the Electrical DSM for lighting control requirements. Integration points shall be as defined in Table 13-5: Lighting and Control EMCS Integration Points.

Table 13-5: Lighting and Control EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Trouble alarm	True / False	Yes	No	No
On/off, each zone	On/Off	Yes	Yes	Yes
Normal and after-hours schedule per zone	Norma/After-hours	Yes	Yes	Yes
Occupancy sensor detection state	Occupied/ Unoccupied	Yes	No	Yes
Aggregate occupancy state per zone	Occupied/ Unoccupied	Yes	Yes	Yes
Dimming level, per load	%	Yes	Yes	Yes
Button status, per field switch/device	On/Off	Yes	No	Yes
Occupancy sensor time delay, per sensor	Minutes: Seconds	Yes	Yes	No
Occupancy sensor sensitivity, per sensor	%	Yes	Yes	No
Scene selection, per zone	Scene	Yes	Yes	Yes
Daylight sensor day/night setpoints, per sensor	fc	Yes	Yes	No
Daylight sensor fade time, per sensor	Minutes: Seconds	Yes	Yes	No
Daylight sensor current light level, per sensor	fc	Yes	No	Yes
Daylight sensor operating mode, per zone	Mode	Yes	Yes	Yes
Wall switch lock status	True/False	Yes	Yes	Yes
Demand (3 phases combined)	kW	Yes	No	Yes

13.2.7 Lighting Inverters

All Lighting Inverters shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-6: Lighting Inverter EMCS Integration Points.

Table 13-6: Lighting Inverter EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Trouble alarm	True/False	Yes	No	No
Standby/Emergency Power Mode	True/False	Yes	No	Yes

13.2.8 UPS Systems

All UPS systems shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-7: UPS EMCS Integration Points.

Table 13-7: UPS EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Trouble Alarm	True/False	Yes	No	No
Low battery condition	True/False	Yes	No	Yes
Standby/Backup power mode	True/False	Yes	No	Yes

13.2.9 Photovoltaic Inverters

All Photovoltaic Inverters shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-8: Photovoltaic Inverter EMCS Integration Points.

Table 13-8: Photovoltaic Inverter EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Trouble Alarm	True/False	Yes	No	No
Total Energy Produced	kWh	Yes	No	Yes
Total Power Output (3 phases combined)	kW	Yes	No	Yes
Peak Power Output (3 phases combined)	kW	Yes	No	No
Output Voltage (per phase)	V	Yes	No	Yes
Output Current (per phase)	A	Yes	No	Yes

13.2.10 Surge Protection Devices

All Surge Protection Devices shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-9: Surge Protection Device EMCS Integration Points.

Table 13-9: Surge Protection Device EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Trouble Alarm	True/False	Yes	No	No
Surge Event, with timestamp	Event & Date & Time	Yes	No	Yes

13.2.11 Ground Power Units

All Ground Power Units shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP. Integration points shall be as defined in Table 13-10: Ground Power Units EMCS Integration Points.

Table 13-10: Ground Power Units EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Trouble alarm	True/False	Yes	No	No
On / Off Status	On / Off	Yes	Yes	Yes
Total Energy Consumed	kWh	Yes	No	Yes
Demand (3 phases combined)	kW	Yes	No	Yes
Demand (per phase)	kW	Yes	No	Yes
Output Voltage (per phase)	V	Yes	No	Yes
Output Current (per phase)	A	Yes	No	Yes
Peak Demand (3 phases combined)	kW	Yes	No	No

13.2.12 Engine Generators

All Generators shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-11: Engine Generator EMCS Integration Points.

Table 13-11: Engine Generator EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Generator Running	On / Off	Yes	No	Yes
Low Engine Oil	True/False	Yes	No	No
Low Oil Pressure	True/False	Yes	No	No

Table 13-11: Engine Generator EMCS Integration Points (Continued)

Integration Point	Units	Status	Command	Trend
Battery Charger Fault	True/False	Yes	No	No
Low Battery Voltage	True/False	Yes	No	No
AC Sensing Loss	True/False	Yes	No	No
Not in Auto	True/False	Yes	No	No
Over-Crank	True/False	Yes	No	No
Output Undervoltage	True/False	Yes	No	No

13.2.13 Sump Pump Controllers

All sump pump controllers shall have BACnet Native connectivity, either via BACnet/IP or BACnet/MSTP, and shall be determined by the specific installation and shall be on a dedicated BACnet network. Integration points shall be as defined in Table 13-12: Sump Pump Controller EMCS Integration Points.

Table 13-12: Sump Pump Controller EMCS Integration Points

Integration Point	Units	Status	Command	Trend
Trouble alarm	True/False	Yes	No	No

13.3 Design Requirements

13.3.1 Drawing Requirements

Designer shall include, at a minimum, the following elements in their design drawings:

A. EMCS riser diagram, including existing and new components in the project area
B. Floor plans indicating locations of all EMCS devices

NOTE: Device locations may be shown on individual discipline floor plans (e.g., HVAC control devices on HVAC plans, metering on electrical plans, etc.).

13.4 EMCS Graphics

13.4.1 General

An HMI is any interface allowing for an operator to monitor or control a machine. A GUI is a type of HMI that provides a digital, graphical user interface generated on a display screen.

All equipment integrated into the EMCS shall be provided with a GUI for monitoring and control. All graphics must be designed to prioritize ease of use for the intended end user. Graphic screens should be intuitive, easy to navigate, use consistent labeling and iconography, and shall be designed to minimize eye strain for operators.

13.4.2 Metasys UI Graphics

All graphics developed shall be developed for the current Metasys UI environment.

13.4.3 Integration with Existing Systems

All new graphics and modifications to the existing graphics must be carefully reviewed by DEN stakeholders, including any impacted operations and maintenance groups. The EMCS is implemented at DEN through multiple software platforms, and any new graphics must be incorporated into the appropriate software platform based on the location and type of equipment affected. New software platforms shall be prohibited unless specifically approved in writing by the DEN Project Manager and DEN Maintenance.

All entities working within the existing EMCS software environments shall possess adequate training for programming and modification of those systems. Contractor access to the EMCS must be formally requested and approved by DEN Maintenance prior to the start of work. Any programming errors, device conflicts, or other issues introduced by a contractor shall be expeditiously resolved by the contractor at the direction of the DEN Project Manager and DEN Maintenance.

13.4.4 Equipment Page Design

A dedicated equipment graphic page is required for all mechanical equipment and any other equipment with more than (1) associated control point.

13.4.4.1 Blocks and Templates

There are many existing graphics in the EMCS, including interactive symbols for pumps, fans, lights, piping, ductwork, etc. Existing graphics are also laid out with standardized page arrangements for ease of use. New graphics pages for equipment that is similar to existing equipment shall utilize symbology and page layouts to match the existing graphics. For equipment types with no existing equivalent, the contractor may propose a new layout and submit it to DEN for review and approval.

13.4.4.2 Color Coding

Where symbols contain color coding to indicate a status or other condition, match the color coding utilized in existing graphics. If no similar system exists, coordinate color coding requirements with DEN Maintenance and the DEN Project Manager.

13.4.4.3 Equipment Values and Status

Analog readouts and equipment statuses should be clearly labeled, with appropriate units of measure indicated, and placed as close to the associated graphical item as possible. All analog values should include two decimal point precision.

13.4.4.4 Command and Control

Equipment control buttons should be clearly labeled and placed as close as possible to the associated equipment. Visually differentiate command and control elements from readouts and status elements to avoid potential operator confusion. Maintain consistency in depiction and function across the equipment page and consistency in placement between each similar equipment page.

13.4.4.5 Alarms

The EMCS shall have the capability of setting an alarm based on certain status or conditions detected in the system. An EMCS alarm will typically be in the form of a user alert or notification. Alarms for equipment are managed by multiple groups at DEN. Due to the overall quantity of buildings and equipment integrated into the EMCS, careful coordination is required to determine alarm definition, priority, notification requirements, and other details. For projects adding a significant amount of new equipment, a work session is recommended to determine alarm strategy in coordination with the DEN Project Manager, DEN Maintenance, and other affected stakeholders.

13.4.5 Page Navigation

Existing navigation layouts have been developed for locating equipment according to its physical location, including a standardized page navigation bar, key plans, floor plans, enlarged plans, hierarchical navigation, and categorized lists.

13.4.5.1 Page Navigation Bar

Utilize a standardized page navigation bar on each graphical page. The navigation bar should include the following:

- Title Bar: Description of current page or equipment
- Basic weather information: Temperature, humidity, wet bulb, cloud cover
- Homepage navigation buttons: DEN Home, Building Home
- Building Key Plan

13.4.5.2 Home Page

Navigation design shall be hierarchical in nature, allowing the operator to begin at an overall view of the facility or building with options to “drill down” into areas or types of equipment. Refer to Figure 13-1: Example of a GUI EMCS Home Page: Concourse B for an example of a typical building home page.

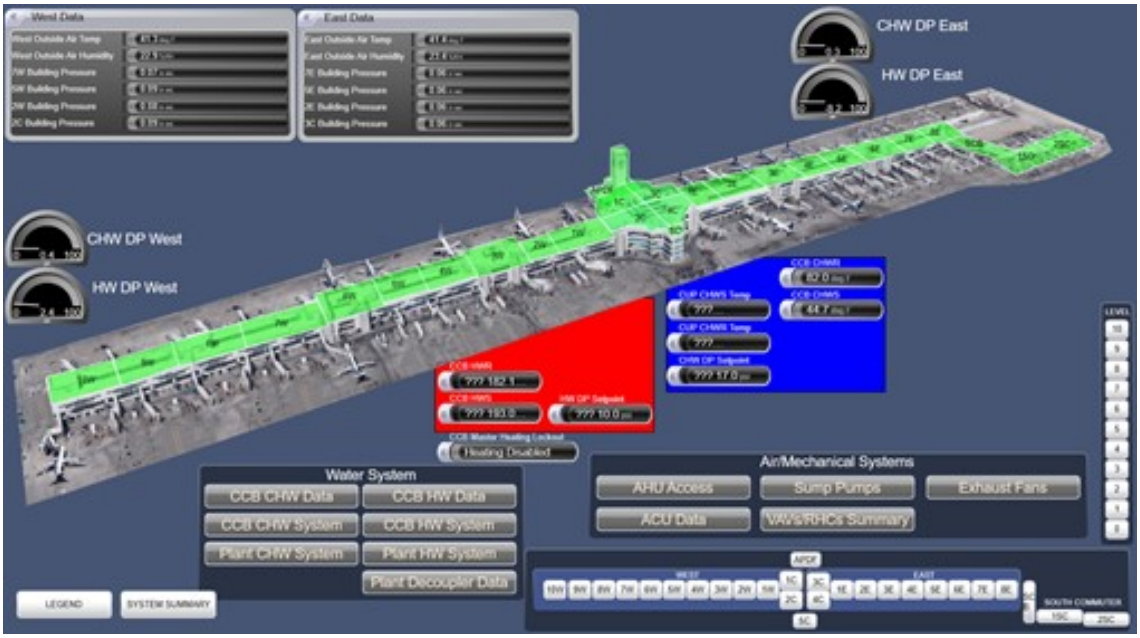

Figure 13-1: Example of a GUI EMCS Home Page: Concourse B

13.4.5.3 Floor Plan Graphics

Floor plan graphics are generally arranged to provide a graphics page for each Core Area of a building within the Terminal Complex and each floor for out-buildings, as shown in Figure 13-2: Example of a Floor Plan: Concourse B. When new equipment is added to existing buildings where new floor plans are not required, all existing floor plan graphics where that equipment may appear shall be modified to graphically depict each piece of new equipment that is integrated into the EMCS, including mechanical equipment, lighting, meters, sensors, and control devices. For equipment with a separate graphical equipment page, provide the ability for the user to select the equipment on the floor plan and navigate to the associated equipment graphics.

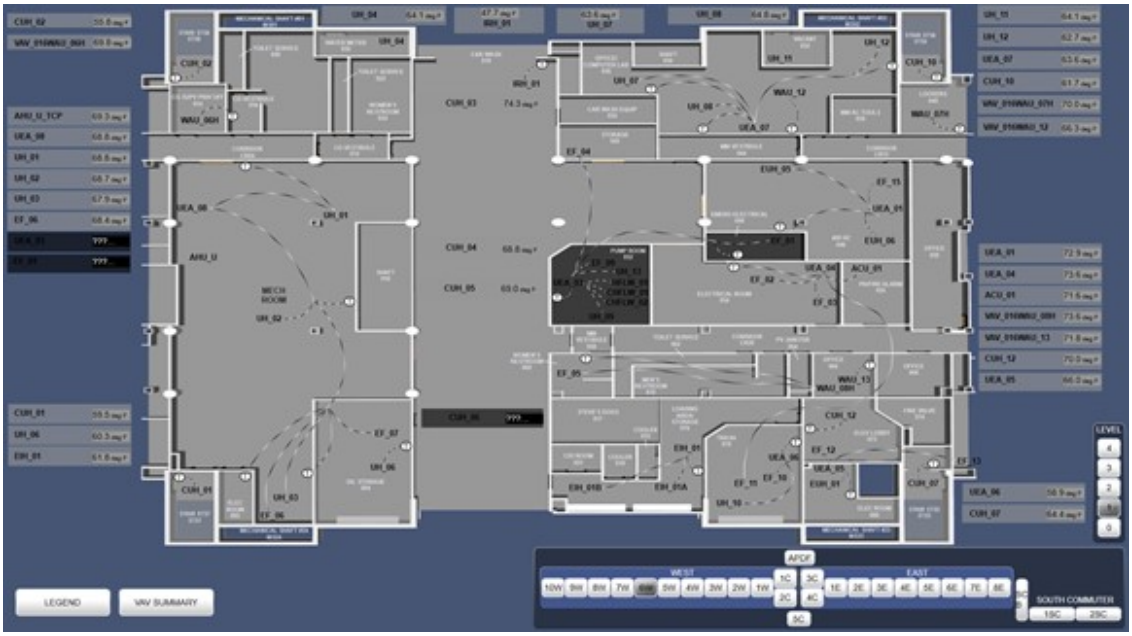

Figure 13-2: Example of a Floor Plan: Concourse B

When new buildings or expansions of existing buildings are constructed, or when existing floor plans are substantially modified, new floor plan graphics shall be provided, based on the most current BIM model of the affected area(s), to accurately reflect the general architectural layout (walls, doors, stairs, and other major features) as well as to graphically depict each piece of equipment that is integrated into the EMCS, including mechanical equipment, lighting, meters, sensors, and control devices. For equipment with a separate graphical equipment page, provide the ability for the user to select the equipment on the floor plan and navigate to the associated equipment graphics.

13.4.5.4 Key Plans

Key plans are provided for single-selection access to each core area within the Terminal Complex and for each floor of out-buildings. When a building floor plan is added, the key plan page must be updated to include the new floor plan.

Figure 13-3: Example of a Key Plan: Concourse B

13.4.5.5 Enlarged Plus

Enlarged plans are required for congested areas, such as mechanical rooms, to allow for all equipment to be depicted in a usable way.

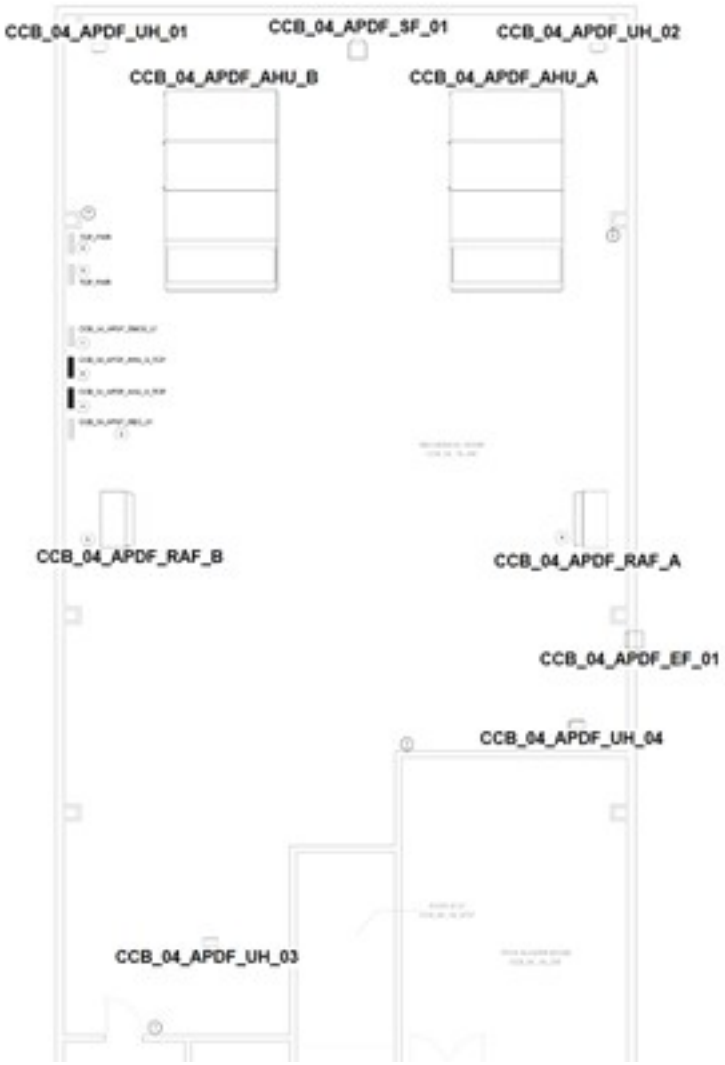

Figure 13-4: Example of an Enlarged Plan: Concourse B

End of Chapter

Chapter 14 - Technical Specification Requirements

14.0 General

Designers are required to provide project specifications on all DEN projects in accordance with the Standards and Criteria DSM, Chapter 11. The project specifications should encompass all aspects of the project and be based on industry-standard construction methods and products, with content based on the DEN Standard Specifications (where available) or from an industry-standard guide specification.

14.0.1 How to Use This Chapter

14.0.1.1 DEN Standard Specifications

The DEN Standard Specifications listed in this chapter have been developed to ensure project consistency and compliance with DEN policy and procedure. For sections available as DEN Standard Specifications, the designer must obtain and use these sections for their project.

14.0.1.2 DEN Technical Requirements

This chapter, as well as similar chapters in other DSMs, provides DEN-specific requirements that must be included in nonstandard specifications for all DEN projects. An itemized list of DEN-specific technical specification requirements is provided, which may include general requirements, product requirements, and execution requirements. The designer shall incorporate these requirements into their project specification content as appropriate for the project scope. Requirements are provided in an outline format similar to construction specifications for ease of incorporation. Content may be copied directly from this chapter, with article/paragraph numbering and structure modifications as needed to ensure a cohesive document.

Note: This chapter is intended to be used as an aid to the development of a project specification and ***is not intended to represent a complete specification as presented***.

The designer is responsible for developing a complete specification, incorporating the requirements of this chapter, which encompasses all aspects of the project and complies with general specification requirements outlined in the Standards & Criteria DSM, Chapter 11. After incorporating the requirements listed herein, the project specification should be reviewed to ensure it is free of redundant and/or conflicting information.

14.0.1.3 Notes to the Designer

Notes to the designer are included throughout the chapter, shown in red highlighted text. These are provided for guidance and clarification of requirements, and are intended for use only by the designer in development of their specification.

Notes to the designer shall not be incorporated into the final project specifications.

14.0.2 Specification Numbering

14.0.2.1 Numbering of Deliverables

Project deliverables should utilize Section names and numbers contained in the latest edition of *MasterFormat Numbers & Titles* at the time of project kickoff, which may vary from those in this chapter. It is the designer's responsibility to ensure that all applicable DEN requirements are reflected accurately in the appropriate sections of the project specifications.

14.0.2.2 Numbering Provided in This Chapter

Specification section names and numbers provided in this chapter are based on *MasterFormat Numbers & Titles*, 2014 edition.

14.0.3 Product and Manufacturer Listings

Where manufacturers and products are listed in this chapter, they represent approved manufacturers and/or products. Do not include additional manufacturers and/or products for that Article or paragraph without written permission from the DEN Project Manager.

For sections without manufacturer and/or products listed in this chapter, designer shall select a basis of design based on current industry standards which complies with all applicable requirements in this and other DEN DSMs, the DEN Standard Specifications, and the Denver Building Code. Provide at least (2) acceptable alternatives to the basis of design for all products, for a total of (3) or more acceptable products, except where a sole-source selection has been approved in writing by the DEN Project Manager.

14.1 DEN Standard Communication and Electronic Systems Specifications

Refer to Table 14-1: DEN Standard Specifications – Division 27: Communications and Table 14-2: DEN Standard Specifications – Division 28: Electronic Safety and Security for a listing of DEN standard communication and electronic systems specification sections. The following Sections must be obtained from the DEN Project Manager for use in the project.

Table 14-1: DEN Standard Specifications – Division 27: Communications

Section No.	Section Title
272100	Local Area Networks (LANs)
272101	Public Wireless LAN (WiFi)
273200	Telephone System
274111	Video Surveillance and Environmental Monitoring System (VSEMS)
274133	Master Antenna Television System
274219	Multi-User Flight Information Display System (MUFIDS)
274220	Common Use Passenger Processing Systems (CUPPS)
275123	Emergency Communications System
275313	DEN Standards for Time Synchronization
275319	Public Safety Distributed Antenna System (DAS)

Table 14-2: DEN Standard Specifications – Division 28: Electronic Safety and Security

Section No.	Section Title
281300	Access Control
282300	Video Surveillance
283300	Compressed Gases
283801	Emergency Fuel Shutoff System (EFSO)

14.2 DEN Technical Requirements – Division 27: Communications

Except where directed by designer notes, add the following requirements to project specification sections. Where there are similar or matching specification section names, include all content below in addition to the content in the generic specifications. The content below may be omitted where related equipment, mechanical systems, and furnishments are not in the project scope.

Section 270526: Grounding and Bonding for Communications Systems

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

3.01 APPLICATION

A. Provide each communications room with a ground bar for equipment bonding.

B. Provide minimum #6 copper grounding conductor from each communications room ground bar and connect to nearest referenced ground bar in the electrical room.

C. Bond together all communications equipment racks, cable trays, equipment enclosures, and metal raceway systems. Connect to the nearest equipment ground bar.

Section 270528: Pathways for Communication System

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION

A. Denver International Airport (DEN) owns and operates a private telecommunications infrastructure that provides voice, data and video services to all airport, airline and tenant facilities throughout the fifty-three square mile site. Tenants developing leasehold spaces or facilities on ground-leased sites are required to design their horizontal wiring pathways in accordance with these guidelines. Horizontal wiring pathways include all types of raceway systems to support voice, data, LAN, CATV and fiber cabling between DEN telecommunications rooms and outlets in the tenant, public or City areas.

B. Designers are required to submit a complete set of plans and specifications for their projects to the DEN Telecommunications Department for review and approval. Designers are also required to meet with representatives from the DEN Telecommunications Department at one or more times during the course of design to work out specific interface details prior to the final submittal.

C. Tenants and designers are encouraged to utilize the services of the current DEN Premise Wiring and Communications System (PWCS) contractor for installation of all horizontal cabling, outlets and termination. The City's contract with this contractor stipulates that all wiring and other components installed by the PWCS contractor be serviced and maintained by that contractor as part of the ongoing PWCS system maintenance agreement. The PWCS contractor is permitted to add a fair and reasonable amount to any such work to cover the expected maintenance through the duration of the current contract. The use of the PWCS contractor for this work affords the tenant a single party with end-to-end responsibility for the horizontal cabling system.

D. A tenant may elect to install a privately owned and maintained system of horizontal wiring within its leasehold space. This wiring would extend from outlets within the leasehold area to a designated point of demarcation with the DEN PWCS system. In this configuration, circuits ordered through the PWCS contractor or regulated telephone company will be terminated and tagged at the designated point of demarcation. Responsibility for cross connecting these circuits from the point of demarcation to their final destination remains the responsibility of the tenant.

The PWCS contractor will troubleshoot any reported problems with a circuit only as far as the designated point of demarcation.

E. Any tenant vacating their leasehold space shall leave any horizontal wiring in place and in serviceable condition. This shall include outlets, horizontal wiring and termination blocks at the telecommunications equipment room.

1.02 INTERMEDIATE DISTRIBUTION FACILITIES

A. Intermediate Distribution Facilities shall be provided at locations as required to reach any area of the facility with a 90-meter length of cabling.

1. Reserve fifteen meters of this cabling length for patch cord connections between horizontal cabling terminations in the IDF and tenant LAN equipment in a directly adjacent tenant equipment room space.

B. The IDF will serve as the demarcation point between the DEN Premise Wiring and Communications System backbone cabling system and horizontal cabling system. In addition to cable terminations, these rooms may contain active electronic equipment for DEN Local Area Network services, data circuit conditioning equipment, DEN access control (card reader) equipment, DEN closed circuit television equipment and other equipment that may be required by DEN Telecommunications to support the building.

C. Tenant equipment shall not be permitted within any IDF room.

1. Provide a separately accessible tenant equipment room to support tenant LAN equipment in lockable tenant provided cabinets.
2. Cabling for tenant LAN services will be terminated in the DEN IDF room and extended with Category 5e jumpers to the tenant equipment.

D. IDF rooms shall not be placed in locations that are subject to the effects of water infiltration, steam infiltration, humidity from nearby water or steam, excessive heat (e.g., direct sunlight) or any other corrosive atmospheric or environmental conditions.

1. Avoid locations that are below grade unless preventive measures against water infiltration are employed.
2. The room must be free of plumbing and electrical utilities that are not directly required to support the equipment room function.
3. A floor drain is required if there is any risk of water entering the facility.

E. NEC Section 110-16 requires three (3) feet of clear working space around equipment with exposed live parts. This shall apply to all communication equipment in the IDF room.

F. Telecommunications equipment requires heating, ventilating and air conditioning equipment to functions properly at all times.

1. All IDF spaces shall be designed to maintain a temperature range 64 degrees to 75 degrees F at 30 percent to 55 percent relative humidity.
2. Heat Dissipation 750 to 5000 BTUs per cabinet (number of cabinets to be determined through consultation with DEN Telecommunications).

G. The floor rating under distributed loading must be greater than 250 Ib/ft.2. The floor loading under equipment racks and other concentrated loads must be greater than 1000 lbs per square foot.

H. Floor finish shall be static resistant vinyl tile.

I. IDF room walls should extend from the finished floor to the structural ceiling (e.g., the slab), be covered with two coats of fire-retardant white or light colored paint, and carry a minimum fire rating of two hours or as required by the applicable codes and regulations.

1. All equipment room walls shall be lined with ¾" fire retardant B/C plywood to a height of 8'-0" above the finished floor.
2. Plywood shall be painted with fire retardant paint to match room finish.

J. Where ceilings must be installed, provide accessible ceiling system.

1. The recommended height of the finished ceiling to the finished floor is a minimum of 8'-6" to allow for cable ladder and cabling above the racks and frames.
2. Any ceiling protrusions (ventilation, sprinklers, etc.) must be placed to assure a minimum clearance height of 8 ft.
3. The ceiling finish must minimize the introduction of dust, and be white to enhance room lighting.
4. Hard, non-accessible ceilings shall not be used in IDF rooms under any circumstance.

K. IDF rooms shall be provided with adequate and uniform lighting that provides a minimum equivalence of 540 lux (50 footcandles) when measured 3 ft. above the finished floor

1. Illuminate wall mounted equipment and the front and rear surfaces of racks and frames.
2. Locate lighting fixtures a minimum of 8 ft. 6 in. above the finished floor.
3. Locate light switches near the entrance(s) to the equipment room.
4. Power for lighting should not come from the same circuits as power for the communications equipment.
5. Provide emergency lighting as required by applicable building codes.

L. Provide 12" x 2" x 1/4" isolated ground bar directly below IDF room electrical panel board. Extend #6AWG bare conductor from ground bus on the panel board to the room ground bar. Extend #2AWG bare copper from ground bar to building electrical service ground.

M. All IDF spaces shall be provided with smoke detector(s) interconnected with the building fire alarm system.

1. One portable type ABC fire extinguishers shall be located in the room close to the entrance.

N. All IDF spaces shall be equipped with a DEN access control system card reader inside and outside the IDF door.

1. Equip door with door position switch, electric hinge and solenoid operated lockset which remains operable from inside the room at all times. Refer to Section 281300 “Access Control”.

O. A contiguous 12-inch wide cable ladder shall be provided around the full perimeter of all walls of the IDF room at a height of 84-inches measured from the bottom of the cable runway to the finished floor.

1. Wall brackets used to support cable ladder shall be of sufficient length to allow the passage of a 4-inch EMT conduit between the cable ladder and finished wall.
2. Provide bonding strap at all connections between sections of cable ladder.
3. Provide one #6AWG bare copper bond from cable ladder system to IDF ground bar.
4. Two-inch and larger conduits entering the room from above shall be terminated at a height of 24-inches above the cable ladder system. Smaller conduits shall terminate at a height of 12-inches above the cable ladder system.
5. All conduits shall terminate with a bonding bushing which is in turn bonded individually or in groups to the cable ladder.

P. Do not allow conduit to be embedded in the floor or ceiling slab of any IDF room.

PART 2 PRODUCTS

PART 3 EXECUTION

3.01 PATHWAY APPLICATION

A. Minimum Pathway Size for all telecommunications pathways: 3/4-inch trade size.

1. Minimum size for any optical-fiber cable pathways: 1 inch.

B. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

Section 270544: Sleeves and Sleeve Seals for Communication Pathways and Cabling

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

3.01 SLEEVE APPLICATION

Edit to suit project where additional locations/applications of sleeves are needed.

A. Vertically aligned IDF and MDF rooms shall be linked with a series of 4-inch rigid metallic sleeves.

1. Sleeves must not obstruct wall terminating space.
2. Sleeves shall be provided with a minimum of a 4 inch high chamfered curb as measured from the finished floor.
3. All sleeves shall be fire sealed in accordance with project specifications.
4. The following table provides general guidelines for determining the number of 4 in. sleeves required, based on ANSI/EIA/TIAA-569:

Total Area Served (sq. ft)	City of Sleeves
Up to 50,000	3
50,000 – 100,000	4
100,000 – 300,000	5-8
More than 300,000	9-12

Section 271100: Communication Equipment Room Fittings

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

3.01 ENTRANCE FACILITIES

A. Contact DEN Project Manager and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by DEN Project Manager.

Section 271300: Communications Backbone Cabling

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION

A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. There are three (3) distinct elements of backbone cabling required at DEN. The first of these is Category 3 copper cabling that extends from major wire centers at each major building out to each IDF room. The second element is point-to-point single mode fiber that generally follows the same path as the copper from major wire centers to each IDF room. The third element involves single mode ring cable(s) that provide diversely routed uplinks from access layer switches to their respective distribution switches.

C. Category 3 copper cable will generally extend from 110 block fields at the major wire centers out to 110 block backbone fields at each IDF room. This cabling will be used for delivery of copper-based services such as PABX, POTS lines and Frame Relay circuits. Copper count for each IDF room is shown on the contract drawings.

D. Single Mode point-to-point fiber will extend from the major wire center in each building or network region out to each IDF room. Most single mode fiber will terminate on 24-port LGX-118 cassettes with type LC connectors. The last 24 strands of single mode fiber will terminate in a blank LGX-118 splice module to serve systems like the Distributed Antenna System (DAS) which must be fusion spliced. Duraline duct material is required for this point-to-point fiber allowing one tube to be dropped at each IDF room.

E. DEN has implemented a system of single mode ring cables to provide path diversity for enterprise, ECS and Security (SACN) uplinks to their respective distribution switches. Ring cables are generally 144 or 288 strand single mode. These ring cables originate at the red distribution switch location and terminate at the blue distribution switch. All strands are terminated on LGX-118 14-port LC patch panel cassettes.

F. The ring cable is routed through or past each IDF room. At the first room the blue 12-strand buffer is broken and the twelve strands in each direction are terminated on an LGX-118 24-port LC patch cassette while the other buffers express past unbroken. The next IDF has the orange buffer broken and terminated while the other buffers pass by unbroken. This arrangement continues so that each IDF room is served with a different buffer. Strands 1 and 2 in each direction are used for Enterprise network uplinks. 3 and 4 are used for ECS network uplinks and strands 5 and 6 are used for Security (SACN) network uplinks.

G. Strands 11 and 12 in each direction on the ring terminate with APC high return loss connectors on both ends. These strands are used for distribution of broadcast television (DIA TV).

H. Backbone copper and fiber cabling at DEN are assigned unique numbers that allow cabling pair and strand assignments to be managed by the DEN cable management system. Backbone (BB) and Inter-Building (IB) cable number assignments shall be coordinated with the DEN Business

Technologies to ensure that numerical assignments do not conflict with existing cable designations used elsewhere in the airport.

PART 2 PRODUCTS

2.01 PATHWAYS

A. Innerduct shall be HDPE or plenum as appropriate for the installed location.

1. Innerduct installed in cable trays shall be plenum rated.
2. Innerduct shall have a smooth exterior and longitudinally fluted interior construction to reduce cable pulling tension.
3. Install woven aramid pulling tape in all unused innerducts and tie-off on both ends. Tape shall have incremental footage marks at one-foot intervals.

2.02 UTP CABLE HARDWARE

A. Where indicated on the drawings and where required to achieve length, copper splice cases shall be utilized to house splicing between cable segments.

1. Splice cases at outdoor or underground locations shall be filled with the manufacturer recommended gel after testing is complete.

2.03 OPTICAL FIBER CABLE HARDWARE

A. DEN has standardized on the AFL Polimod fiber termination system for all single mode fiber terminations. Strand count shall be as shown on the drawings.

1. Provide AFL fanout kit to separate fiber strands among different Polimod modules.
2. The drawings will indicate which strands terminate on 24-port LC Polimod cassettes and strands to be stored in blank Polimod cassettes for fusion splicing.

B. Where indicated on the drawings and where required to achieve length, fiber splice cases shall be utilized to house splicing between cable segments.

1. Splice cases at outdoor or underground locations shall be filled with the manufacturer recommended gel after testing is complete

PART 3 EXECUTION

3.01 APPLICATION

A. Innerduct shall be used for all interior and outdoor fiber installations.

3.02 INSTALLATION

A. General requirements for cabling:

1. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals and cross-connects.
2. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.

B. Optical fiber cable installation:

1. Exterior fiber cables shall be loose tube construction, with water blocking tape in all installations.
2. Interior fiber cables shall be tight buffered and subject to the same restrictions as copper cabling when installed in cable trays.

C. Separation from EMI sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.03 IDENTIFICATION

A. Identify system components, wiring, and cabling using backbone and inter-building cable numbers as assigned by DEN Technologies Premise Wiring & Communications.

1. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Cable and Wire Identification:

1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.
4. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware.

Section 271500: Communication Horizontal Ceiling

PART 1 GENERAL

1.01 DEN TELECOMMUNICATIONS HORIZONTAL CABLING POLICY

A. Tenants and designers of new DEN facilities are required to install raceways, outlet boxes and pull cords for all communications outlets in accordance with the worksheets that accompany these guidelines.

B. Tenants and designers are encouraged to utilize the services of the current DEN Premise Wiring and Communications System (PWCS) contractor for installation of all horizontal cabling, outlets, and termination. The City's contract with this contractor stipulates that all wiring and other components installed by the PWCS contractor be serviced and maintained by that contractor as part of the ongoing PWCS system maintenance agreement.

C. A tenant may elect to install a privately owned and maintained system of horizontal wiring within its leasehold space. This wiring would extend from outlets within the leasehold area to a designated point of demarcation with the DEN PWCS system. In this configuration, circuits ordered through the PWCS contractor or regulated telephone company will be terminated and tagged at the designated point of demarcation. Responsibility for cross connecting these circuits from the point of demarcation to their final destination remains the responsibility of the tenant. The PWCS contractor will troubleshoot any reported problems with a circuit only as far as the designated point of demarcation.

D. Any tenant vacating their leasehold space shall leave any horizontal wiring in place and in serviceable condition. This shall include outlets, horizontal wiring, and termination blocks at the telecommunications equipment room.

1.02 EMI INTERFERENCE

A. EMI causes severe problems with electronic equipment, telecommunications and data communications, avoidance of all potential sources or, electromagnetic interference must be a primary consideration when designing a horizontal distribution system. To avoid electromagnetic interference, all distribution pathways should provide clearances of at least:

1. Four (4) ft. from large motors and/or transformers.
2. One (1) ft. from conduit and cables used for electrical power distribution.
3. Five (5) in. from fluorescent lighting

B. Note: Horizontal Distribution Pathways should cross perpendicular to fluorescent lighting and electrical power cables or conduits.

PART 2 PRODUCTS

2.01 UTP CABLE HARDWARE

A. Manufacturer: Panduit Mini-Com

1. DEN has standardized on Panduit Mini-Com series terminations for all horizontal cabling for both copper and fiber horizontal cabling terminations. Patch panels and outlets by other manufacturers shall not be considered.

14.3 DEN Technical Requirements – Division 28: Electronic Safety and Security

Except where directed by designer notes, add the following requirements to project specification sections. Where there are similar or matching specification section names, include all content below in addition to the content in the generic specifications. The content below may be omitted where related equipment, mechanical systems, and furnishments are not in the project scope.

Section 280513: Conductors and Cables for Electronic Safety and Security

PART 1 GENERAL

1.01 FIELD CONDITIONS

A. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 PRODUCTS

Include product requirements below in addition to other products included in this Section.

2.01 FIRE ALARM WIRE AND CABLE

A. General Wire and Cable Requirements:

1. NRTL listed and labeled as complying with NFPA 70, Article 760.
2. All Fire Alarm System wiring shall comply with NEC and NFPA requirements for power limited wiring.
3. Fire Alarm Wire Schedule:

Circuit	Color (+)	Color (-)	Size (AWG)	Type	Insulation
Audible NAC (horn only)	Red	Black	12	Stranded (19)	THHN
Visual NAC (Strobe or H/A)	Red	Brown	12	Stranded (19)	THHN
IDC	Red w/ white stripe	Black w/ white stripe	16	Solid	THHN
SLC (IDNet)	Red	White	16	Solid, twisted par	TFN
Remote Lights	Yellow	Purple	16	Solid	TFN
24 volt power	Red	Black	14	Solid	THHN
RUI Communications	Red	Black	16	Solid, twisted pair	Shielded
Audio NAC (Fire Alarm Speaker)	Red	Black	16	Solid, twisted pair	Shielded
Duct Detector Remote Test Switch	Red/Blue	Black/Brown	16	Solid	THHN
Addressable Notification	Red	Brown	12	Stranded (19), twisted pair	THHN, unshielded
Test Switches	Blue	White	16	Solid	THHN

4. Wire for test switches with indicating lights shall be a 14 AWG stranded THHN wire with the following color code: red +, black -, blue terminal # 3, white terminal # 4 for the test switch.
5. Wire associated with the AGTS Train Platform deluge systems activation circuits (i.e., key activated stations) shall be an IDC with blue (+) and white (-) wire.
6. Subject to compliance with Simplex and NEC requirements, local suppliers include but are not limited to the following: Liberty, Westpenn, ALLCABLE

7. All wiring shall test free from grounds and short circuit faults.No connections to the FACP shall be made until the system wiring has been accepted by the Owner's Designated Representative and the equipment supplier.
8. Wire and cable shall be a type listed for its intended use by an approval agency acceptable to the Authority Having Jurisdiction and shall be installed in accordance with the appropriate articles from the current approved edition of NFPA 70, National Electrical Code (NEC).
9. Contractor shall obtain from the Fire Alarm System Manufacturer written instructions regarding the appropriate wire/cable to be used for this installation. No deviation from the written instruction shall be made by the Contractor without the prior written approval of the Fire Alarm System Manufacturer, the Engineer and the DEN Project Manager.
10. Existing wiring may be used if warranted as new and with approval by the DEN Project Manager.
11. SLC communication (IDNet) channels shall utilize 16 Gauge solid twisted wire. The wire installed shall not exceed 35 pF/ft and shall have 12 twists per foot. These wiring guidelines allow for a distance of 3600ft to the furthest device on a channel with a maximum of 250 devices, and an overall wire length of 10,000 ft. No SLC channel shall exceed .60 uF total capacitance and 35 Ohms resistance. Any conduit that is used for multiple circuit types along with 1 or more SLC channels shall conform to the table below.
12. Circuits in the same conduit are limited as follows:
    a. Unless approved in writing by the Engineer and DEN Project Manager, wiring for NAC and SLC Circuits shall not be routed in the same conduit.
    b. SLC circuits and 24 volt power from a fire alarm control panel may be routed in the same conduit. A maximum of 5 amps of NAC circuits shall be in the same conduit with SLC circuits.
    c. No DC inductive loads greater than 5 amps 30VDC, or any AC voltage wiring, shall share the same conduit as an SLC circuit at any time.

Section 281600: Intrusion Detection

PART 1 GENERAL

1.01 QUALITY ASSURANCE

A. FM Global Compliance: FM-Approved and -labeled intrusion detection devices and equipment.

PART 2 PRODUCTS

PART 3 EXECUTION

3.01 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Section 260553 "Identification for Electrical Systems."

Section 281643: Perimeter Security Systems

PART 1 GENERAL

PART 2 PRODUCTS

2.01 SYSTEM COMPONENT REQUIREMENTS

A. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit shall be selected and configured with accessories for full compatibility with the following equipment:

Edit this list to suit project.

1. Door hardware specified in Section 087100 "Door Hardware."
2. Access control system and electronic door hardware specified in Section 281300 “Access Control”

PART 3 EXECUTION

3.01 SYSTEMS INTEGRATION

A. Integrate perimeter security system with the following systems and equipment:

1. Electronic door hardware
2. Elevators
3. Network lighting controls
4. Intercommunications and program systems
5. Public address and mass notification systems
6. Access control
7. Fire-alarm system
8. Intrusion detection system
9. Video surveillance
10. <Insert applicable systems and equipment>

Section 283111: Digital, Addressable Fire Alarm System

PART 1 GENERAL

PART 2 PRODUCTS

2.01 FIRE ALARM WIRE AND CABLE

A. General Wire and Cable Requirements:

1. NRTL listed and labeled as complying with NFPA 70, Article 760.
2. All Fire Alarm System wiring shall comply with NEC and NFPA requirements for power limited wiring.
3. Fire Alarm Wire Schedule:

Circuit	Color (+)	Color (-)	Size (AWG)	Type	Insulation
Audible NAC (horn only)	Red	Black	12	Stranded (19)	THHN
Visual NAC (Strobe or H/A)	Red	Brown	12	Stranded (19)	THHN
IDC	Red w/white stripe	Black w/ white stripe	16	Solid	THHN
SLC (IDNet)	Red	White	16	Solid, twisted pair	TFN
Remote Lights	Yellow	Purple	16	Solid	TFN
24 volt power	Red	Black	14	Solid	THHN
RUI Communications	Red	Black	16	Solid, twisted pair	Shielded
Audio NAC (Fire Alarm Speaker)	Red	Black	16	Solid, twisted pair	Shielded

Duct Detector Remote Test Switch	Red/blue	Black/brown	16	Solid	THHN
Addressable Notification	Red	Brown	12	Stranded (19), twisted pair	THHN, unshielded
Test Switches	Red / Black / Blue / Brown	N/A	16	Red + LED, Black - LED, Blue + Test Switch, Brown - Test Switch	
AGTS Deluge Activation (IDC)	Blue	White	16	Solid	THHN

PART 3 EXECUTION

3.01 CABLE APPLICATION

A. Fire alarm cable use schedule:

	Circuit List 1	**Wiring Requirements**
1	DC NAC	Any NEC 760 Wire
2	Analog Audio Riser	RSC on Analog Riser only
3	Digital Audio Riser	UTP on digital riser only
4	4100U Speaker NAC	UTP on Speaker NAC only
5	Other Speaker NAC	TSP on Speaker NAC only
6	Remote Microphone	TSP on remote microphone only
7	Fire Fighter's Phone	TSP on telephone wiring only
8	True Alert Addressable	Any NEC 760 Wire
9	RUI/RAI/RSI	Any NEC 760 Wire
10	(Another) IDNET+ Channel	Any NEC 760 Wire
11	MAPNET II Isolated	Any NEC 760 Wire
12	MAPNET II Non-isolated	TSP on MAPNET II only
13	Network Communications	UTP on Network Only
TSP - Twisted Shielded Pair UTP - Unshielded Twisted Pair 4100 U MAPNET communications can be either isolated or non-isolated. Refer to installation instructions 579-022 for details. Interaction between other types of circuits must still be considered (e.g., Speaker NAC and RUI/RAI/RSI, Firefighter's phones & Network Communications, etc.) Refer to 900-242 Field Wiring Specifications for details.		

3.02 DEFINITIONS OF NFPA 72 17.7 TRADE CLEANUP

A. Walls – all finishes (paint, tile, stainless steel, FRP, etc.)

B. Floors finished (carpet, tile, etc.)

C. Ceiling tiles installed

D. All power and lighting complete and inspected (signed off) by the City and County of Denver

E. Emergency (ECS) installed, tested, and signed off by DFD

F. Media and Shutdown devices installed

G. Counters and cabinets installed

H. All kitchen equipment installed and connected

I. Exhaust hoods, Pollution Control Units, Makeup Air Units, and associated interlocks complete, and their operations verified.

J. Ansul systems completed and ready for testing

K. HVAC Units and environmental controls complete, inspected, and ready for testing

L. Knox Box and Fire Extinguishers (ABC & K) installed as directed

M. Fire suppression (sprinklers) signed off by the City and County of Denver

N. Fire alarm signed off by the City Electrical Inspector “OK to test” prior to the Life Safety tie-in and pre-test.

Section 283500: Refrigerant Detection and Alarm

Designer shall provide this Section for projects where it is required. Common refrigerant types at DEN include R-22 and R-134a.

End of Chapter

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