DENVER INTERNATIONAL AIRPORT

DESIGN STANDARDS MANUAL

Jet Fuel System

Design, Engineering and Construction

Revised: Q2 2024

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Table of Tables

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Summary of Revisions

The following tables list the revisions made to the Fuel Systems Design Standards Manual (DSM).

2024 Revisions

Second Quarter

Reference	Revision Description
2.2 Hydrant System	Updated language and description of system functionality
4.5.1 Welding	GTAW procedures to be used on all welded piping connections
10.2.2 Periodic Leak Detection Testing of Hydrant System	Updated language and testing procedures
10.3 Flushing	Section reformatted and rewritten for DEN specific system and procedures: Tanker flush description and requirements D1/D2 Temporary Flush Station requirements Flow meter required for all flushing operations. DEN Flushing Equipment available for contractor use.
10.3.3 D1/D2 Temporary Flush Station	Updated description of Temporary Flushing Facilities
10.4 Dead Leg Flushing and Hydrant Checks	New section identifying requirements for dead leg flushing
Table 11-1: Fuel System DEN Standard Specification	Added specification sections

2023 Revisions

Second Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes
Organization	Moved Fuel Storage Facility Chapter ahead of Hydrant System Chapter so that the document follows the flow of jet fuel throughout the system.
3.4 Pump Manifold	Added section within Fuel Storage Facility chapter.

Second Quarter

Reference	Revision Description
3.5 Fuel Storage Facility Valves	Added section within Fuel Storage Facility Chapter and referenced 5.3 Fuel Storage Facility Valves.

2022 Revisions

Fourth Quarter

Reference	Revision Description
Throughout	Minor punctuation and grammar changes
9.4 Initiating Device	Updated EFSO initiating device model number
Chapter 11- Technical Specification Requirements	DEN Standard Fuel System Specifications removed and now published in separate documents.

Second Quarter

Reference	Revision Description
Throughout	Updated format and content organization
1.0 Scope	Added new information, reorganized layout
1.1 Limitations	Updated information and layout
1.2.2 Governing Codes and Standards	Removed Terms and Definitions table
Chapter 2: Aviation Fuel System Planning and Design	Combined with Chapter 3 “Aviation Fuel System Design” (from previous version) and distributed specific content to appropriate chapters throughout document.
Chapter 3: Hydrant System Piping	Updated chapter
Chapter 4: Fuel Storage Facility	New chapter
Chapter 5: Valves and Valve Vaults	Updated previous ‘Valves’ chapter
Chapter 10: System Inspection, Testing, and Flushing	Added specific flushing procedures
Chapter 11: Technical Specification Requirements	Included fuel system technical specs to conform with DSM format

2021 Revisions

Second Quarter

Reference	Revision Description
Throughout	Heading and body text appearance changes. Notation style for revisions updated from colored text to lines in margin. Minor grammatical and layout updates
3.0.3 Valves	Added requirements
3.0.6 Testing	New section
3.0.6 Testing	New section
3.1.1 Hydrant Fueling System, 3.2.1 Fuel Storage Facility	Revised pressure requirement
5.1.2 Hydrant Pits	Added requirements for internal coating
7.1.2 Concrete Valve Vault Wall and Floor Coating	New Section
11.0 General	Added description

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

1.0 Scope

These design guidelines are to provide an overview of general practices and guidance in the planning and design of the Aviation Fuel Storage Facility and Hydrant Fueling System at DEN. It is to be used as a reference for design elements and criteria to ensure quality and consistency with code compliance, industry standards, and local requirements.

These guidelines are applicable to the design of the new or modifications of existing facilities and systems at DEN including but not limited to, fuel storage, fuel receipt, fuel distribution, hydrant cart test stands (HCTS), product recovery, piping, pumps, valves, filtration, corrosion protection, cathodic protection, fire protection, leak detection, controls and instrumentation, and system commissioning.

Some design elements and criteria are described IN general while others are described in more detail. It is the responsibility of the Design Professional to ensure all current federal, state, and local codes and requirements are followed.

1.1 Limitations

This document is intended to be a complimentary guide to the industry regulations and standards. The Design Professional shall use it as such, and actual system set points shall be designed and prescribed by the Design Professional.

This document is not all-encompassing and provides basic guidance for planning, designing, constructing, and altering new or modifications of existing Aviation Fuel Storage Facilities and Hydrant Fueling Systems at DEN. If an item is not specified or covered herein, the Design Professional is responsible for compliance with local, the State of Colorado, federal regulations, and industry standards for hydrant fueling systems. Additionally, this DSM does not include guidelines for Motor Vehicle Gasoline (MoGas), diesel, or Compressed Natural Gas (CNG) fueling operations at DEN.

1.2 Criteria

1.2.1 Designer Qualifications

Due to the specialized nature of aviation fueling systems, the Design Professional shall meet the following requirements:

A. A minimum of ten (10) years of experience in the design of aviation fueling systems
B. Completed the design of at least three (3) aviation fueling projects of similar scope and size within the previous ten (10) years
C. Is a Colorado licensed Engineer

1.2.2 Governing Codes and Standards

All aviation fueling system work at DEN, including new, repair, and modifications, will require engineering drawings for review and approval to obtain Denver Fire permits in accordance with the currently adopted International Fire Code (IFC), as adopted and amended by the City and County of Denver. A table of required permits must be provided by the engineer or contractor on a project-by-project basis to the DEN Project Manager during design development.

All applicable current federal, state, and local codes, regulations, industry standards, and best practices shall be followed, including, but not limited to, the governing bodies listed in Table 1-1: Governing Bodies.

Table 1-1: Governing Bodies

Acronym	Governing Body
A4A	Airlines for America, formerly Air Transport Association of America (ATA)
AASHTO	American Society of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
API	American Petroleum Institute
APWA	American Public Works Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASPE	American Society of Plumbing Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association of America
AWS	American Welding Society
AWWA	American Water Works Association
CFR	Code of Federal Regulations
CSDOI	Colorado State Department of Oil Inspection
DBC	Denver Building and Fire Code
DBD	Denver Building Department
DOT	U.S. Department of Transportation - Office of Pipeline Safety
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FM	Factory Mutual Insurance
IBC	International Building Code
ICC	International Codes Council
IFC	International Fire Code
NACE	National Association of Corrosion Engineers

Table 1-1: Governing Bodies (Continued)

Acronym	Governing Body
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
NFPA	National Fire Protection Association
OSHA	Occupation Safety and Health Administration
SAE	Society of Automobile Engineers
SSPC	Steel Structures Painting Council
STI	Steel Tank Institute
U.L.C.	Underwriters Laboratories - Canada
UL	Underwriters Laboratories

End of Chapter

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Chapter 2 - Aviation Fuel System Planning and Design

2.0 General

The aviation fuel system shall be designed to safely and adequately store and supply fuel to aircraft arriving at and departing from DEN airport. Ease of operation and maintainability shall be considered when designing any new facilities or upgrades. Items to consider during the planning phases shall include, but not be limited to:

A. Compliance with all federal, state, and local laws and regulations and industry standards
   a. Compliance with fuel quality standards in ATA 103
   b. Compliance with NFPA 407
   c. Compliance with OSHA safety requirements
B. DEN's objectives and requirements
   a. Long-term ownership costs
   b. Budget limitations
   c. Schedule limitations
   d. Impact on existing operations
C. Operator requirements
   a. Accessibility
   b. Compatibility with existing equipment
   c. Familiarity/preferences for certain equipment types/manufactures
   d. Minimize long-term maintenance
   e. Compliance with leak detection/secondary containment requirements
D. Fuel Considerations
   a. Fuel source
   b. Quality control
   c. Days of reserve
   d. Fuel additives
E. DEN's needs for future airport expansion
   a. Current fuel consumption and peak demand
   b. Future fuel consumption and peak demand
   c. Redundancy in mission-critical systems
   d. Required maintenance schedules and operations
F. Redundancy in mission-critical systems
G. Required maintenance schedules and operations

2.1 Fuel Quality and System Design

Fuel quality is essential in aviation fuel system design. The design shall consider the thermal stability of the fuel, potential physical contaminants such as debris from initial construction, and regular maintenance, including but not limited to the removal of water, rust, and other particulates.

Thermal stability of the fuel is critical to aircraft operation as the aircraft uses the fuel as a heat sink to cool oil in engines or transfer heat away from critical components such as avionics. Thermal stability can be affected when the fuel comes into contact with certain metals and alloys. All piping in contact with fuel shall be internally coated carbon steel or uncoated stainless steel. Copper, zinc, cadmium, lead, and their alloys shall not be used in the systems in contact with the fuel. Bare carbon steel is acceptable in limited amounts, such as at welded joints, fittings six (6) inches and smaller, and piping two (2) inches and smaller.

2.2 Hydrant System

The DEN hydrant fueling system shall be designed to accommodate aircraft fueling operations as determined by DEN, in collaboration with hydrant fueling system operators and users. The system flow capacity shall be based on an analysis of current and future flight activity levels and daily peak fuel consumption. The hydrant fueling system shall be on-demand and be sized to provide adequate flow and pressure to all hydrant fueling positions during peak operating hours. Provisions for future expansion shall be included in the design.

Design considerations:

A. Aircraft mix
B. Aircraft uploading flow rates
C. Number of simultaneous refueling events
D. Aircraft fueling and turnaround times

The hydrant fueling system shall be designed in accordance with ATA 103, NFPA 407, and ASME B31.3 Process Piping Code. The system piping and components shall be ASME class 150 pressure rating. This pressure rating has a maximum allowable working pressure of 275 pounds per square inch gauge (psig) at temperatures between-20 and 100 degrees F. Pumps at the fuel farm maintain the nominal pressure of the hydrant system at ~150-175 psig. As fueling occurs at the hydrants and system pressure falls, the pumps automatically engage until pressure increases back up to designated system pressure. The design shall ensure that if lower pressure-rated components are used, they will not be damaged from higher system pressures.

Hydrant fueling pits shall conform with NFPA 407, NFPA 415, and other building codes and be coordinated with aircraft parking plans to ensure necessary fueling operations are possible at each aircraft gate.

Positive isolation valves (API 6D DBB plug valves) shall be installed in valve vaults throughout the hydrant fueling system for maintenance, testing, emergency operations, and leak detection.

2.3 Fuel Storage Facility

New facilities or upgrades at DEN shall be designed to minimize the impact to current operations. A thorough analysis shall be conducted of the current operations, tank capacities, days of reserve, future airport growth, fuel delivery modes (current and future), fuel receipt capabilities, truck loading, and product recovery systems.

Location siting, new designs or upgrades to existing, shall consider FAA clearances, site access, available utilities, security requirements, site topography and surface water drainage, subsurface conditions, environmental requirements including SPCC requirements, and shall be coordinated with the DFD and any other authorities having jurisdiction.

2.4 Other Considerations

2.4.1 Operations Building

Operations buildings may be included in fuel facility designs. They may include but are not limited to:

A. Office space for supervisors and managers
B. Fuel facility control room and dispatch
C. A “Locker room” and break room for fueling personnel
D. Fuel testing facilities

2.4.2 Maintenance Facilities

Maintenance facilities are often required for performing regularly scheduled maintenance for fueling service equipment and should be considered during design.

2.4.3 Fuel Other than Aviation Fuel

Products other than jet fuel should be considered when designing fuel storage facilities. Often other products such as unleaded gasoline, diesel fuel, and other grades of aviation gasoline (Avgas) can be stored at fuel storage facilities.

These products are not within the scope of this document, but the design of these systems should be considered as they may be required and are specialty systems with their own industry codes and standards.

2.4.4 Fire Protection

The DFD shall be consulted to determine the extent of the fire protection required for any new facility and upgrades to existing fuel storage facilities or tanks. Firewater protection (fire hydrants) in fuel storage facilities is typically required. Foam suppression systems for fuel storage tanks may be required. At a minimum, requirements of NFPA 11, NFPA 24, and NFPA 30 shall be followed.

2.4.5 Environmental Considerations

Secondary containment shall be provided at any areas where there is a potential for fuel spill, including all aboveground tanks, loading/unloading areas, and equipment parking areas in accordance with applicable codes and regulations.

Review 40 CFR part 112 for general SPCC regulations/requirements.

Review current applicable regulations to ensure compliance with product emissions.

Review current environmental regulations/requirements for any special handling procedures and discharge restrictions for water with potential hydrocarbons present.

End of Chapter

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Chapter 3 - Fuel Storage Facility

3.0 Fuel Storage Facility Sizing and Layout

The fuel storage facility shall be sized to provide adequate flow to the hydrant system during the peak hours of operations. Tank capacities shall be sized based on analysis of the current and projected daily consumption, desired days of the reserve, fuel resupply capabilities and methods, and fuel quality.

The fuel storage facility shall be designed in accordance with ATA103, NFPA 30, and ASME B31.3 Process Piping Code. The system piping and components shall be ASME class 150 pressure rating. This pressure rating has a maximum allowable working pressure of 270 psig at ambient conditions and 180 psig at ~400 degrees F. However, some aircraft fueling components are not rated for this working pressure, and some system components could have a higher pressure rating. The design shall ensure that if lower pressure-rated components are used, they will not be damaged from higher system pressures.

The fuel storage facility site layout shall be based on NFPA 30 setback requirements. Secondary containment provisions shall meet the requirements of NFPA 30, 40 CFR part 112, state, and local requirements.

3.1 Fuel Receipt

The current and future fuel delivery methods should be analyzed to determine the optimal solution for maintaining adequate inventory with uninterrupted service. When considering a new or expanded facility, consideration should be given at a minimum for space to accommodate equipment, flow rates, land and airspace usage clearances, fuel quality, facility access, security, public impact, and environmental.

All fuel delivery methods shall be processed and filtered in accordance with all local, State, and federal regulations and industry standards and based on anticipated impurities for aviation fuel.

3.1.1 Pipeline Delivery

When designing for expanded or new pipeline delivery systems, take into consideration existing and planned pipeline operating agreements as well as the expected flow rates, tank fill piping configurations and sizes, and expected operating pressures. Multi-product pipelines and breakout tanks as appropriate for the project.

Provide surge tanks as needed. Requirements for controls communications with the pipeline shall be coordinated with the DEN Project Manager.

Coordinate the custody transfer point and the delineation point between pipeline and client ownership/responsibility with the DEN Project Manager.

3.1.2 Truck Receipt

When designing for expanded or new truck delivery systems, provide sufficient as required for multiple unload positions and for truck maneuvering. Coordinate the number of offloading positions required as appropriate for the project. The truck receipt area shall be designed for efficient use of manpower while in operation and minimal impact to the public through traffic congestion. Provide sufficient access for delivery vehicles and staging areas for waiting for delivery vehicles. Provide reinforced concrete pavement under the truck offload area.

Offload stand shall be provided with secondary containment to comply with applicable API standards and this manual. The truck offload containment area shall be sized to contain the largest truck compartment.

Provide reinforced concrete slab with perimeter curbs under fueling equipment. All slab joints shall be sealed with a fuel-resistant joint sealant, and exposed concrete surfaces shall be sealed with a fuel-resistant penetrating sealer/hardener. Containment areas shall be sloped and drained into an oil/water separator.

3.1.3 Other Receipt Methods

Rail delivery could be considered; however, a receiving/pumping station would need to be built approximately 10 miles to the west or tracks diverted to the tank farm facility to accommodate this method if it was determined to be a viable option.

3.2 Fuel Sampling and Processing (Filtration)

Fuel processing is an important factor in fuel quality and is required by ATA-103. Fuel receipt, issue, and recirculation shall have the necessary fuel processing equipment installed based on anticipated impurities which may include:

A. Prefilters for removal of solids
B. Clay treaters for removal of surfactants
C. Filter/Separators for the removal of fine solids and water separation

Fuel sampling connections shall be installed where necessary per ATA 103. Relaxation tanks shall be installed in the system where necessary per NFPA 407.

3.3 Fuel Storage Tanks

Once the necessary fuel storage capacity has been determined based on the current and future fuel demand analysis, the number and size of additional or future fuel storage tanks shall be determined. Space for future additional tanks shall be considered.

3.3.1 Aboveground Fuel Storage Tanks

Aboveground fuel storage tank design shall comply with the latest editions of the following standards:

A. Overall tank design and construction: API 650
B. Seismic design: API 650, Seismic use group III (Essential Facility)
C. Gauging: API 2350
D. Venting: API 2000
E. Leak detection: API 650
F. Internal coatings: API RP 652

Tank design shall include internal and external coatings, suction nozzles, and fill nozzles. Suction nozzles shall be equipped with floating suction arms, and fill nozzles shall be equipped with diffusers. The tank shall also be equipped with a center sump and water draw-off.

Tank shall have a cone-down configuration with the bottom plates sloped toward the center sump. Tank design shall include the necessary freeboard to accommodate seismic sloshing. Provide freeboard height to prevent the sloshing waves from reaching the tank roof framing or from damaging the internal floating pan. Leak detection shall be provided for all aboveground fuel storage tanks.

Provide tank anchorage as necessary to resist seismic and wind loads, with hydrostatic buoyancy assuming an empty tank with water exterior of the tank at a level 6" above the shell manhole invert. Tank anchorages shall meet the shell displacement limitations listed in API 650 Table E.8.

3.3.2 Reinforced Concrete Foundations

Reinforced concrete foundations shall be provided under each tank. Foundations shall be either reinforced concrete ringwall or mat slab as appropriate. Foundations shall be designed in accordance with API 650, ACI 318, and ACI 350 requirements. The design shall include provisions to minimize cracks.

Geotechnical investigations shall be performed to obtain the necessary design parameters. Where required, use only hot-dipped galvanized anchor bolts for tank anchorage. Tank perimeter chime shall be sealed to prevent the water migration under the tank.

3.3.3 Under Tank Secondary Containment

Under tank, secondary containment shall be provided when using ringwall foundation systems. Provide a reinforced membrane liner (40 mil minimum thickness) to serve as an impermeable barrier to prevent accidental fuel release to the surrounding soil.

Provide an impressed current cathodic protection system to protect the tank bottom plates. Locate the rectifier equipment in an easily accessible location for periodic testing. Provide a sand layer between the membrane liner and the underside of the tank for cathodic protection bedding. Sand shall be clean with chloride content less than 100 mg/kg and a minimum electrical resistance of 25,000 ohms per cm.

Provide HDPE or FRP pipe system to drain the under-tank sand bedding and to serve as leak detection. Pipes shall be drained into a sump and shall prevent water migration into the sand bedding.

When using a mat foundation system, provide a concrete sump under the tank center sump. Top of foundation shall be sloped down towards the center sump to match the tank configuration. Top surfaces of the foundation shall be grooved to promote free-draining toward the center sump. Concrete surfaces shall be sealed with penetrating sealer/hardener to improve surface impermeability. Provide HDPE or FRP pipe system to drain the center sump and to serve as leak detection. Pipes shall be drained into an exterior sump but shall prevent migration of water back into the sump.

3.3.4 Mat Foundation System

When using a mat foundation system, provide a concrete sump under the tank center sump. Top of foundation shall be sloped down towards the center sump to match the tank configuration. Top surfaces of the foundation shall be grooved to promote free-draining toward the center sump. Concrete surfaces shall be sealed with penetrating sealer/hardener to improve surface impermeability. Provide HDPE or FRP pipe system to drain the center sump and to serve as leak detection. Pipes shall be drained into an exterior sump but shall prevent migration of water back into the sump.

3.3.5 Tank Containment Area

Provide a secondary containment area with vertical concrete dike walls around all tanks. Limit dike wall height to 6'-0" maximum. Concrete dike walls shall be designed in accordance with ACI 318 and 350. Locate wall joints as necessary to minimize and control cracks. All wall joints shall be equipped with fuel-resistant waters tops and joint sealants.

The floor of the containment area shall be lined with a reinforced flexible membrane liner (FML). Provide 4" minimum gravel surfacing material and geotextile filter fabric over the FML. Where the containment area is accessible to vehicles, the FML shall be protected. Provide a minimum of 2'-0" of soil between the geotextile filter fabric and the liner. The FML shall be anchored to concrete dike walls and tank foundations using embedded anchor strips compatible with the FML.

Provide galvanized steel access stairs into the dike containment areas. Locate access stairs at locations suitable for access and emergency egress. Provide a minimum of two unobstructed egress paths from each containment area. Where vehicle entry is required, the designer shall coordinate the types of expected vehicle traffic with the DEN Project Manager and provide ramps designed to support those vehicles.

3.4 Pump Manifold

Each fuel storage tank feeds the pump manifold with two separate 30” suction lines, one to the east and one to the west for redundancy and flexibility of the system. Pump manifold is fed using one tank at a time after settling and testing has been performed as per ATA 103. As additional storage tanks are added to the system, dual feed to pump manifold shall be considered. Specific information on pumps within the pump manifold can be found in Chapter 6-Pumps.

3.5 Fuel Storage Facility Valves

Valves shall be provided on all tank piping nozzles for isolation. Double block and bleed valves are recommended for this service. Valves shall be fire safe and meet API 607. DFD shall be consulted on the use of fire rated motors for MOVs and self-closing fire safety valves. Additional information on Fuel Storage Facility Valves can be found in 5.3.Fuel Storage Facility Valves.

3.6 Refueler Truck Loading

Refueler trucks are an important secondary means for fueling operations that need to be accomplished in areas where the hydrant system does not reach or on aircraft where overwing fueling is the primary means of refueling. Refueling trucks can also be used in a situation where a portion of the hydrant system is offline.

Additional refueling truck loading positions should be considered per the flights being serviced by the refueler tanker and loading turnaround times. While the location of the loading positions is typically at the fuel storage facility, they may be located elsewhere based on operational needs. They should be located as close to the airport operations area (AOA), or if possible, on the AOA, to minimize the amount of refilling time. Coordinate with Airport Operations, Denver Airport Authority, DFD, and Operator.

Jet fuel truck loading positions shall be an extension of the hydrant system piping or have their own pump and filtration. Refueler truck loading positions are typically equipped with an Overflow Protection and Grounding system and shall be coordinated with the refueler service equipment. For each refueler truck loading position, an EFSO station is required. Refueler truck loading positions shall be bottom loading only. Relaxation tanks shall be installed as necessary per NFPA 407.

3.6.1 Loading Area Secondary Containment

Provide reinforced concrete pavement under the truck loading area. The truck loading containment area shall be sized to contain the largest truck compartment. Provide reinforced concrete slab with perimeter curbs under fueling equipment. All slab joints shall be sealed with a fuel-resistant joint sealant, and exposed concrete surfaces shall be sealed with fuel-resistant penetrating sealer/hardener. Containment areas shall be sloped and drained into an oil/water separator.

End of Chapter

Chapter 4 - Hydrant System Piping

4.0 General

The jet fuel hydrant system at DEN consists of a series of underground piping that runs from the Fuel Storage Facility to each of the concourse gates. This chapter outlines general design considerations and specifications for piping, connections, hydrant pits, and other components of the hydrant system.

4.1 Pipe Sizing and Fuel Velocity

Fuel quality can be affected by contaminants that have passed through the filtration and water separation process due to failure of filter media, construction, or regularly scheduled maintenance. Hydrant fueling system piping shall be sized to allow proper flow rates, pipe maintenance, and static relaxation.

Typical design velocities are five (5) to ten (10) feet per second (fps) at peak flow rates to ensure lines are kept clear and any contaminants are swept to the low point drains. Velocities below three (3) fps are not recommended as they do not facilitate the movement of water and particulate in the piping.

Piping shall be sloped to facilitate removal of air, water, and particulate at the high point vents and low point drains. Fuel piping should slope at a minimum of 0.5%. If a lesser slope is necessary for design purposes, DEN approval is required, and slope shall not go below 0.2%.

Lateral pipe sections should slope at a minimum of 1 percent, sloping down towards the main fuel pipe. The distance of the hydrant fueling pit from the main hydrant fueling loop must be considered when sizing the hydrant fueling laterals due to potential surge issues. The minimum lateral pipe size connecting the hydrant fueling pit to the main fuel pipe is six (6) inches, but, for long laterals serving widebody aircraft, an eight (8)-inch diameter lateral may be required. Should an 8-inch lateral be required, it shall be reduced just outside the hydrant fueling pit.

4.2 Layout and Spacing

Fuel pipe main lines shall be located to minimize lateral pipe lengths. Fuel pipe mains shall not be located under a building or passenger terminal.

Pipe spacing shall be per applicable codes. Spacing shall allow a minimum of six (6) inches of flowable fill to be placed horizontally and 12 inches vertically between pipes and shall consider cathodic protection requirements. Piping shall be spaced a minimum of 36 inches horizontally and 12 inches vertically to leave room for utilities. If these distances cannot be met, provide insulating material and consider the cathodic protection of the piping and the encroaching utilities.

4.3 Excavation and Backfill

Pipe bedding material for exterior coated steel pipe shall be flowable fill. Acceptable flowable fill shall be a controlled low-strength material (CLSM); the designer shall utilize the DEN standard CLSM specification or provide a flowable fill mix design developed by an independent testing laboratory for review. The flowable fill shall consist of sand conforming to ASTM C33 or C144, fly ash conforming to ASTM C618, Portland cement conforming to ASTM C150, or other materials approved by the Engineer. The flowable fill shall have a 28-day compressive strength of not less than 25 psi or more than 100 psi. The pH range of the flowable fill shall be 8-10.

Ensure the pavement structure does not encroach into the backfill over lateral piping sections.

The flowable fill resistivity shall be submitted to the Cathodic Protection Engineer to coordinate the design of the cathodic protection system, including confirming that the flowable fill will not shield the cathodic current.

Cathodic protection anodes shall not be buried in flowable fill.

4.4 Fuel System Piping

The fuel piping shall meet the following requirements:

A. The system piping shall be ASME Class 150 pressure rating unless otherwise required for higher system working pressures
B. Changes in direction shall be accomplished with fittings
C. Pipe Diameter
    a. Pipe 2 inches and smaller shall be seamless Schedule 80
    b. Pipe 2-1/2 inches through 10 inches shall be Schedule 40 (Standard Weight)
    c. Pipe 12 inches or larger shall be 3/8-inch (0.375-inch) wall thickness (Standard Weight)
D. Shall be designed in accordance with ASME B31.3 Process Piping Code
E. Piping in contact with fuel shall be internally coated carbon steel as specified below or uncoated stainless steel
F. Copper, zinc, cadmium, lead, and their alloys shall not be used in the system
G. Galvanized piping and fittings shall not be used in the system
H. System pipe shall be ASTM 53 Grade B, ASTM A106 Grade B, or API 5L Grade B
    a. All piping shall be stamped with the specification and grade. If factory coated specification and grade shall be stenciled
        • Carbon steel piping 2-1/2 inches and larger shall be internally coated
        • Flanges shall be forged weld neck type

    Slip-on flanges shall only be used when approved by DEN/Operator

4.5 Connections and Fittings

4.5.1 Welding

All connections on buried piping shall be welded connections. Gas Tungsten Arc Welding (GTAW or TIG) procedures shall be used on the initial 'root' pass and subsequent 'hot' pass(es) to prevent excess slag on the inside of the pipe. All welding shall be in accordance with applicable welding procedures and specifications, including but not limited to ASME B31.3 and ASME Boiler and Pressure Vessel Code section IX.

4.5.2 Fittings

Fittings used in the system shall meet the following requirements:

A. Fittings 2-1/2 inches or larger shall be internally coated
B. All buried fittings shall be butt welded and suitable for radiograph inspection
C. Fittings 2-1/2 inches and larger shall be ASTM A234 Grade WPB with wall thickness to match pipe
D. Fittings 2 inches and smaller shall be ASTM A105
E. Elbows shall be a long radius
F. Changes in a direction other than 45 degrees or 90 degrees shall be made by cutting elbows to the proper angle and shop beveling the edges. Lines shall be parallel, perpendicular, or 45 degrees to existing mains.

4.6 Pipe Supports

Supports shall be provided for aboveground fuel pipes. Supports shall be located and designed to resist both vertical and lateral loads as appropriate. Pipe stress modeling and analysis shall be conducted using a software package specifically designed for that purpose. Pipe supports shall have low-friction, non-metallic isolation pads installed between the piping and support. Pipe support structures may be reinforced concrete or steel. All steel supports exposed to the outdoor environment shall be galvanized. Where required, paint coating may be applied over the galvanized surfaces.

4.7 Hydrant Pits

4.7.1 Hydrant Pit Placement

Hydrant pit placement shall be coordinated with DEN Airside Planning. The placement and number of hydrant pits should be minimized based on aircraft parking plans and aircraft mix.

Hydrant fueling pits shall optimally be located within a 25-foot horizontal radius from the aircraft fueling points. Hydrant fueling pits shall not be located directly under the aircraft fuselage, engine cowlings, directly under the fueling connection point of any aircraft, or in areas subject to drive-over by the aircraft landing gear, including both main gear and nosewheel. Locate the hydrant fueling pits as far away from aircraft engine intakes and exhausts as possible, accounting for the above location constraints.

Two (2) hydrant fueling pits are required for wide-body aircraft for each wing's fuel connection point. If only one hydrant pit is provided for wide-body aircraft, it shall be located to supply the left-wing fueling connection.

Locate hydrant fueling pits to minimize the effects of jet blasts from taxiing aircraft on fueling operations. Locate the hydrant fueling pits so that the connection to the hydrant pits does not interfere with aircraft fuel port access, particularly with aircraft types having low wing clearance or low jet engine clearance to the ramp (i.e., Boeing 737 and similar aircraft).

Verify that each hydrant fueling pit position has a clear line of sight to nearby EFSO stations.

Locate hydrant fueling pits a minimum of 50 feet from terminal or concourse buildings in accordance with NFPA 407. Locate hydrant fueling pits and other potential spill points at least 100 feet from the terminal or concourse building glazing where possible. Where hydrant fueling pits and spill points are located less than 100 feet from building glazing, provide an automatic sprinkler system at the face of the building in accordance with NFPA 415.

Locate the hydrant fueling pits away from wing end vents to avoid encountering fuel vapors and promote a more fire-safe condition.

4.7.2 Ground Service Equipment

Ground servicing operations shall be considered when selecting a hydrant fueling pit location. Assure that the hydrant fueling pit locations consider the presence of possible aircraft access bridges, catering vehicles, baggage handling, and other potential ramp equipment in the vicinity.

Verify the actual hydrant fueling servicing equipment to be utilized in order to visualize where the servicer must be parked during fueling operations. Determine whether the proposed hydrant fueling pit location accommodates the hydrant fueling servicer in a parked position while accessing the aircraft fuel point without blocking other ramp equipment.

Locate the hydrant fueling pits so there is no interference with the travel way between wings of adjacent aircraft.

4.7.3 Drainage

Paving adjacent to hydrant fueling pits and all other fuel pits shall have positive drainage to help shed surface water away from the pits as per NFPA 407, 4.1.12.4.1. Refer to the Civil DSM for pavement design guidelines. Locate the hydrant fueling pits such that the crown will not result in localized high-slope areas. Locating the hydrant fueling pit in the center of either a PCC pavement quarter panel or whole panel center typically accommodates this

Verify that hydrant fueling pits are located away from apron drainage storm inlets as well as other utility access lids.

4.7.4 Hydrant Pit Requirements:

A. General Requirements: Assembly to be complete with a shutoff valve, hydrant pit valve, strainer, and piping accessories to be installed in a concrete pavement apron, suitable for interfacing the fixed fuel system components with the hydrant fueling vehicle

B. Access Cover shall:

   a. Identification, "FUEL" shall be in raised letters on the cover door
   b. Be water resistant
   c. Be aircraft-rated cast aluminum

C. Performance: Designed to permit a fueling flow rate of 800 gpm. Liquid to be jet fuel with a specific gravity of 0.81 +0.05.

D. Hydrant lateral taps shall be made in the top of the main utilizing a Sweepolet or Vesselet. Weldolets shall not be utilized for underground piping taps.

E. Hydrant pit laterals shall be installed perpendicular, parallel, or at 45 degrees to the existing mains. Line markers shall be installed at a grade above all changes in direction.

F. Pit structures shall be designed as secondary containment and shall be constructed to be watertight.

G. Construction:
   a. Pits shall be side entry.
   b. Body shall be one-piece molded fiberglass with built-in concrete anchors.
   c. Valve Pit structure may consist of a prefabricated fiberglass pit with reinforced concrete encasement or a cast-in-place reinforced concrete structure. Pit structure (walls and slabs) shall be designed to handle direct and indirect aircraft wheel loads.
   d. Pit shall have a sealed interior pipe entry with a steel sleeve encapsulated in fiberglass. Sleeve penetrations shall be suitable for segmented mechanical seals (a total of two per pipe penetration) and installation of heat shrink boot seals on the exterior of the pipe penetration.

H. Internal Coating: Hydrant pits shall be internally coated with a two-part, spray-on polyurea coating. Coating will reduce permeability and enhance fuel resistance of the secondary containment system.

4.8 High Point Vent and Low Point Drain Pits

High Point Vents and Low Point Drains shall be installed throughout the hydrant system and fuel storage facility in order to fill, drain, vent, and test fuel system lines. The number of high point vents (HPVs) and low point drains (LPDs) shall be minimized while meeting the pipe slope criteria. However, they shall be provided in sufficient numbers to allow for proper draining and filling of the system as well as to allow periodic purging of air in HPVs and drainage of accumulated water, sediment, and debris in LPDs. Where possible, HPVs and LPDs shall be located within isolation valve vaults (IVVs). When HPVs and LPDs cannot be installed in IVVs, provide individual or combination HPV/LPD pits.

HPV and LPD locations shall be coordinated with aircraft parking plans such that they are accessible without impeding aircraft and airport operations while performing monthly services. HPV and LPD locations shall not be located in aircraft movement areas. Where possible, IVVs shall be positioned such that a lid will not be affected by jet blast when in the open position.

Piping from HPVs and LPDs shall be extended up to a level such that they are accessible by maintenance personnel without requiring confined space entry and equipped with a ball valve and camlock connection with a dust cap.

Molded prefabricated fiberglass construction complete with hinged aluminum access cover valves and piping. Piping shall:

A. Be extended up such that confined spaces entry is not required for monthly checks and services

B. Clearly marked as "High Point" or "Low Point."

C. Be 2-inch diameter

D. Have API 607 Fire Safe lockable ball valve

E. Have camlock connection with dust cap.

F. Access Cover shall:
   a. Be aircraft-rated, cast aluminum
   b. Be water resistant
   c. Have "Jet-A High Point," "Jet-A Low Point," or "Jet-A High/Low Point" engraved on the lid

4.9 Surge Suppression

Hydraulic and surge analysis shall be performed as directed by DEN Project Manager using software to model hydraulic steady state friction losses and transient surge pressures. Analyses shall simulate worst case scenarios to determine if emergency fuel shutoff (EFSO) or hydrant fueling valve closures can produce pressures exceeding allowable code and determine whether surge suppression is required.

Suppressors shall be carbon steel or stainless-steel construction with removable top. Suppressor shall have isolation valves installed on inlet to allow for periodic maintenance. Isolation valve shall be DBB if suppressor is installed in section of piping that will be pressure tested. Suppressor shall have a check valve installed on the inlet and a 1" bypass line with a ball valve and ½" drain valve to allow unrestricted flow into the suppressor and restricted flow out. Suppressors shall be nitrogen filled with Buna-N bladders.

Design shall consider the use of thermal relief valves for limiting the pressure of the piping in accordance with code requirements.

4.10 Testing

All temporary and permanent piping shall be tested in accordance with NFPA 407, ATA 103, and ASME B31.3 as outlined in Chapter 10- System Inspection, Testing, and Flushing. The Denver Fire Department (DFD) Aircraft Fueling Process Piping Permit Responsibilities Form, available upon request from DFD, shall be used for guidance. Verify with the DFD that the provided form is the most current version prior to implementation.

4.11 Miscellaneous

4.11.1 Hydrant Cart Test Stands

HCTS are typically located at the fuel storage facility but can be located elsewhere. HCTS are used for required monthly checks and services of fuel service equipment. The HCTS can be an extension of the hydrant system piping or have their own pump and filtration. The HCTS will have a hydrant valve to connect the fuel service equipment, single-point connections for the ground, and elevated single-point nozzles.

The HCTS will have a throttling valve to supply back pressure to the system simulating an aircraft during refueling. Provide a pressure gauge between the throttling valve and the single-point connections. Back pressure on the fuel return line of the HCTS shall not exceed 25 psig at normal flow rates.

HCTS piping shall be sized to accommodate pipe velocities of 6-8 feet per second at normal flow rates. The maximum flow rate shall be coordinated with the fuel system operator. The HCTS can return fuel to the bulk storage tanks through filtration or to its own operating tank.

Provide a positive displacement meter for proving hydrant cart meters as required. Provide meter proving connections as necessary for positive displacement meter.

4.11.2 Product Recovery

Product recovery systems typically consist of a large above-ground product recovery tank (PRT) and a sump tank at the fuel storage facility. The PRT is typically configured to receive fuel from thermal relief valves, equipment sumps, equipment drains, sump separators, high-point vents, low-point drains, and other fuel collection points. The PRT will be outfitted with a pump to return the fuel to the system when the tank reaches the full level. This can be accomplished automatically with integrated tank gauging or manually.

The sump tank is typically configured to receive waste fuel/water mixture from equipment sumps and sump separators that has been determined to be unsuitable for return to the system. It is common to have one or two pumps installed to offload the tank when it reaches full capacity and to allow the operator’s vacuum truck to be offloaded into the tank as needed. It should be determined if a tank heater should be installed in the sump tank as its contents will be a large percentage of water.

End of Chapter

Chapter 5 - Valves and Valve Vaults

5.0 General

Fuel thermal stability shall be considered when selecting valve materials and construction. Internal epoxy coating, compatible plating, or material selection such as steel or stainless steel shall be specified. Seal material shall be nitrile, Viton, Teflon, or other fuel-compatible material. Avoid neoprene, ethylene propylene diene monomer (EPDM), or natural rubber.

Double Block and Bleed (DBB) type plug valves shall be used in isolation valve vaults or other locations where positive isolation is required. Use ball valves for piping two (2) inches or smaller for general maintenance isolation. Butterfly valves shall only be used for non-critical isolation. Avoid the use of gate valves in the aviation fueling system. All valves shall be API 607 “fire safe” or similar. All Valves are to be coated to prevent corrosion as defined in Chapter 7- Corrosion Protection.

5.0.1 Valve Criteria

Valves used in the system shall meet the following minimum criteria:

A. Carbon or stainless-steel construction with fire-safe rating per relevant API documentation
B. Bidirectional flow
C. Class VI bubble tight shutoff construction per ANSI B16.104
D. Valves required to be full port shall be called out as such in design documents
E. Stainless steel trim
F. Seats and seals shall be suitable for Jet A service and fire safe in accordance with applicable industry codes and standards.
G. Raised face Suitable for service in specified ASME Class 150 piping

5.1 Hydrant System Valves

5.1.1 Butterfly Valves

Butterfly valves, at minimum, shall be fire-safe, high performance, lug style meeting API STD 607 and API STD 609. Isolation butterfly valves shall be installed upstream of hydrant valves to allow maintenance and replacement of the hydrant valve without removing fuel from the system.

5.1.2 Ball Valves

Ball Valves, at minimum, shall be fire-safe, meeting API STD 607 and API STD 6D. In piping 14 inch and larger, ball valves shall be trunnion mounted.

5.1.3 Double Block and Bleed Plug Valves

DBB Valves, at minimum, shall have slip replacement from the bottom. For valves 12 inches and smaller, ensure sufficient room beneath the valve is provided to maintain the valve and allow for slip replacement. Valves shall meet the requirements of API SPEC 6D. Provide a manual bleed valve and a body cavity thermal relief discharging upstream of the valve.

DBB valves are required to obtain successful leak detection test results prior to being put into service.

5.1.4 Control Valves

Control Valves, at minimum, shall have ductile iron or cast steel construction with stainless steel internals, control pilots, and tubing. All non-stainless-steel surfaces in contact with fuel shall have a 3-mil minimum chrome or nickel plating. All control valves with solenoid operators shall have a manual bypass, and all control valves shall have manual isolation valves installed upstream and downstream for maintenance.

5.1.5 Check Valves

Check valves 2-1/2 inches and smaller shall be threaded, forged steel, Class 800, lift check valves.

Check valves 3 inches and larger shall be non-slam, spring-assisted, center-guided, wafer-style suitable for 275-psig working pressure. Valves shall be constructed with class ASME Class 150 raised face flanges and meet the requirements of API STD 594.

The specifying and indicating of double-plate check valves should be limited to where low-pressure drop across check valves is required.

Double-plate check valve specifications (if required):

A. Valve shall be a dual-plate wafer style suitable for 275 psig working pressure, designed and tested to API 594.
B. Valve body and plate shall be carbon steel with ASTM A216 GR WCB, 410SS plates, and pin, ASTM A217 GR CA15, Inconel Spring, metal to metal seat ring.
C. Ends shall be suitable for installation between ASME Class 150 raised-face flanges.
D. Valves shall be suitable for horizontal or vertical installation as indicated.

5.1.6 Hydrant Values

At a minimum or approved otherwise, the hydrant valve shall be 6x 4-inch of ductile iron construction with a Class 150 inlet flange. Valves shall have a 4-inch EI Specification 1584, latest edition, adapter outlet flange unless approved otherwise. Hydrant valves shall match existing hydrant valves unless approved otherwise.

Existing hydrant valves:

- Carter Model 61654BX with #64230 Actuator Assembly and #47576 Connector Assembly, manufactured by Eaton Aerospace Group Inc

5.2 Isolation Valve Vaults

IVVs shall be included at strategic locations throughout the hydrant system to provide positive isolation for maintenance operations, emergency operations, and leak detection as required. The number and locations of the IVVs shall be coordinated with the DEN Project Manager.

IVVs shall be installed at a minimum of every five gates in order to minimize the impact on aircraft in case of maintenance or issues with the hydrant system.

Isolation vaults and valves shall be located to optimize the isolation of segments by minimizing the volume of above-ground piping being tested while maximizing test result accuracy. If leak detection is not included in the design, the flexibility to accommodate future leak detection installations shall be discussed and included in the current design, if requested by DEN, to accommodate any future leak detection installations. If leak detection is included in the design, the system shall be designed to accommodate any potential technological advances and upgrades to the system.

IVV locations shall be coordinated with aircraft parking plans such that they are accessible without impeding aircraft and airport operations while performing monthly services per ATA 103. IVVs shall be located such that they are easily accessible in emergency situations. IVVs shall not be located in aircraft movement areas. IVVs shall be positioned so that the lid will not be affected by the jet blast when in the open position.

IVVs shall be equipped with the following:

A. Intermediate platform with removable aluminum grating to allow access to actuators and maintenance items without confined spaces entry
B. Lids for Valve Vaults shall:
    a. Have “Fuel Valve Access” engraved in the lid
    b. Be waterproof

c. Be aircraft-rated cast aluminum
d. Have torsion springs or a hydraulic operator for assisted opening

C. Fixed access ladder
D. An 18" X 18" X 12" deep sump with a grating cover in one corner of the vault.
E. A two (2) inch sump pipe routed from the corner sump above the intermediate platform with a camlock connection.
F. Construction: Valve Vaults shall be constructed of a cast-in-place reinforced concrete structure. Vault structure (walls and slabs) shall be designed to handle direct and indirect aircraft wheel loads.
G. Vault structures shall be designed as secondary containment and shall be constructed to be watertight. Provide waterproofing or dampproofing as appropriate on the exterior side of the cast-in-place vault walls. All joints in the walls and slabs in cast-in-place concrete vaults shall be equipped with fuel-resistant water stops.
H. Interior surfaces of these Vaults shall be coated with white-colored epoxy coating. The white-colored coating will aid visibility inside the vaults, while the epoxy coating will reduce permeability and enhance the fuel resistance of the secondary containment system.
I. Vaults below grade shall be designed for buoyancy conditions and provide a minimum factor of safety of 1.10 against buoyancy during construction. The critical design condition during construction shall assume an empty vault (prior to soil backfill) with an exterior water level up to the top of the surrounding grade. The final backfilled installation shall be provided with a minimum factor of safety of 1.50 against buoyancy under a fully submerged condition (with water at grade level).

5.3 Fuel Storage Facility Valves

Valves shall be provided on all tank piping nozzles for isolation. Double block and bleed valves are recommended for this service. Valves shall be fire safe and meet API 607. DFD shall be consulted on the use of fire-rated motors for MOVs and self-closing fire safety valves. Determine the necessity of hydraulically or electrically operated valves to prevent tank overfilling.

Generally, gate valves are not recommended; however, WKM Through-Conduit Safety Seal Gate Valves with pneumatic open/spring return close actuators are preferred for storage tank isolation due to their rapid actuation and sealing reliability while exposed to fire.

5.3.1 Fusible Link Quick Closing Tank Valve

Fusible link tank valves are not required in all locations. DFD shall be consulted on the use of fusible link tank valves. The valve body shall be cast of carbon steel. Shaft packing shall be of graphite composite, combustion-resistant material.

5.3.2 Tank Containment Valve Actuators

The need/desire for fire resistive casing insulation should be discussed with the DFD, the design team, and Owner. If fire-rated actuators are to be provided, the fire-rated cable should be provided in tank dike areas to maintain fire integrity.

To reduce the cost of actuators and power required when large suction lines are present, downsize actuators. Actuators shall be capable of operating with a 275-psi upstream to downstream line pressure differential, with corresponding 275-psig upstream and 0-psig downstream pressures, while complying with handwheel requirements specified under “Manual Operation.”

5.3.3 Automatic Recirculation Valve

Automatic recirculation valves shall be installed on pump manifold discharge headers to provide minimum recirculation flow specified by the pump manufacturer to protect the system centrifugal pumps from cavitation and pump deadheading. The valve shall modulate between full recirculation flow at zero system demand and zero recirculation at full system demand.

In addition, 2-inch differential pressure relief valves shall be installed on each pump discharge line.

5.3.4 Water Slug Valve

Shall be located downstream of filter/separator and close by electric or hydraulic signal upon detection of water by the float pilot or water detection probe contained within the filter/separator. The valve shall normally be closed and flow to open.

5.3.5 Refueler Loading Control Valve

The truck loading flow control valve is designed for regulating flow when handling turbine jet fuel to 400 gpm. It shall provide solenoid-controlled, two-stage opening and closing in conjunction with a pre-set feature on the electronic metering control system. The valve shall also control the flow rate to 400 gpm, provide surge control, and include manual override. All functions shall be externally adjustable. The surge control pilot shall respond to pressure changes sensed downstream. When downstream pressure increases to the set point of the pilot, the control system shall function to close the main valve until normal downstream pressure is restored. The surge pilot shall function in the range of 30 to 70 psig.

5.3.6 Tank High-Level Shut-off Valves

A. Shall be hydraulically operated and shall be provided with a tank-mounted float controller. Activation point of the float for opening and closing the high liquid level shut-off valve shall be determined in coordination with the Engineer. Upon a rise in fluid level to the float activation point, the float control system shall cause the main valve to close tightly. The main valve shall remain closed until a drop-in tank fluid level occurs. Upon a drop-in fluid level beneath the float activation point, the float control shall allow the main valve to open completely. Valve shall be non-throttling type, normally closed, and flow to open.

B. Tank high-level shut-off valves are no longer recommended in commercial fueling systems for pipeline receipt. Pipeline receipt overfill prevention should be accomplished by other means, such as MOVs hard-wired to high-high level switches and ATG alarm points initiating action. Use of these valves should be limited to other applications such as a truck receipt, PRTs, etc.

5.3.7 Terminal Main Control Valves

Shall provide solenoid open-close service and pressure-reducing control.

5.3.8 Hydrant Cart Test Stand Control Valve

Shall be identical to the terminal main control valves with exceptions listed in provided specifications.

End of Chapter

Chapter 6 - Pumps

6.0 General

Primary pumps for the fuel system are located at the fuel storage facility and are designed to pressurize and deliver fuel to the hydrant system. Size and quantity of pumps are determined based on the peak fuel demand of the airport. Pump types include centrifugal and positive displacement pumps. Other required pumps include:

A. Hydrant system pumps
B. Fuel delivery offload pumps
C. Fuel Service truck loading pumps
D. Product recovery tank pumps
E. Sump tank load/offload pumps
F. Hydrant cart test stand pumps
G. Oil water separator pumps
H. Sump separator pumps
I. Tank “stripping” pumps
J. Tank-to-tank transfer pumps
K. Water draw-off pumps

Strainers shall be installed upstream of all pumps. Air eliminators are specifically required for pumps used in custody transfer, not to allow air to pass through the meter, and shall be installed as needed.

6.1 Centrifugal Pumps

Centrifugal pumps shall be API 610 latest edition construction. The impeller and shaft shall be 12% chrome steel overhung type, and all other construction materials shall be per API-610 S-6 material classification. The pump shall be manufactured specifically for handling jet fuel or the medium being pumped. Pumps shall be complete with pump, motor, coupling, mounting base, accessories, and all other parts and materials necessary for a complete installation. Pump motors shall be UL listed for Class-1 Division-1 service.

Temperature and vibration sensing equipment shall be provided to shut down the pump during high temperatures and excessive vibration, in addition to the NFPA-required motor winding high-temperature shut-down.

Mechanical seals shall conform to API Std. 682. Couplings shall have sufficient spacer length to permit maintenance or removal of the mechanical seal and/or rotating element without removing the motor or disturbing the piping connections.

Performance shall be identical for all similar service pumps and for additional or replacement of similar service pumps. Pumps shall be selected for the existing suction head conditions. Pumps of similar service shall be supplied by a single manufacturer.

Shop tests shall be conducted on all pumps in the manufacturer’s shop, and hydrostatic pressure and performance tests will be performed in accordance with API-610.

6.2 Positive Displacement Pumps

Positive Displacement pumps shall be API 676 latest edition construction. All pumps shall be self-priming and manufactured specifically for handling jet fuel or the pumped medium. Pumps shall be complete with pump gear reduction, drive motor, coupling, mounting base, accessories, and all other parts and materials necessary for a complete installation.

Pumps shall be selected and free of flashing and cavitation for the operating conditions listed. Pump casings shall be ductile iron with ASME Class 150 flanged side suction and top discharge piping connections. Rotors shall be ductile iron. Pumps shall have a mechanical seal. Pumps shall be furnished with motor winding temperature switches.

Performance shall be identical for all similar service pumps and for additional or replacement of similar service pumps. Pumps shall be selected for the existing suction head conditions. Pumps of similar service shall be supplied by a single manufacturer.

Shop tests shall be conducted on all pumps in the manufacturer's shop in accordance with the standards of API-676.

End of Chapter

Chapter 7 - Corrosion Protection

7.0 General

To protect fuel quality and system integrity, fuel system corrosion shall be addressed with internal and external system coatings as well as cathodic protection where necessary. The specifications provided cannot cover all anticipated environmental conditions. The Design Professional shall be knowledgeable in the design and application of the coating and cathodic protection systems in accordance with all applicable industry codes, standards, and best practices as applicable to the existing conditions.

7.1 Coatings

Fuel quality is a top priority in fuel system design. One potential cause of contamination is rust caused by the degradation of the system internally. Internal and external coatings shall be used to prevent the degradation of the system caused by corrosive soils, environmental conditions, and the introduction of water into the system.

7.1.1 Piping

All fuel system piping shall be internally and externally coated carbon steel or externally coated stainless-steel piping (below grade only). Piping and fittings 2-1/2 inches or larger shall be internally epoxy coated.

Piping in buried service shall have a fusion bonded epoxy external coating coordinated with the cathodic protection designer. Piping in valve vaults and hydrant pits shall have an external epoxy coating.

Pipe supports shall avoid metal-to-metal contact with the pipe and include Teflon (or similar material composition) wear pads installed between the piping and the support saddle.

7.1.2 Concrete Valve Vault Wall and Floor Coating

All walls and floor of concrete valve vaults shall be coated with amine-cured, high solids, catalyzed epoxy with a minimum of 80% solids by volume, in compliance with local VOC requirements.

7.1.3 Fuel Storage Facility

All tank systems shall be internally and externally coated. Aboveground steel fuel storage tanks shall be completely externally coated per specifications, and Protective Coating Systems provided. All steel fuel storage tanks shall be internally coated per specifications, and Protective Coating Systems provided.

All tanks shall include labels to identify tank number, contents, volume, and hazards per NFPA hazard diamond.

7.2 Cathodic Protection

Cathodic protection shall be provided for any portion of the tank and piping which is not fiberglass and shall be in accordance with standards published by the American Petroleum Institute and the National Association of Corrosion Engineers, including but not limited to, the following:

A. API 651, Cathodic Protection of Aboveground Petroleum Storage Tanks
B. API 1632, Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

End of Chapter

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Chapter 8 - Electrical

8.0 General Codes and Standards

The system shall be designed, installed, configured, programmed, commissioned, and tested in accordance with the following:

A. NFPA 30, Flammable and Combustible Liquids Code
B. NFPA 407, Standard for Aircraft Fuel Servicing
C. ATA-103, Standards for Jet Fuel Quality Control at Airports.

The system shall comply with the Requirements of the Environmental Protection Agency.

8.1 Airport Wide Specifications

All additions, repairs, and modifications to the existing fuel facility are subject to and shall be in accordance with the following DEN Standard Technical Specifications:

A. Section 260400 – Basic Electrical Requirements
B. Section 260510 – Testing, Acceptance, and Certification
C. Section 260505 – Selective Demolition for Electrical
D. Section 260519 – Low-Voltage Electrical Power Conductors and Cables
E. Section 260523 – Control-Voltage Electrical Power Cables
F. Section 260529 – Hangers and Supports for Electrical Systems
G. Section 260533 – Raceways and Boxes for Electrical Systems
H. Section 260553 – Identification for Electrical Systems

8.2 Emergency Fuel Shutoff Specifications

All additions, repairs, and modifications to the existing fuel facility are subject to and shall be in accordance with the following fuel facility specifications:

A. Section 283801 – Emergency Fuel Shutoff (EFSO) System

8.3 Instrumentation

All additions, repairs, and modifications to the existing fuel facility are subject to and shall be in accordance with the following fuel facility specifications:

A. Section 330952 – Instrumentation for Fuel Systems

8.4 Grounding/Bonding

All fueling systems components shall be grounded in accordance with applicable requirements/regulations. Locations to consider shall include but not be limited to points of fuel transfer such as bonding as required for tank truck loading and HCTS. Tank grounding shall be per applicable codes. Lightning protection may be required for tanks and shall be per NFPA 780.

End of Chapter

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Chapter 9 - Emergency Fuel Shut-Off

9.0 General

EFSO system shall be installed throughout the hydrant system and fuel storage facility in order to stop the flow of fuel when the EFSO button is activated or in case of electrical power loss to the system. EFSO system design shall be considered when adding or modifying the fuel storage facility and hydrant system design.

Additions or modifications to the EFSO station marking, placement, design, and operation shall be in accordance with NFPA 407.

The EFSO system shall be complete and functional and shall also meet the requirements of the Denver Fire Department.

EFSO system shall comply with IBC as adopted and amended by the City and County of Denver; IBC Amendments, Appendix S contains additional requirements. It shall represent all the requirements of the agency Insurance Underwriters.

The current EFSO system uses a Programmable Logic Controller (PLC) based monitoring and control system with addressable modules at the push button stations to uniquely identify each station over common wiring. The hydrant fueling system is sectioned into five (5) EFSO zones: Concourse A, Concourse B, Concourse C, United Airlines (UAL) Hanger Building, and South Cargo Area. In the event the EFSO is activated in a zone, motor-operated valves (MOVs) on each end of the zone will close to isolate the entire zone.

The whole hydrant fueling system is monitored by, and can also be controlled by, the "master" PLC at the fuel storage facility. Local EFSO push buttons at the fuel storage facility can shut down all the pumps, thereby stopping fuel delivery to the entire hydrant system. The EFSO system is intended to be reset after it has been activated, from the master PLC at the fuel storage facility, after the cause of the initial activation has been investigated and cleared for restoration of fuel flow.

9.1 Drawing Requirements

For ease of understanding and submittal, drawings have been split into three categories, A/E Construction, Shop, and Interim. All portions of EFSO Systems shall be fully designed, detailed, and specified in the Contract Documents. Below is the breakout of those drawings to comply with Code requirements.

9.1.1 A/E Construction Drawings

These drawings are submitted to the City Building Department and receive a *LOG* number and, upon approval, obtain a *CommCon* number for approved construction. These drawings shall include all devices that activate the EFSO System and/or notify DEN Operations of an emergency situation. The design shall be code compliant to the appropriate codes adopted by the City at the time the drawings are completed. The design shall comply with the appropriate codes adopted by the City when the drawings are completed.

9.1.2 Shop Drawings (Installer)

These drawings are submitted to the City as a deferred submittal, per Denver Building Code Amendments, to obtain the appropriate Fire permit for construction. These drawings shall take the design of the A/E team and apply the appropriate technical information to provide an appropriate and complete installation of the submitted system. Drawings shall contain all necessary information needed to comply with Denver Fire Department (DFD) requirements as listed in Appendix N.

9.1.3 More Stringent Document Requirements

If there is a conflict among the requirements of this document, the International Building Code (IBC), International Fire Code (IFC), National Fire Protection Association Standards (NFPA), and Denver Building Code Amendments (DBCA) documents referenced above, the Design Consultant shall comply with the more stringent requirements.

9.1.4 Reviews

All levels of drawings shall be reviewed by the DEN Fuel System Engineer prior to issuance as a "Construction Drawing" or submitted to the Permit Counter.

9.1.5 Drawing Format

All design submittals shall be developed in BIM. Comply with all applicable requirements in the Standards and Criteria and Digital Facilities and Infrastructure (DFI) DSMs.

9.2 Design Documents

Design documents shall be produced using BIM, as set forth in the DFI DSM instructions. All Design documents shall contain the following as a minimum.

A. Plans showing the as-built location and circuiting of the existing and new space
B. Plan locations of the existing and new EFSO push button.
C. Riser Diagram for the system.
D. Identification of the Gates is affected by this project.
E. DEN Specifications shall be edited as required for the specific scope of work.
F. Den Master diagrams are available upon request from the DEN Design, Engineering, and Construction Team. Master diagrams shall be updated and returned to the DEN Project Manager at IFC and Record Document phases.
G. Shall follow the information similar to a Fire Alarm System.

9.3 Design Analysis Requirements

9.3.1 Building Description

A. Building Name
B. Construction Type
C. EFSO Button Location

9.3.2 Applicable Codes

The list of Codes that this system is required to follow for the Shop Drawings:

A. International Building Code
B. International Fire Code
C. NFPA 407

9.3.3 Design Responsibility

The Engineer of Record for the Shop Drawings. A Professional Engineer (PE) Seal applied to the drawings. EFSO is considered part of the group of Life Safety Systems. NICET is NOT authorized as a substitute for a PE.

9.4 Initiating Device

A. EFSO High visibility button
    a. Pilla #FS120-KR-MS w/ PILCLHCOV1
    b. Backplane – Bright Yellow that extends 2" beyond the edges of the button

9.5 Notification

A. Blue Light above the EFSO Button
B. Fire Alarm System notification (Alarm and Supervisory)

9.6 Action/Control

A. Shutdown of Fueling valves
B. Supervision
C. Circuits supervision shall be provided consistent with NFPA 72

9.7 Power

All Emergency Fuel Shut Off panels and equipment shall be designed to operate from 120VAC, 60 Hertz, single-phase Emergency power source.

9.8 Survivability

The backbone of this system shall follow the same guidelines as dictated in the Life Safety DSM under the Fire Alarm and Detection System.

All branch wiring shall be in conduit.

End of Chapter

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Chapter 10 - System Inspection, Testing, and Flushing

10.0 General

All tests (radiographing and other pipe welding NDE, pressure testing, holiday testing, and flushing) shall be performed in accordance with ASME B31.3, NFPA 407, and as approved by the Denver Fire Department (DFD):

10.1 Hydrant System

10.1.1 Coating

Perform holiday testing of coating systems on all piping, including joints. All Holidays shall be patched as outlined in Section 335246- Fuel System Coatings for Corrosion Protection.

10.1.2 Welding

Radiographing, testing of PLIDCO couplings, magnetic particle, and dye penetrant testing shall all be as outlined in Section 335245- Fuel System Pipe, Connections, and Installation and in accordance with applicable codes and standards. All underground piping connections shall be welded and have 100% X-ray inspection. PLIDCO couplings shall not be used in future designs.

10.1.3 Pneumatic Testing

Pneumatically test fuel containment and carrier piping as outlined in Section 335253- Inspection, Testing, and Flushing and in accordance with ASME B31.3, all applicable codes, and standards.

10.1.4 Hydrostatic Testing

Hydrostatically test fuel piping as outlined in Section 335253- Inspection, Testing, and Flushing and in accordance with ASME B31.3, all applicable codes, and standards. Hydrostatic pressure tests shall use a grade of aviation kerosene approved by DEN.

10.1.5 Insulating Flanges and Joints

Each insulating flange and joint assembly shall be tested as outlined in 335253 - Inspection, Testing, and Flushing and in accordance with all applicable codes and standards.

10.2 Pressure Testing/Leak Detection

Testing of the underground fuel piping shall be accomplished with an automatic fixed or portable leak detection system. The leak detection system shall progammatically determine, using pressure sensing equipment if a pressure reduction is occurring in the isolated section of piping over a given period. The system shall have the ability to discriminate between changes in pressure due to fluid compressibility, thermal expansion/contraction, or due to a leak over the given period.

Testing shall be performed by isolating piping sections with double block and bleed valves. The valves can be actuated by either motor-operated or manually-operated isolation valves.

Modification of existing hydrant systems to include leak detection connections shall be coordinated with DEN. All new hydrant systems shall include connections for automatic or mobile leak detection systems.

10.2.1 Testing for New Installation or Modifications to Hydrant System

After filling the system, a pressure test shall be conducted to 1.5 times the maximum design operatingpressure or to a pressure specified by local codes. This pressure should be held for 24 hours minimum.

Final coating and/or wrapping of joints should not be performed until final pressure testing has been completed and accepted as per ATA 103.

10.2.2 Periodic Leak Detection Testing of Hydrant System

Periodic leak detection testing shall conform with requirements set forth in 7CCR 1101-14 Section 2.5 for Airport Hydrant Systems. Leak detection testing shall be performed on a semi-annual basis using a self-contained volumetric leak detection system designed specifically for the DEN hydrant system. The hydrant system has been divided into 16 test segments so that leak testing tolerance requirements may be achieved. Fuel system operator will typically schedule testing segments throughout the calendar year to distribute testing workload and limit operational impacts. Leak detection testing shall be coordinated with DEN Operations and Into-plane operators to minimize impact on fueling operations.

10.3 Flushing

10.3.1 General Flushing Requirements

Before a new, modified, or repaired hydrant fuel system, or portion thereof, is placed into service, all piping affected by change shall be flushed to ensure system cleanliness before aircraft fueling is permitted.

A. Flushing procedures, sampling, and testing shall be in accordance with ATA 103.
B. Pumps at DEN Fuel Storage Facility are used to pump jet fuel from Fuel Storage Tanks for flushing operations.
C. Hoses and couplings shall be aircraft-type with a minimum 300 psig rating and shall be hydrostatically tested. Multiple manifold hoses may be required to achieve flow rates during flush.
D. Flushing through control valves, meters, and hydrant heads is prohibited.
E. Velocity of flush is a minimum of 10 feet per second through the largest diameter line at the location of the modification or installation and downstream thereof to flushing tanks (either tank trucks or flushing facility).
F. Maximum fluid velocity through any jet fuel piping, component, or hose is 17 fps during flush.
G. A calibrated flow meter shall be used to verify fluid rate/velocity during flushing.
H. Minimum flush volume is 3x line fill from the location of fuel system modifications to flushing outlet.
I. Test samples shall be drawn at flushing outlet, ahead of any filtration and receiving tanks/tankers. Samples must pass the Membrane Filtration test prior to flush completion.
J. Airline fuel quality assurance representatives, or designees, have final decision on system cleanliness and acceptance before aircraft fuel servicing is permitted.
K. All flushing fuel shall be filtered per ATA 103 prior to returning to the fuel storage facility.
L. DEN owned flushing equipment may be utilized for flushing operations. Flushing equipment is stored at the Fuel Storage Facility and includes custom spools, valves, and manifold equipment. Equipment shall be cleaned, inspected, and maintained/repaired prior to use. Once flushing is complete, equipment is to be returned to storage facility in clean, functional condition with proper labeling and DEN approval.

10.3.2 Main Line Flushing Into Tanker Trucks

Flushing is performed by pumping fuel from the DEN Fuel Storage Facility through the new, modified, or repaired section of the fuel system, and out jet fuel hydrants into fuel transport tanker trucks.

A. Tanker trucks are stationed on the apron to receive flushed jet fuel from hydrants.
B. Number of tankers required depends on overall rate of main line flush.
C. Maximum number of hydrants to be used during Tanker Truck Flush is 5.
D. Maximum line size that can be flushed using the Tanker Truck Flush method is 16” (Concourses A and C main lines). Concourse B main line flushing (20”) requires a ‘DI/D2 Temporary Flush Station’.

After the main pipeline is clean, each hydrant fueling lateral shall be flushed clean.

10.3.3 D1/D2 Temporary Flush Station

Flushing is performed by pumping fuel from the Fuel Storage Facility, through the new, modified, or repaired section of the fuel system to a temporary flushing facility at either the D1 or D2 fuel vaults.

A. Related Specification Sections:
   - SECTION 335253.13: D1-D2 FLUSHING STATION OPERATIONS
   - SECTION 335248.13: D1-D2 FLUSHING STATION ACCESSORIES
   - SECTION 335247.13: D1-D2 FLUSHING STATION VALVES
   - SECTION 334713.13: BASIN LINERS FOR D1-D2 FLUSHING STATIONS

B. D1 flushing station shall be utilized to flush modifications on the west side of the concourses. D2 flushing station shall be utilized to flush modifications on the east side of the concourses.

C. Frac tanks are manifolded together and receive flush fluid via the 20” main line outlets from either the D1 or D2 Fuel Vaults.

D. The number of frac tanks is based on the flush volume required. Flushing may be separated into multiple nights depending on volume requirements, sot that frac tanks may be emptied during the day.

10.4 Dead Leg Flushing and Hydrant Checks

Out-of-service fuel lines/’dead legs’ and unused hydrants lasting longer than 90 days shall be fully flushed and the hydrant head shall be tested and verified functioning prior to returning to service. Flush volume shall be at least the line fill volume of the dead leg. Flushing and flow checks shall be coordinated and performed by fuel system operator and into-plane operator. Dead leg flushing may be performed on lines that have been out of service for less than 90 days as an extra precaution or if issues are expected.

10.5 Fuel Storage Facility Testing

10.5.1 Tank Testing

Tanks shall be tested in accordance with applicable codes and standards for the type of tank constructed. At a minimum, the following shall be performed:

A. Field Fabricated (API 650) Tanks

10.5.1.1 Welding

All tank shell welded joints shall have full penetration and complete fusion and be tested in a method in accordance with API 650.

10.5.1.2 Water Test

A hydrostatic test shall be performed on all new tanks and modified field-erected fuel storage tanks with potable water as the medium in accordance with API 650.

10.5.2 Underground Fuel Storage Tanks

A. Detailed procedures for testing methods shall include all radiographing, pressure testing, and holiday testing.

B. Detailed inspection with an appropriate voltage holiday tester of all tank coatings and joint coatings shall be conducted prior to the lowering of the tank.

C. Tanks shall be field tested for leakage immediately prior to installation.
   a. Tanks that have been repaired and those which have been dropped or impacted after the test shall be retested. Tanks shall continue to be retested until a successful leakage test is obtained.

D. All insulating flanges and joints shall be electrically tested.

10.5.3 Shop Fabricated Fuel Storage Tanks

A. Detailed procedures for testing methods shall include all radiographing, pressure testing, and holiday testing.

B. Detailed inspection with an appropriate voltage holiday tester of all tank coatings and joint coatings shall be conducted prior to the lowering of the tank.

C. Primary tank and interstitial space shall be pressure tested in the manufacturer's shop per relevant codes

D. After the tank is set on its foundation, the Contractor shall perform applicable pressure tests of the primary/inner tanks followed by differential air pressure test of the secondary/outer tanks.

E. Any leakage or other defects shall be considered a failure of these tests. Necessary repairs shall be made upon failure, and the test shall be repeated until all defects are eliminated as acceptable.

End of Chapter

Chapter 11 - Technical Specification Requirements

11.0 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.

11.1 DEN Standard Fuel System Specifications

The DEN Fuel System Specs have been developed to ensure project consistency and compliance with DEN policy and procedure.

The designer shall incorporate these specifications as appropriate for the project scope. Specifications are provided in an outline format similar to construction specifications for ease of incorporation.

Refer to Table 11-1: Fuel System DEN Standard Specification for a list of DEN standard fuel system specification sections. The following sections are published on the DEN Business Requirements website and must be obtained for use in the project.

Table 11-1: Fuel System DEN Standard Specification

Section No.	Section Title
134713	Cathodic Protection
283801	Emergency Fuel Shutoff System
330105	Fuel Piping Removal
330107	Site Preparation and Earthwork for Fuel Systems
330522	Fuel System Utility Casings
330952	Instrumentation for Fuel Systems
334713.13	Basin Liners for D1-D2 Flushing Solutions
335243	Fuel System General Requirements
335244	Identification of Fuel Piping and Equipment
335245	Fuel System Pipe, Connections, and Installation
335246	Fuel System Coatings for Corrosion Protection
335247	Fuel System Valves
335247.13	D1-D2 Flushing Station Valves
335248	Fuel System Accessories
335248.13	D1-D2 Flushing Stations Accessories
335250	Fuel System Pumps
335251	Fuel System Filtration
335252	Fuel System Hydrant Components

Table 11-1: Fuel System DEN Standard Specification (Continued)

Section No.	Section Title
335253	Fuel System Inspection, Testing, and Flushing
335253.13	D1-D2 Flushing Station Operations

It is the designer's responsibility to ensure that all applicable DEN fuel system specs are accurately reflected in the project specifications' appropriate sections.

11.1.1 Specification Format

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

11.1.2 Product and Manufacturer Listings

Where manufacturers and products are listed in the spec, 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, the designer shall select a basis of design based on current industry standards which comply 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.

End of Chapter