LIVE LIFE. TRAVEL WELL.

Design Standards Manual
Fueling Systems
Denver International Airport
Airport Infrastructure Management

Q2 2020
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Summary of Revisions

The following table lists revisions to the Fuel Systems Design Standards Manual (DSM).

2020 Revisions

Second Quarter Revisions

<table>
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<tr>
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<tr>
<td>1.0.2 Limitations</td>
<td>Requirements clarified</td>
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<td>1.1.2 Governing Codes and Standards</td>
<td>Requirements clarified, added governing body</td>
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<tr>
<td>2.1 Fuel Dispensing</td>
<td>Requirements clarified</td>
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<tr>
<td>Chapter 3 - Aviation Fueling System Design</td>
<td>Throughout – updates to grammar and terms</td>
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<tr>
<td>3.0.1.4 Excavation and Backfill</td>
<td>Updated flowable fill requirements</td>
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<td>3.0.1.5 Corrosion Prevention</td>
<td>Added requirements for piping under paved surfaces</td>
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<tr>
<td>3.0.1.6 Testing</td>
<td>Requirements updated</td>
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<tr>
<td>3.1.2 Isolation Valve Pits</td>
<td>Revised coordination and testing requirements</td>
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<tr>
<td>3.1.4.5 Drainage</td>
<td>Clarified drainage requirement and added cross-reference to Civil DSM</td>
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<tr>
<td>3.1.4.6 Pipe Sizing</td>
<td>Updated descriptions</td>
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First Quarter Revisions

No revisions were published in the First Quarter 2020.

2019 Revisions

Fourth Quarter Revisions

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<td>Throughout</td>
<td>Section numbering changed to hierarchical outline numbering.</td>
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<td>3.0.1.3 Layout and Spacing</td>
<td>Requirements added</td>
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<td>3.1.1 Hydrant System</td>
<td>Specification added</td>
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<td>5.1.3 High Point Vent and Low Point Drain Pits</td>
<td>Specification added</td>
</tr>
<tr>
<td>5.2.1 High Point Vents and Low Point Drains</td>
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**NOTE:** Added information is displayed in green. Updated information is displayed in blue.
Purpose of this Document

The Denver International Airport (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 intended to be 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 for DEN have 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. 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 others. To understand the overall thematic and design standards for DEN, the manuals must be utilized together and not separated from the Design Standards Manuals as a whole.

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.
Chapter 1 - General

1.0. Scope

1.0.1. Purpose

The purpose of these design guidelines is 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 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.

1.0.2. 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 the planning, design, construction, and alteration of 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.

1.1. Criteria

1.1.1. 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’ 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.

1.1.2. 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>
<thead>
<tr>
<th>Acronym</th>
<th>Governing Body</th>
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<tr>
<td>A4A</td>
<td>Airlines for America, formerly Air Transport Association of America (ATA)</td>
</tr>
<tr>
<td>AASHTO</td>
<td>American Society of State Highway and Transportation Officials</td>
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<tr>
<td>ACI</td>
<td>American Concrete Institute</td>
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<tr>
<td>ADA</td>
<td>Americans with Disabilities Act</td>
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<td>AIA</td>
<td>American Institute of Architects</td>
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<tr>
<td>AISC</td>
<td>American Institute of Steel Construction</td>
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<td>ANSI</td>
<td>American National Standards Institute</td>
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<td>API</td>
<td>American Petroleum Institute</td>
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<tr>
<td>APWA</td>
<td>American Public Works Association</td>
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<td>ASCE</td>
<td>American Society of Civil Engineers</td>
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<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
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<tr>
<td>ASPE</td>
<td>American Society of Plumbing Engineers</td>
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<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
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<tr>
<td>ATA</td>
<td>Air Transport Association of America</td>
</tr>
<tr>
<td>AWS</td>
<td>American Welding Society</td>
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<td>AWWA</td>
<td>American Water Works Association</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
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<tr>
<td>CSDOI</td>
<td>Colorado State Department of Oil Inspection</td>
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<tr>
<td>DBC</td>
<td>Denver Building and Fire Code</td>
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<tr>
<td>DBD</td>
<td>Denver Building Department</td>
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<tr>
<td>DOT</td>
<td>U.S. Department of Transportation - Office of Pipeline Safety</td>
</tr>
<tr>
<td>EPA</td>
<td>United States Environmental Protection Agency</td>
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<tr>
<td>FAA</td>
<td>Federal Aviation Administration</td>
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<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
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<td>FM</td>
<td>Factory Mutual Insurance</td>
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<td>IBC</td>
<td>International Building Code</td>
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<tr>
<td>NACE</td>
<td>National Association of Corrosion Engineers</td>
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<tr>
<td>NEC</td>
<td>National Electrical Code</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturer’s Association</td>
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<td>NFPA</td>
<td>National Fire Protection Association</td>
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<td>OSHA</td>
<td>Occupation Safety and Health Administration</td>
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<tr>
<td>SAE</td>
<td>Society of Automobile Engineers</td>
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<tr>
<td>SSPC</td>
<td>Steel Structures Painting Council</td>
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<td>STI</td>
<td>Steel Tank Institute</td>
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<tr>
<td>U.L.C.</td>
<td>Underwriters Laboratories - Canada</td>
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<td>Underwriters Laboratories</td>
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**Table 1-2 – Terms and Definitions**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tr>
<td>Double Block-and-Bleed (DBB) Valve</td>
<td>A single valve with two seating surfaces that, in the closed position, provides a seal against pressure from both ends of the valve, with a means of venting/bleeding the cavity between the seating surfaces.</td>
</tr>
<tr>
<td>Mat Foundation</td>
<td>A mat foundation, also called a raft foundation, is essentially a continuous slab resting on the soil that extends over the entire footprint of the building, thereby supporting the building and transferring its weight to the ground. This reduces the stress on the soil.</td>
</tr>
<tr>
<td>Pigging</td>
<td>The practice of using devices known as pigs or scrapers to perform various maintenance operations. This is done without stopping the flow of the product in the pipeline. These operations include but are not limited to cleaning and inspecting the pipeline. This is accomplished by inserting the pig into a pig launcher (or launching station) — an oversized section in the pipeline, reducing to the normal diameter. The launching station is then closed and the pressure-driven flow of the product in the pipeline is used to push the pig along down the pipe until it reaches the receiving trap — the pig catcher (or receiving station).</td>
</tr>
</tbody>
</table>

End of Chapter
2.0. General

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

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 issues
   a) Supply issues
   b) Quality issues
   c) Days of reserve
   d) Additive injection

E. DEN’s needs for future airport expansion
   a) Current fuel consumption and peak demand
   b) Future fuel consumption and peak demand

F. Redundancy in mission critical systems

G. Required maintenance schedules and operations

2.1. Fuel Dispensing

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 upon a thorough analysis of current and future estimated enplanements, daily fuel consumption, and daily peak demand. Provisions for future expansion shall be included in the design.

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.
As detailed in the applicable DEN Standard Technical Specifications, positive isolation valves (API 6D DBB plug valves) shall be installed in valve vaults throughout the hydrant fueling system for maintenance, emergency operations, and leak detection.

2.2. 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.

End of Chapter
Chapter 3 - Aviation Fueling System Design

3.0. General

3.0.1. Piping

Fuel quality is a top priority in aviation fueling 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.

3.0.1.1. Materials and Connections

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.

Provide a piggable system including 3D bends, barred tees, pig barrels or connections for installation thereof, and full port valves where necessary.

All connections shall be welded on buried piping. Refer to DEN Technical Specification Section 335245 – Fuel System Pipe, Connections, and Installation for details regarding piping connections.

3.0.1.2. 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. The fuel pipes shall slope at a minimum of 0.5%.

3.0.1.3. Layout and Spacing

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. Separation distances for utilities shall be a minimum of 36 inches horizontally and 12 inches vertically. If these distances cannot be met, provide insulating material and consider the cathodic protection of the piping and the encroaching utilities.

Locate the fuel pipe mains to minimize lateral pipe lengths.

3.0.1.4. 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.
3.0.1.5. Corrosion Prevention

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

Cathodic protection anodes shall not be buried in flowable fill.

Fuel pipe mains shall not be located under a building or a passenger terminal. Fuel pipe mains located under paved surfaces shall be placed in a steel casing pipe (NFPA 407).

3.0.1.6. Testing

All temporary and permanent piping shall be tested in accordance with ATA 103 and ASME B31.3 as outlined in Chapter 10. 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.

3.0.2. High Point Vents and Low Point Drains

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 number as 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 pits (IVPs). When HPVs and LPDs cannot be installed in IVPs, 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, IVPs shall be positioned such that the 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 dust cap.

3.0.3. Valves

Valve materials and construction shall be considered regarding thermal stability when selecting valves to be installed in the aviation fueling system. Internal epoxy coating, compatible plating, or material selection such as steel or stainless steel shall be specified. Seals shall be of nitrile, Viton, Teflon, or other fuel compatible material. Avoid neoprene, ethylene propylene diene monomer (EPDM) or natural rubber.

Positive isolation valves used in isolation valve pits or other locations where positive isolation is required shall be DBB type plug valves. 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.

3.0.4. Surge Analysis and Thermal Expansion

Hydraulic and surge analysis of the aviation fueling system shall be performed using software specifically designed for modeling hydraulic steady state friction losses and transient surge pressures. The 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 if surge suppression is required.

Thermal expansion can cause excessive pressure buildup in the hydrant fueling system. Design shall consider the use of thermal relief valves for limiting the pressure of the piping in accordance with code requirements.
3.0.5. Emergency Fuel Shutoff

Effects upon the EFSO system shall be considered when making additions or modifications to 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 and DEN Standard Technical Specification Section 283801 – Emergency Fuel Shutoff (EFSO) System.

The EFSO system shall be complete, functional, and shall also meet the requirements of the local Authority Having Jurisdiction.

The currently installed system is a Programmable Logic Controller (PLC) based monitoring and control system, utilizing 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 from, the “master” PLC at the fuel storage facility. Local EFSO push buttons at the fuel storage facility can shut down all the pumps, and thereby stop 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.

3.1. Hydrant Fueling System Sizing and Layout

3.1.1. Hydrant Fueling System

The hydrant fueling system shall be an on-demand system and be sized to provide adequate flow and pressures to all hydrant fueling positions during peak operating hours. The flow capacities shall be based upon an analysis of current and future peak demands on the system with variables including but not limited to:

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), however, some aircraft fueling components are not rated for this working pressure. The design shall ensure if lower pressure rated components are used, they will not be damaged from higher system pressures.

3.1.2. Isolation Valve Pits

IVPs 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 IVPs shall be coordinated with the DEN Project Manager.

Isolation valves with positive shutoff (DBB valves) are required to obtain successful leak detection test results prior to being put into service. Isolation valves and pits shall be located to optimize 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 try and accommodate any potential technological advances and upgrades to the system.

IVP 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. IVPs shall be located such that they are easily accessible in emergency situations. IVPs shall not be located in aircraft movement areas. Where possible, IVPs shall be positioned such that the lid will not be affected by jet blast when in the open position.

3.1.3. Hydrant Fueling Pits and Lateral Piping

Hydrant fueling pits shall be side entry, one-piece, molded fiberglass, with built-in concrete anchors. Pits shall have sealed interior pipe entry with steel sleeve encapsulated in fiberglass. Sleeve penetrations shall be suitable for segmented mechanical seals (total of two per pipe penetration) and installation of heat shrink boot seals on the exterior of the pipe penetration.

3.1.4. Hydrant Fueling Pit Placement

3.1.4.1. Coordination

Coordinate hydrant fueling pit placement with DEN Airside Planning, taking into consideration aircraft parking plans and planned aircraft mix.

To minimize the number of hydrant fueling pits required at a gate, and to meet the hydrant fueling pit location criteria, adjust the aircraft parking plan by shifting the design aircraft nose gear locations along the aircraft centerline to consolidate the aircraft fuel points for the potential aircraft design group(s), if possible.

3.1.4.2. Aircraft Constraints

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, or in areas subject to drive-over by 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.

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).

3.1.4.3. Ground Service Equipment

Ground servicing operations shall be considered when selecting 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 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.

3.1.4.4. Safety Considerations

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 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 promoting a more fire safe condition.

3.1.4.5. 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. 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.

3.1.4.6. Pipe Sizing

Review the hydrant fueling pit detail and depth of the lateral pipe exiting the hydrant fueling pit, to ensure the depth of the pavement structure does not encroach into the backfill over the lateral pipe. The lateral pipe 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.

3.1.4.7. Valves

Hydrant valves shall have isolation butterfly valves installed upstream to allow maintenance and replacement of the hydrant valve without removing fuel from the system.

3.2. Fuel Storage Facility Sizing and Layout

3.2.1. Fuel Storage Facility

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 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 275 psig, 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 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.

3.2.2. Fuel Storage Tanks

Once the necessary fuel storage capacity has been determined based on the current and future fuel demand analysis, the number and capacity of the additional or future fuel storage tanks shall be determined. Space for future additional tanks shall be considered. The combined total shell capacity of the all existing and any new aboveground storage tanks (ASTs) must exceed 90% of the total system volume which shall include the piping,
3.2.2.1. 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.
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. Fill nozzles shall be equipped with diffusers. 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 sloshing wave 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 as listed in API 650 Table E.8.

3.2.2.2. 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. 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 migration of water under the tank.

3.2.2.3. Undertank Secondary Containment

Undertank 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 minimum electrical resistance of 25,000 ohms per cm.

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

3.2.2.4. 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.

3.2.3. 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 waterstops 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 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, designer shall coordinate the types of expected vehicle traffic with the DEN Project Manager and provide ramps designed to support those vehicles.

3.2.4. Fuel Sampling and Processing (Filtration)

Fuel processing is an important factor in fuel quality and 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. Coalescers (haypacks) for removal of large “slugs” of water
B. Prefilters for removal of solids
C. Clay treaters for removal of surfactants
D. Filter/Separators for the removal of fine solids and water separation
E. Fuel sampling connections shall be installed where necessary per ATA 103. Relaxation tanks shall be installed in the system where necessary per NFPA 407.

3.2.5. 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, federal regulations, industry standards, and based on anticipated impurities for aviation fuel.
3.2.5.1. 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 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.

3.2.5.2. 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. Truck receipt area shall be designed for efficient use of manpower while in operation, and minimal impact to public through traffic congestion. Provide sufficient access for delivery vehicles, and staging areas for waiting delivery vehicles. Provide reinforced concrete pavement under truck offload area.

Offload stand shall be provided with secondary containment to comply with applicable API standards and this manual. 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 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.

3.2.5.3. 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.

3.2.6. 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 off-line.

A minimum of two refueler truck loading positions shall be included in any fueling system design. Additional loading positions shall be added as required per the flights being serviced by 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.

Refueler truck loading positions can be an extension of the hydrant system piping or have their own pump and filtration. Typically, refueler truck loading positions are 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.

3.2.6.1. 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 fuel resistant joint sealant. Exposed concrete surfaces shall
be sealed with fuel resistant penetrating sealer/hardener. Containment areas shall be sloped and drained into an oil/water separator.

3.2.7. 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 and 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. 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.

3.2.8. 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 have 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.

3.2.9. Environmental

3.2.9.1. Spill Containment

Provide secondary containment for all aboveground tanks, loading/unloading areas, and equipment parking areas in accordance with applicable codes and regulations.

3.2.9.2. SPCC

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

3.2.9.3. Emissions

Review current applicable regulations to ensure compliance with product emissions.

3.2.9.4. Storm Water Discharge

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

3.2.10. 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. Fire water protection (fire hydrants) in fuel storage facilities
are 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.

3.2.11. Other Considerations

3.2.11.1. Operations Building
Operations buildings are often included in fuel facility designs. They may include but are 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

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

3.2.11.3. 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 and as they may be required and are specialty systems with their own industry codes and standards.

End of Chapter
4.0. Fuel Storage Facility

4.0.1. General

The following DEN Standard Technical Specifications provides additional technical details.

- Section 335250 - Fuel System Pumps

The main pump selection in an aviation fuel storage facility is for the hydrant system pumps, however other pumps are may be required for tasks such as tanker truck loading/unloading pumps, “stripping” pumps, and fuel transfer pumps. Pumps used are typically centrifugal or positive displacement pumps. A list of possibly required pumps is below:

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 to not allow air to pass through the meter and shall be installed as needed.

4.0.2. Centrifugal Pumps

Centrifugal pumps shall be API 610 latest edition construction. Impeller and shaft shall be 12% chrome steel overhung type, and all other materials of construction shall be per API-610 S-6 material classification. 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.

It has become common practice to provide temperature and vibration sensing to shut down pump upon high temperatures and excessive vibration. These requirements for temperature and vibration sensing and shutdown shall be discussed with DEN and implemented as required.

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 test, and performance test performed in accordance with API-610.
4.0.3. Positive Displacement Pumps

Positive Displacement pumps shall be API 676 latest edition construction. All pumps shall be self-priming and be manufactured specifically for handling jet fuel or the medium being pumped. 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 be 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 standards of API-676.

End of Chapter
Chapter 5 - Piping

5.0. General

The following DEN Standard Technical Specifications provide additional technical details:

A. 335243 - Fuel System General Requirements
B. 335244 - Identification of Fuel Piping and Equipment
C. 335245 - Fuel System Pipe, Connections, And Installation
D. 335246 - Fuel System Coatings for Corrosion Protection
E. 335247 - Fuel System Valves
F. 335248 - Fuel System Accessories
G. 335252 - Fuel System Hydrant Components

See the following details:

A. High Point Vent Pit
B. Hydrant Pit
C. Isolation Valve Pit
D. Low Point Drain Pit
E. Pipe Penetration Through a Fiberglass Pit Wall

5.0.1. Fittings

Fittings used in the system shall meet the following requirements:

A. Fittings 6 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 long radius
F. Changes in direction other than 45 degrees or 90 degrees shall be made by cutting elbows to the proper angle and shop beveling the edges

5.0.2. Welding

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.

5.0.3. 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 outdoor environment shall be galvanized. Where required, paint coating may be applied over the galvanized surfaces.
5.0.4. Fuel 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

5.1. Hydrant System

5.1.1. Isolation Valve Pits

IVPs 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. Fixed access ladder.

C. Valve vault lids shall:
   a) Have “Fuel Valve Access“ engraved in lid
   b) Be waterproof
   c) Be aircraft-rated cast aluminum
   d) Have torsion springs or hydraulic operator for assisted opening

D. An 18” X 18” X 12” deep sump with grating cover in one corner of the pit.
   a) A two (2) inch sump pipe routed from the corner sump, above the intermediate platform with a camlock connection.

E. Pit structure may consist of prefabricated fiberglass pit with reinforced concrete encasement or cast-in-place reinforced concrete structure. Pit structure (walls and slabs) shall be designed to handle direct and indirect aircraft wheel loads.
F. Pit structures shall be designed as a secondary containment and shall be constructed to be watertight. Provide waterproofing or dampproofing as appropriate on the exterior side of the cast-in-place pit walls. All joints in the walls and slabs in cast-in-place concrete pits shall be equipped with fuel resistant waterstops.

G. The interior surfaces of these pits shall be coated with white-colored epoxy coating. The white-colored coating will aid visibility inside the pits, while the epoxy coating will reduce permeability and enhance fuel resistancy of the secondary containment system.

H. Pits below grade shall be designed for buoyancy conditions. Provide a minimum factor of safety of 1.10 against buoyancy during construction. The critical design condition during construction shall assume an empty pit (prior to soil backfill) with 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).

5.1.2. Hydrant Pits

Hydrant Pits shall be provided as follows:

A. General Requirements: Assembly to be complete with 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. Performance: Designed to permit a fueling flow rate of 1000 gpm. Liquid to be jet fuel with a specific gravity of 0.81 +0.05.

C. Construction:
   a) Pits shall be side entry.
   b) Body shall be one-piece molded fiberglass, with built-in concrete anchors.
   c) Pit shall have sealed interior pipe entry with steel sleeve encapsulated in fiberglass. Sleeve penetrations shall be suitable for segmented mechanical seals (total of two per pipe penetration) and installation of heat shrink boot seals on the exterior of the pipe penetration.
   d) Access Cover shall:
   e) Product identification shall be in raised letters in the cover door. Identification shall be "FUEL."
   f) Be water resistant
   g) Be aircraft-rated cast aluminum

5.1.3. High Point Vent and Low Point Drain Pits

High point Vent and Low Point Drain Pits shall be provided as follows:

A. 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:
   g) Be aircraft-rated, cast aluminum
5.1.4. Valve Vaults

Valve vaults shall be equipped with the following:

A. Two access covers minimum. One of the covers shall be larger and sized top allow removal of the largest valve inside the vault.

B. Vault access covers shall:
   a) Have “Fuel Vault Access” engraved in lid
   b) Be water resistant
   c) Be aircraft-rated cast aluminum
   d) Have torsion springs or hydraulic operator for assisted opening

C. Fixed access ladder

D. An 18” X 18” X 12” deep sump with grating cover in one corner of the vault

E. 2-inch sump pipe routed from the corner sump, above the intermediate platform with a camlock connection.

F. Valve vault 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 a secondary containment and shall be constructed to be watertight. Provide waterproofing or dampproofing as appropriate on the exterior side of the vault walls. All joints in the walls and slabs shall be equipped with fuel resistant waterstops.

H. The interior surfaces of these vaults shall be coated with white-colored epoxy coating. The white-colored coating will aid visibility inside the pits, while the epoxy coating will reduce permeability and enhance fuel resistancy of the secondary containment system.

I. Vaults below grade shall be designed for buoyancy conditions. 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 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).

5.1.5. Surge Suppression

Surge suppressors shall be provided when determined necessary by surge analysis. 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 device installed on the inlet to allow unrestricted flow into the suppressor and restricted flow out. Suppressors shall be nitrogen filled with Buna-N bladders.

5.2. Fuel Storage Facility

5.2.1. High Point Vents and Low Point Drains

High points and low points in the piping shall provide a means of removing trapped air or particulate/water in the entirety of the piping system. High Point Vents and Low Point Drains shall be provided as necessary in the piping as follows:
Piping shall:

A. Be 2-inch diameter
B. Have API 607 Fire Safe lockable ball valve
C. Have camlock connection with dust cap.

5.2.2. Valves

Valves shall be provided on all tank piping nozzles for isolation. Double block and bleed valves are recommended for this service. Gate valves shall not be used for tank isolation. 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.

End of Chapter
Chapter 6 - Valves

6.0. General

6.0.1. General

The following DEN Standard Technical Specifications provide additional technical details:

A. 335247 - Fuel System Valves
B. 335248 - Fuel System Accessories
C. 335252 - Fuel System Hydrant Components

See the following details:

A. High Point Vent Pit
B. Hydrant Pit
C. Isolation Valve Pit
D. Low Point Drain Pit

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

6.0.2. Butterfly Valves

Butterfly valves at minimum shall be fire safe, high performance, lug style meeting API STD 607 and API STD 609.

6.0.3. 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.

6.0.4. 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.

6.0.5. 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. All control valves shall have manual isolation valves installed upstream and downstream for maintenance.
6.0.6. 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 construction 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 limited to where low pressure drop across check valves is required. If required double-plate check valves shall be as outlined in Section 335247 - Fuel System Valves.

6.1. Hydrant System

6.1.1. Hydrant Valves
At a minimum or approved otherwise, hydrant valve shall be 4-inch of ductile iron construction with 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.

6.2. Fuel Storage Facility

6.2.1. 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. Valve body shall be cast carbon steel. Shaft packing shall be of graphite composite, combustion resistant material.

6.2.2. 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, 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".

6.2.3. Automatic Recirculation Valve
Automatic recirculation valves shall provide minimum recirculation flow specified by the pump manufacturer to protect the system centrifugal pumps from cavitation and pump dead heading. The valve shall modulate between full recirculation flow at zero system demand and zero recirculation at full system demand.

6.2.4. Control Valves

6.2.4.1. 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. Valve shall be normally closed, flow to open.

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

6.2.4.3. 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 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, 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 truck receipt, PRTs, etc.

6.2.4.4. Terminal Main Control Valves

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

6.2.4.5. 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 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. Specifications provided cannot cover all anticipated environmental conditions. The Design Professional shall be knowledgeable in the design and application of coating and cathodic protection systems in accordance with all applicable industry codes, standards, and best practices as applicable to the existing conditions.

The following DEN Standard Technical Specification provides additional technical details:

A. 335246 - Fuel System Coatings for Corrosion Protection
   a) PCS E-12
   b) PCS E-12A
   c) PCS E-15
   d) PCS E-4
   e) PCS E-5
   f) PCS T-1
   g) PCS T-2
   h) PCS T-3
   i) PCS T-3S

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 2-1/2 inches or larger and fittings 6 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 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. 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
Chapter 8 - Electrical

8.0. General Electrical

8.0.1. 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 Requirements of the Environmental Protection Agency.

8.0.2. Airport Wide Specifications
All additions, repairs, and modifications to the existing fuel facility are subject to and shall be 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

8.0.3. Emergency Fuel Shutoff Specifications
All additions, repairs, and modifications to the existing fuel facility are subject to and shall be accordance with the following fuel facility specifications:

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

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

A. Section 253001 – Instrumentation for Fuel Systems

8.0.5. 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
Chapter 9 - Leak Detection

9.0. General

The original construction of the hydrant system included a Pal-Com leak detection system which has since been abandoned. Pressure leak tests are performed quarterly on the hydrant system. As of this writing, this test is performed by an outside contractor using a self-contained Vista HT-100 volumetric leak detection system designed specifically for the DEN hydrant system. The entire fuel system can be tested from the fuel storage facility or divided into smaller sections as needed.

9.1. Hydrant System

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

Testing of the underground fuel piping shall be accomplished with an automatic fixed or portable leak detection system. The leak detection system shall programmatically determine, through the use of pressure sensing equipment, if a reduction of pressure 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 thermal expansion and contraction or due to a leak over the given period.

Both systems test piping by isolating piping sections with double block and bleed valves. The valves can be actuated by either motor operated or manually operated isolation valves. Isolation valves for the hydrant system shall be located as follows:

A. Each 1/2 mile on distribution mains
B. Each terminal branch mains
C. Provide 2-inch test connections adjacent to the DBB valve for pressurization of the underground piping
   a) Test connections shall include a 2-inch ball valve, hose adapter and dust cap

End of Chapter
Chapter 10 - Emergency Fuel Shut Off

10.0. General

EFSO system shall be provided in accordance with the currently adopted editions of the standards and codes listed in the DSMs and in the IFC 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 following description of fire protection requirements is based on NFPA codes.

10.1. Scope

This chapter provides design guidance to the Engineer in the area of EFSO system, which is utilized for all systems that extinguished a fire activating a sprinkler or detector or a combination of both.

10.2. System Description

These systems provide immediate suppression to a detected fire. The suppressant may include more than one medium. The typical medium used is water and may be activated by several different methods.

10.3. Drawing Requirements

Refer to 105.1 A/E Construction Drawings – 105.6 Drawing Format.

10.4. 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 AIM 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.

10.5. Design Analysis Requirements

10.5.1. Building Description

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

10.5.2. Applicable Codes

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

a) All wiring shall be installed in conduit
10.5.3. Design Responsibility
The Engineer of Record for the Shop Drawings. 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.

10.6. Initiating Device
A. EFSO High visibility button.
   a) Pilla #FS120-KR-MT4
   b) Backplane – Bright Yellow that extends 2” beyond the edges of the button

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

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

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

10.10. 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
Chapter 11 - System Inspection, Testing and Flushing

11.0. General

The following DEN Standard Technical Specifications provide additional technical details:

A. 335245 - Fuel System Pipe, Connections, and Installation
B. 335246 - Fuel System Coatings for Corrosion Protection
C. 335253 - Inspection, Testing, and Flushing
D. Per Chapter 3 Section 300.2, see Appendix A

11.1. Hydrant System


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.

11.1.2. 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.

11.1.3. Pneumatic Testing

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

11.1.4. 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.

11.1.5. Flushing

Before a new, modified, or repaired hydrant fuel system, or portion thereof, is placed into service, all piping affected by change shall be flushed with a grade of aviation kerosene approved by DEN to ensure system cleanliness before aircraft fueling is permitted. All flushing procedures, fuel sampling and testing shall be as outlined in 335253 - Inspection, Testing, and Flushing and in accordance with ATA 103, latest revision.

It shall be the responsibility of the airline fuel quality assurance representative, or his designee, to have final decision on system cleanliness and acceptance before aircraft fuel servicing is permitted.

11.1.6. 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.
11.2. Fuel Storage Facility

11.2.1. 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

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

11.2.1.2. 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.

11.2.2. 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 which have been repaired and those which have been dropped or impacted after 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.

11.2.3. 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 tank is set on its foundation, 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