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Aviation Fuel Facilities

RATIONALE

This SAE Aerospace Recommended Practice contains general criteria for the planning, design, and construction of military and commercial ground based aviation fueling facilities that receive, store, distribute, and dispense liquid aviation turbine fuels at airports. Its purpose is to provide a description of practices that are commonly recognized throughout the industry as proving beneficial in the planning, design, and construction of aviation fuel systems at airports.

FOREWORD

The purpose of any aviation fueling system is to safely deliver clean, dry, on specification fuel to an aircraft. As is true for any type of system, there are peculiarities inherent to handling aviation fuels that are not readily apparent to anyone who does not design, build, or use these systems regularly. Aviation fueling systems represent a barely measurable percentage of the overall construction industry; there are therefore very few companies or individuals who are aware of these peculiarities. With both the commercial airlines and the military going through a protracted cycle of downsizing and outsourcing, the portion of the industry that pays for and is ultimately responsible for these systems is losing many of its most experienced personnel. The purpose of this guide is to provide key individuals who are responsible for aviation fuel facilities an overview of general practices which have proven beneficial in planning, design, and construction.

This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary and its applicability and suitability for any particular user, including any patent infringement arising there from, is the sole responsibility of the user.

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1. SCOPE:

This document contains general criteria for the planning, design, and construction of military and commercial ground based aviation fueling facilities that receive, store, distribute, and dispense liquid aviation turbine fuels at airports to both fixed and rotary wing aircraft.

1.1 Purpose:

The purpose of this document is to provide a description of practices that are commonly recognized throughout the industry as proving beneficial in the planning, design, and construction of aviation fuel systems at airports.

1.2 Field of Application:

This document is intended for use with airport facilities that handle common aviation turbine fuels including Jet A, Jet A-1, Jet B, JP-5, and JP-8. It is not intended for:

a. Portable or temporary systems such as military tactical systems

b. Mobile equipment such as hydrant carts or tank trucks

c. Retail or consumer aviation fueling facilities

d. Any facility with gasoline whether aviation or motor vehicle type

e. Military aircraft facilities with special or uncommon fuels such as JP-4, JP-7, JP-10, and JPTS

1.3 Selecting Design Engineers, Project Managers, and Contractors:

The selection process should include qualification criteria that include, at a minimum, the following:

a. Firms should have experience in fuel facilities equal to the current project in value and complexity.

b. Firms should have experience in the same types of facilities being designed and constructed.

c. The project personnel assigned to the project should be the individuals with the actual experience described above.

d. Other unique experience factors as determined by the Owner.

1.4 Limitations:

1.4.1 This document is not mandatory and does not replace regulatory requirements. It is meant to be complementary to other approved codes and regulations applicable to fuel system planning, design and construction, whether statutory or in general use. It does, however, identify practices that are commonly recognized throughout the industry as proving beneficial in use within the aviation fueling industry.

1.4.2 This document is intended to apply to new facilities and retrofitting existing facilities.

1.4.3 This document presents a basic outline of the essential elements of an aircraft fuel handling system. It will not give complete details of any systems or equipment.

1.4.4 This document is not intended to suggest or treat any property, equipment, or technology in a preferential manner.

1.4.5 Numerical setpoints given in this document are typical and are presented for demonstration purposes only. They are not prescriptive. The actual setpoints shall prescribed by the Engineer.

1.5 Military Fueling Systems:

1.5.1 Military fueling systems differ from commercial systems and typically follow standard designs. Major factors which cause the differences between military and commercial systems include:

1.5.1.1 Additives and Filtration: Military fuels always contain additives. JP-5 and JP-8 fuel is received at the military installation with an additive package consisting of fuel system icing inhibitor (FSII) and a corrosion inhibitor/lubricity improver (CI). JP-8 also includes a static dissipater additive (SDA). Receipt filtration is normally by filter/separators conforming to API/IP SPEC 1581. A variety of receipt pre-filtration options are available depending on contaminants such as water or particulate that may be in the fuel. Clay filtration is not used because it strips the fuel of the additives.

1.5.1.2 Fuel Thermal Stability: Fuel thermal stability is critical to military aircraft since they use fuel as a coolant and heat sink for avionics, air conditioning, and other functions that may drive the fuel temperature to the point that it begins to break down. Since fuel received may be at the minimum allowable thermal stability, military systems are designed to prevent further degradation. Military systems use coatings, plating, aluminum and stainless steel to minimize contact with ferrous materials from receipt to issue.

1.5.1.3 Low Daily Throughput with High Peak Demand Requirements: Military systems are typically designed for a maximum flow rate of 2400 to 3000 gpm (151 to 189 L/s). Normally, this rate is experienced during military peak demand operations. During normal operations, flow rates may be much lower causing conflicts between the need to maintain a minimum velocity of 7 ft/s (2.1 m/s) while preventing pressure surges during high flow rates. To minimize surges, systems are designed in a loop that circulates fuel from the storage tank through the loop and back to the storage tank. By controlling pumps, a minimum amount of fuel is returned to the tanks. All systems require a surge analysis and on occasion surge arrestors. Where higher flow rates are required, multiple systems are installed.

1.5.1.4 Defuel Capability: To maximize the cargo carrying capacity of military aircraft, fuel is often removed so more cargo can be added. Additionally, fuel must be removed for certain maintenance functions to be performed. Due to the large fuel loads in certain military aircraft, hydrant fueling systems are designed to both fuel and defuel aircraft through the hydrant. Normally this requires a diaphragm operated hydrant control valve in the pit that is larger than the valves used in commercial systems and requires a larger hydrant pit.

1.5.1.5 Standardization: Military systems are designed for minimum maintenance due to manning limitations and are standardized to minimize the learning curve for replacement technicians and augmentees deployed during contingencies.

1.5.1.6 Tank Fire Protection: Because of the high cost of maintaining Aqueous Film Forming Foam (AFFF) fire protection systems over the life of a tank, military fire experts have stopped requiring such systems. Instead they require a honeycomb type floating pan that limits fire exposure to the rim area. The internal pans are equipped with rim seals to minimize vapor loss and preclude debris from entering the fuel.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-00001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org

AS5877	Nozzle, Aircraft Pressure Refueling

2.1.2 ANSI and ASME Publications: Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org. Available from ASME, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (US and Canada), 95-800-843-2763 (Mexico), 973-882-1167 (International), www.asme.org

ANSI B16.104	Control Valve Seat Leakage
ANSI/ASME B31.3	Chemical Plant and Petroleum Refinery Piping
ASME	Boiler and Pressure Vessel Code

2.1.3 API and IP Publications: Available from API, 1220 L Street NW, Washington, DC 20005-4070, Tel: 202-682-8000, http://api-ec.api.org

2003 MPMS	Manual of Petroleum Measurement Standards
SPEC 5L	Specification for Line Pipe
SPEC 6D	Specification for Pipeline Valves, End Closures, Connectors and Swivels
STD 607	Fire Tests for Soft-Seated Quarter-Turn Valves
STD 609	Dimensional Standard for Butterfly Valves
STD 610	Centrifugal Pumps for Refinery Service
STD 650	Welded Steel Tanks for Oil Storage
STD 653	Tank Inspection, Repair, Alteration, and Reconstruction
BUL 1529	Aviation Fueling Hose
SPEC 1581	Specifications and Qualification Procedures for Aviation Jet Fuel Filter/Separators
SPEC 1583	Specifications and Qualification Procedures for Aviation Jet Fuel Monitors

STD 1584 Four-inch Aviation Hydrant System Adaptor

STD 2000 Venting Atmospheric and Low-Pressure Storage Tanks (Methods for calculating vent sizes on tanks)

2.1.4 ASTM Publications: Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

A53 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

A105 Forgings, Carbon Steel, for Piping Components

A106 Seamless Carbon Steel Pipe for High-Temperature Service

A234 Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

A333 Standard Specification for Seamless and Welded Steel Pipe for Low-Temperature Service

D1655 Standard Specification for Aviation Turbine Fuels

D6615 Standard Specification for Jet-B Wide Cut Aviation Fuel

D4021 Glass Fiber-Reinforced Polyester Underground Protection Storage Tanks

2.1.5 ATA Publications: Available from ATA, 1301 Pennsylvania Avenue NW, Suite 1100, Washington, DC 20004-1707, Tel: 202-626-4000, www.airlines.org

SPEC 103 Standards for Jet Fuel Quality Control at Airports

2.1.6 CRC Publications: Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org

CRC Handbook of Aviation Fuel Properties

2.1.7 FAA Publications: Available from FAA, 800 Independence Avenue SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov

Advisory Circular 150/5230-4 Aircraft Fuel Storage, Handling and Dispensing at Airports

2.1.8 ICC Publications: Available from ICC, 5203 Leesburg Pike, Suite 600; Falls Church, VA 22041, Tel: 888-422-7233, www.iccsafe.org

UBC	Uniform Building Code

2.1.9 NACE Publications: Available from NACE International, 1440 South Creek Drive, Houston, TX 77084-4906, Tel: 1-800-797-6223, www.nace.org

2.1.10 NEMA Publications: Available from NEMA, 1300 North 17th Street, Suite 1752, Roslyn, VA 22209, Tel: 703-841-3200, www.nema.org

NEMA	Classifications
MG1	Motors and Generators

2.1.11 NFPA Publications: Available from NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471, Tel: 617-770-3000, www.nfpa.org

11	Standard for Low-Expansion Foam
24	Installation of Private Fire Service Mains and Their Appurtenances
30	Flammable and Combustible Liquids Code
70	National Electrical Code
77	Static Electricity
407	Aircraft Fuel Servicing (Includes EFSO station requirements)
415	Aircraft Fueling Ramp Drainage
780	Installation of Lightning Protection Systems

2.1.12 Steel Tank Institute Publications: Available from STI, 570 Oakwood Road, Lake Zurich, IL 60047, Tel: 847-438-8265, www.steeltank.com

ACT 100

ACT 100U

STI P3

2.1.13 UL Publications: Available from Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, www.ul.com

58	Steel Underground Tanks for Flammable and Combustible Liquids
142	Steel Aboveground Tanks for Flammable and Combustible Liquids
1316	Glass Fiber Reinforced Plastic Underground Storage Tanks
1746	External Corrosion Protection Systems for Steel Underground Storage Tanks

2.1.14 U.S. Government Publications: Available from Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/

40 CFR 112	Oil Pollution Prevention
MIL-DTL-5624	Turbine Fuels, Aviation, JP-4, JP-5, and JP-5/JP-8 ST
MIL-PRF-25017	Inhibitor, Corrosion, Fuel Soluble
MIL-DTL-83133	Turbine Fuels, Aviation, Kerosene Types, NATO F-34 (JP-8), and NATO F-35

2.2 Related Documents:

The following are provided for information purposes only and are not a required part of this Guide.

2.2.1 CSA Publications: Available from CSA International, 178 Rexdale Boulevard, Toronto, Ontario, Canada M9W 1R3, Tel: 416-747-4000, www.csa-international.org

B836-00	Storage, Handling, and Dispensing of Aviation Fuels at Aerodromes

2.2.2 U.S. Government Publications: Available from Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/

UFC 3-460-1	Petroleum Fuel Facilities

2.3 Definitions, Symbols, and Terminology:

ADDITIVE: Chemical added in minor proportions to fuels or lubricants to create, enhance, or inhibit selected properties; example, fuel system icing inhibitor (FSII).

AFFF: Aqueous film forming foam.

AIRCRAFT PARKING AREA: Location designated for aircraft parking or staging.

AMBIENT: Encompassing on all sides, as temperature.

ANODE: The positively charged electrode of an electrolytic cell.

ANSI: American National Standards Institute.

ANSI CLASS: The pressure-temperature rating of a flange, flanged fitting, or flanged vale. For the purposes of this document, an ANSI Class 150 flange has a pressure rating of 275 psig at 100 °F (1896 kPa at 37.7 °C); an ANSI Class 300 flange has a pressure rating of 740 psig at 100 °F (5102 kPa at 37.7 °C).

AOA: Airport Operations Area.

API: American Petroleum Institute.

APRON OR RAMP: A defined area on an airport or heliport intended to accommodate aircraft for the purposes of parking, loading and unloading passengers or cargo, refueling, or maintenance.

ASME: American Society of Mechanical Engineers.

ASTM: American Society for Testing and Materials.

AST: Aboveground Storage Tank.

ATA: Air Transport Association of America

ATG: Automatic tank gauge or gauging.

AUTHORITY HAVING JURISDICTION: Entity responsible for determining the required engineering, construction, and operating standards.

AUTO-IGNITION TEMPERATURE: The temperature at which a substance will ignite without the further addition of energy from an outside source.

BARREL (BBL): Measure of volume as used in the petroleum industry, equivalent of 42 U.S. gallons (0.16 m^3).

BIOCIDE: Additive to jet fuels to prevent microbiological growths in jet fuels.

BLIND FLANGE: Piping flange with no passage through the center.

BONDING: Providing an electrical connection between two objects to equalize their electrical potential.

BOTTOM LOADING: Method of filling tank trucks or tank cars through a tight connection at the bottom.

BREATHING: The movement of vapors into or out of a container because of natural cyclical heating and cooling.

BUNA-N (NITRILE): A copolymer of butadiene and acrylonitrile used as general purpose elastomers in contact with jet fuels.

CALIBRATION: Adjustment of the scale of a graduated device to meet an established standard, especially applicable to the adjustment of meter registers to indicate true volume as determined by a standard measure.

CATHODIC PROTECTION: A technique to control the corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

CENTISTOKES: A centistoke (cSt) is equal to 1 millimeter squared per second.

CENTRIFUGAL PUMP: A rotating device which moves liquids and develops liquid pressure by imparting centrifugal force.

CFR: Code of Federal Regulations.

CI: Corrosion inhibitor.

COALESCER: A filter designed to cause very small drops of water to form larger drops (coalesce) which will separate from fuel by gravity. Coalescer elements form one stage in a typical filter/separator.

COMBUSTIBLE LIQUID: Any liquid having a flash point at or above 100 °F (38 °C).

CONDUCTOR: A substance which permits the flow of electric currents without permanent physical or chemical change such as copper or aluminum.

CONTAMINATED FUEL: Petroleum fuel containing suspended or emulsified water, cleaning chemicals, or other foreign matter such as iron scale, dust, or other solid particles; or containing an unacceptable percentage of noncompatible fuel or other liquids; or containing more than one, or all of these classes of contaminants.

CONTAMINATION: The accidental addition to a petroleum fuel of some foreign material (contaminant) such as dirt, rust, water, or accidental mixing with another grade of petroleum.

CONTRACTOR: A person or entity responsible for constructing a fuel project.

CORROSION: The process of dissolving, especially of metals due to exposure to electrolytes.

CORROSION INHIBITOR: Additive labeled CI that minimizes rusting in pipelines and tanks. Also acts as a dirt dispersant and lubricity improver.

CRC: Coordinating Research Council, Inc.,

CRUDE OIL: Petroleum in its natural state prior to refining.

CSA: Canadian Standards Association.

CUT AND COVER: A style of petroleum storage tank used principally by the military, made by field erecting a steel or concrete/steel tank that is partially or fully below ground.

DEAD-MAN CONTROL: A control device, such as a switch or valve, designed to interrupt flow if the operator leaves his station.

DEFUELER: Tank vehicle used to remove fuel from aircraft.

DENSITY: The mass per unit volume of a substance.

DIEGME: Diethylene glycol monomethyl ether.

DIKE: An embankment or wall, usually of earth or concrete, surrounding a storage tank to impound the contents in case of a release.

DIRECT FUELING SYSTEM: Method used to refuel aircraft; also known as a hydrant system.

DISPENSE OR ISSUE: To transfer fuel from a storage system to a truck or aircraft.

DISSOLVED WATER: Water which is in solution with fuel as opposed to undissolved water (free water in suspension).

DIVERSITY FACTOR: Fuel system design usage factor, normally less than 1.0, to account for unknown non-simultaneous fueling system operations.

DOUBLE BLOCK AND BLEED: A method of proving that two closed piping segments are isolated from each other using two closed valves and an open drain between them. The two seals and the drain may be incorporated into one valve.

DOWNGRADE: To reclassify a petroleum product to a lesser grade than originally specified, due to the changing of properties resulting from contamination.

EFFLUENT: Stream flowing; discharge.

EFSO: Emergency fuel shut-off. (Also called ESO for military fueling facilities.)

EGME: Ethylene Glycol Monomethyl Ether.

ELASTOMERS: Materials with elastic properties.

ELECTRICAL ISOLATION: The condition of being electrically separated from other metallic structures or the environment.

EMULSION: A suspension of small globules of one liquid in a second liquid with which the first will not mix.

ENGINEER: Licensed professional engineer responsible for defining the technical requirements for the design, modification, and construction of fuel system facilities.

EPDM: Ethylene-propylene terpolymer. Not recommended for use in jet fuel systems.

EPOXY COATING: A coating of thermosetting resins having strong adhesion to the parent structure, toughness, and high corrosion and chemical resistance, also used as an adhesive.

EXPLOSION-PROOF: Classification of electrical enclosures for use in hazardous areas designed to prevent the passage of internal arcs, sparks, or flames.

FAA: Federal Aviation Administration.

FAR: Federal Acquisition Regulation.

FIBERGLASS: Composite material consisting of glass fibers in a matrix of resin such as epoxy.

FILTER: A porous substance through which a liquid is passed to remove unwanted particles of solid matter. Also a name for a vessel, usually equipped with paper elements, designed to remove particulate matter from a fuel stream.

FILTER/SEPARATOR: A filter or combination of filters designed to remove particulate matter and to remove entrained water by coalescing it.

FLAMMABLE LIQUID: Any liquid having a flash point below 100 °F (38 °C) and a vapor pressure not exceeding 40 psia (275 kPa) at 100 °F (38 °C).

FLASH POINT: The temperature at which a combustible or flammable liquid produces enough vapor to support combustion.

FLOATING PAN: See the definition for INTERNAL FLOATING ROOF TANK.

FREE WATER: Undissolved water content in fuel.

FSII: Fuel system icing inhibitor.

FUEL QUALITY MONITOR: A special type of filter designed to interrupt the flow of fuel when dirt or water content becomes too great.

GALVANIC ANODE: A metal which, because of its relative position in the galvanic series, provides protection to metal or metals that are more noble in the series, when coupled in an electrolyte.

GALVANIZING: Rust resistant zinc coating applied to iron and steel.

GROUNDING: Providing an electrical connection to earth.

GSE: Ground Service Equipment. All conveyances, except aircraft, used on the ground to transport persons, cargo, fuel or equipment.

HAYPACK FILTER: A filter which uses hay, straw, or excelsior as a filtering medium.

HAZARDOUS AREA: Electrical classification for areas where flammable or combustible liquids or vapors may be present.

HOT REFUELING: Refueling of aircraft which have one or more engines running.

HYDRANT SYSTEM: Distribution and dispensing system for aviation turbine fuels directly to an aircraft from the tank farm without first transferring the fuel to a refueler tank vehicle.

HYDRANT SERVICING VEHICLE: A hydrant servicing vehicle (either self-propelled truck or towed cart) or a pantograph (fixed or towed) is used to complete the link between distribution piping and the aircraft. Pressurization is supplied by the pumps at the fuel storage facility. The hydrant servicing vehicle is equipped with a meter to measure fuel quantity, a filter/separator or fuel monitor to maintain fuel quality, and a primary and secondary pressure control valve.

HYDROCARBON: A compound made up exclusively of hydrogen and carbon in various ratios and molecular arrangements.

HYDROSTATIC TEST: A test for structural integrity and leaks in tanks and piping systems using liquid as the test medium.

IMPERVIOUS: Not easily penetrated. The property of a material that does not allow, or allows only with great difficulty, the movement or passage of a fluid. Also referred to as impermeable.

ICC: International Codes Council

ISSUE OR DISPENSE: To transfer fuel from a storage system to a truck or aircraft.

JP FUEL: Military designation applied to aviation turbine fuels (e.g., JP-4, JP-5, and JP-8).

KEROSENE: A general term covering the class of refined petroleum which boils between 370 °F and 515 °F (188 °C and 268 °C). Mostly used in oil lamps and cooking stoves.

LITER (L): Equivalent to 0.001 cubic meters or 0.264 U.S. gallons.

MICRONIC FILTER: Commonly used name for a pre-filter.

NACE: National Association of Corrosion Engineers.

NEC: National Electrical Code. Another name for NFPA 70.

NEMA: National Electrical Manufacturers Association.

NFPA: National Fire Protection Association.

NIOSH: National Institute for Occupational Safety and Health.

NIPPLE: Short length of pipe, usually used to make side branch connections.

NOZZLE: A spout or connection, usually with a control valve through which fuel is discharged into a receiving container.

NPDES: National Pollutant Discharge Elimination System.

OIL/WATER SEPARATOR: A device used to separate oil from water.

OPA: Oil Pollution Act

OPERATING STORAGE TANK: Storage tank from which fuel is issued directly to the aircraft, sometimes called day tanks or ready-issue tanks.

OPERATOR: Entity designated by the Owner or Owner's representative to have responsibility for fuel system operation and maintenance.

OSHA: Occupational Safety and Health Act of 1970.

OWNER: Entity having ultimate control of the fuel system.

PANTOGRAPH: A series of pipes, joined by rotating joints, used to connect fueling equipment to aircraft or refueler trucks.

PARTICULATE MATTER: Solid particles such as dirt, grit, and rust, which contaminate fuel.

PIGGING: The act of propelling special devices called pigs through a pipeline with liquid or air for the purpose of internal pipe cleaning.

PIPELINES: Piping systems that are not subject to regulation by the Department of Transportation.

PLC: Programmable logic controller.

PREFILTER: A filter, usually equipped with paper elements, designed to remove particulate matter from a fuel stream. It is the term usually reserved for a filter located ahead of additional, more sophisticated, filter vessels such as filter/separators or clay treaters.

PSI: Pounds per square inch, the unit of pressure measurement.

PSIG: Pounds per square inch gauge; pressure above atmospheric.

PSIA: Pounds per square inch absolute; pressure above an absolute vacuum.

RADIOGRAPH: An image produced on radiosensitive film by invisible radiation such as X-ray, specifically the image produced by radiographic inspection of welds and plates.

READY-ISSUE TANK: Storage tank from which fuel is issued directly to the aircraft, sometimes called day tank or operating storage tank.

RECEIPT: To receive fuel into a storage system, normally from a third party provider. Fuel delivery may be by truck, pipeline, barge or other transporting method.

REFUELER TRUCKS OR REFUELERS: Tank truck vehicles used to resupply aircraft with fuel.

RELAXATION CHAMBER: Small tank in a fuel dispensing piping system downstream of high pressure drop components such as filter/separators or fuel quality monitors designed to remove static electricity from the liquid stream before discharge into a receiving tank. The principle is reduced velocity and time, allowing the electrons in the fuel to recombine and the static charge to dissipate.

RUST: Ferric oxide, a reddish-brown scaly or powdery deposit found on the surface of steel and iron as a result of oxidation of the iron.

SAE: Society of Automotive Engineers.

SLUDGE: Heavy viscous oily mass found in the bottom of storage tanks and treatment vessels, often contains rust, scale, dirt, lead additives, wax, gum, or asphalt.

SPCC: Spill prevention control and countermeasure.

SPECIFIC GRAVITY: The ratio of the weight in air of a given volume of a substance to the weight in air of an equal volume of distilled water (62.4 lb/ft^3) (1000 kg/m^3), both taken at the same temperature, usually 60 °F (16 °C).

STATIC ELECTRICITY: Accumulation of electric charge on an insulated body; also the electrical discharge resulting from such accumulation.

STATIC DISSIPATER: Additive labeled CU that raises the electrical conductivity of fuels and allows static electrical charges to dissipate more quickly. Also has mild surfactant properties.

STRAPPING: The process of determining the volume of a storage tank or cargo hold by measuring its linear dimensions and performing calculations to determine its volume per foot of tank height.

STRAY CURRENT: Current through paths other than the intended circuit.

STRIPPER PUMP: A pump used to strip or remove the last bit of liquid from a tank or pipe.

SUMP: A low area or depression which collects drainage.

SURFACTANTS: Short for Surface Acting Agents; also called emulsifiers or wetting agents. They are detergent or soap-like compounds that if in sufficient quantities will disarm (render inoperative) the water removing capabilities of filter/separators.

SURGE: Sudden increase in fluid pressure caused by sudden stopping of a moving stream as by a quick closing valve; hydraulic shock.

SURGE SUPPRESSOR: Device designed to control or reduce hydraulic pressure surges; hydraulic shock absorber.

TANK: A vessel for storing liquids or gases.

TANK CAPACITY: The quantity of aviation turbine fuel that can be stored in a tank. The nominal capacity is usually defined as the volume of the shell of a vertical aboveground storage tank between the floor to shell joint and the roof to shell joint. The nominal capacity of an underground storage tank is usually defined as the volume of the cylinder from end weld to end weld. The usable capacity of a tank is the amount of fuel in a particular tank that is designated as accessible under normal conditions. It is typically defined as the volume contained between the high and low level alarms.

TEFLON: A family of polymerized fluoroethylenes used as general purpose elastomers in contact with jet fuels.

TOP LOADING: Method of filling tank cars and trucks through an opening in the top.

UBC: Uniform Building Code.

UL: Underwriters Laboratories, Inc.

USER: Entity that receives, purchases, and or issues fuel through the fuel delivery system, such as an airline, fixed base operator, division of the military, etc.

UST: Underground Storage Tank.

VAPOR PRESSURE: Internal pressure of vapor in a liquid usually in pounds per square inch; an indication of volatility.

VITON: A family of fluoroelastomer dipolymers used as general purpose elastomers in contact with jet fuels.

VOLATILITY: Measure of the tendency of a liquid to vaporize; vapor pressure.

WASTE OIL: Oil or fuel which has become contaminated with foreign substances causing a level of non-conformance of its original properties sufficient to make it unusable for its original purpose.

WATER DRAW-OFF: A valve or similar device used to remove water from the bottom of a tank.

WATER SLUG SHUTOFF: A valve in the discharge piping from a filter/separator which closes automatically when the water in the unit rises above a set level.

WITHDRAW: To remove product from storage.

3. DESCRIPTION OF JET FUELS:

3.1 Turbine Fuels:

Turbine fuels are refined from crude oils and are made up of hundreds of different hydrocarbon compounds. They are specified by chemical composition and general properties. The exact composition of any particular turbine fuel will therefore vary with the type of crude oils from which they are manufactured as well as the refining process.

3.2 Commercial Jet Fuels:

3.2.1 Jet A: A commercial aviation turbine fuel used primarily in the continental United States. The fuel is a refined, kerosene type, hydrocarbon product defined by ASTM D 1655. Its primary distinguishing characteristics are a -40 °F (-40 °C) freezing point and a minimum flashpoint of 100 °F (37.8 °C). It is typically delivered to the aircraft without additives.

3.2.2 Jet A-1: A commercial aviation turbine fuel used outside the continental United States and in most northern U.S. airports. It is similar to Jet A but with a freezing point of -53 °F (-47 °C). It is similar to JP-8 without the additives. It is also defined by ASTM D 1655 and is typically delivered to the aircraft without antistatic additive.

3.2.3 Jet B: A seldom-used commercial aviation turbine fuel used primarily where a lower freezing point is required. The fuel is a refined, wide cut type (kerosene and naptha mixture), hydrocarbon product defined by ASTM D 6615. It is similar to JP-4 but typically contains no additives. Its primary distinguishing characteristics are a -58 °F (-50 °C) freezing point and a vapor pressure of 2 to 3 psi (14 to 21 kPa).

3.3 Military Jet Fuels:

3.3.1 JP-4: Once widely used in the military, it has been phased out and is used only at a limited number of extremely cold weather locations. The fuel is a refined, wide cut type (kerosene and naphtha mixture), hydrocarbon product defined by MIL-DTL-5624. It contains anti-icing, antioxidant, corrosion inhibitor and antistatic additives with metal deactivator as an option. Its primary distinguishing characteristics are a -72 °F (-58 °C) freezing point and a vapor pressure of 2 to 3 psi (14 to 21 kPa).

3.3.2 JP-5: A military aviation turbine fuel used exclusively by the United States Navy. It is the only fuel allowed on naval vessels for turbine use due to its relatively high flashpoint. The fuel is a refined, kerosene type, hydrocarbon product defined by MIL-DTL-5624. It contains anti-icing, antioxidant and corrosion inhibitor additives with metal deactivator as an option. Its primary distinguishing characteristics are a -51 °F (-46 °C) freezing point and a minimum flashpoint of 140 °F (60 °C).

3.3.3 JP-8 and JP-8 + 100: A military turbine fuel used by the United States Air Force and Army. The fuel is a refined, kerosene type, hydrocarbon product defined by MIL-DTL-83133. It is similar to Jet A-1 with additives including anti-icing, antioxidant, corrosion inhibitor, and antistatic. Metal deactivator and thermal stability enhancer additives are options. When the thermal stability enhancer is used the fuel is referred to as “JP-8 + 100” where “100” refers to the rise in degrees F of the thermal stability point of the fuel. Its primary distinguishing characteristics are a -53 °F (-47 °C) freezing point and a minimum flashpoint of 100 °F (37.8 °C). JP-8 + 100 should never be mixed with, or downgraded to, JP-8 without following the most stringent fuel quality controls.

3.4 Fuel Properties:

For properties of commercial and military jet fuels, refer to ASTM D 1655 and the Handbook of Aviation Fuel Properties as prepared by the Coordinating Research Council, Inc.

3.5 Description of Additives:

Additives are components added to a fuel to improve certain properties or to overcome a particular problem. Refer to Owner’s fuel specifications for additive quantities.

3.5.1 Fuel System Icing Inhibitor (FSII): These additives prevent the formation of ice in fuel. The principle chemical used is diethylene glycol monomethyl ether (DiEGME); however ethylene glycol monomethyl ether (EGME) is also used. They also act as a potent biocide to reduce the potential for microbiological growth at the fuel/water interface.

3.5.2 Corrosion Inhibitor (CI): These additives are intended to minimize rusting in pipelines and tanks. Their composition is controlled by MIL-PRF-25017. The principal chemical used is DCI-4A. It also acts as a dirt dispersant and lubricity improver.

3.5.3 Static Dissipater (CU): These additives raise the electrical conductivity of fuels and allow static electrical charges to dissipate more quickly. The principal chemical used is Dow Stadis 450 which has mild surfactant properties.

3.5.4 Biocide Additives: These are sometimes added to jet fuels to prevent microbiological growths in jet fuels.

3.5.5 Other Additives: Anti-oxidants may be added to prevent formation of gums and peroxides. Metal deactivators react with soluble copper and other metal compounds to prevent undesirable reactions leading to filter-blockage troubles. Thermal stability enhancers raise the temperature at which the basic hydrocarbon structure of the fuel tends to break down; they tend to have strong surfactant properties and are therefore currently injected after the last filter/separator.

3.6 Fuel Contamination:

Jet fuel contamination occurs as a result of poor design, construction, handling, storage, maintenance, and/or operational practices. Contaminants include the following:

3.6.1 Water: Water causes icing of the fuel system, malfunctioning of fuel measurement devices, and corrosion of fuel system components. Water also promotes other types of contamination such as particulate matter and biological growth. Water can also mix with additives to cause many types of fuel quality and contamination issues as well as disarming several common types of filtration and water removal equipment. The primary sources of contamination are rain and atmospheric condensation in storage tanks and free, entrained and/or dissolved water from the refinery or transport (pipeline, barge, truck, etc.).

3.6.2 Particulate Matter: Particulate matter is deleterious to fuel measurement devices and can clog fuel filters and foul valves. Its primary sources are rust from wetted metal surfaces, dust from air vents, and materials left in the fuel system from the construction period.

3.6.3 Biological Growth: Living organisms grow at the fuel and water interface. The presence of organisms may lead to problems with measurement devices, sight glasses, etc.

3.6.4 Metal Ions: Contact between jet fuels and certain types of metals release ions into the fuel, which may lead to a decrease in fuel thermal stability.

3.6.5 Disapproved Additives or Additives Mixed Improperly: Refer to the Owner's specifications for the proper fuel additives, additive mixing procedures and additive quantities.

3.7 Design Considerations Regarding Contaminants:

3.7.1 Jet fuel handling, storage, and distribution system designs shall be designed to both prevent the introduction of contaminants and to remove them after they are introduced.

3.7.2 Water: Design piping systems with adequate slope and velocity to move water to the low points and provide drains to remove the water. Provide water removal filter/separators and monitors to remove water from the fuel before it enters controlled areas such as an aircraft, a refueling vehicle or storage tank. Design storage tanks to minimize rainfall introduction and condensation within the tank.

3.7.3 Particulate Matter: Prevent the corrosion of wetted metal surfaces that may corrode by using non-corrosive materials or coating them. Provide filters and strainers to remove contaminants from the fuel before it enters controlled areas such as an aircraft, a refueling vehicle or storage tank.

3.7.4 Biological Growth: Prevent the introduction of water into the fuel system and provide for its removal after its discovery.

3.7.5 Metal Ions: Limit contact between jet fuels and materials that affect thermal stability by eliminating to the extent practical zinc, zinc alloys, copper, copper alloys or bare carbon steel. Use stainless steel, aluminum or interior coated carbon steel instead.

3.7.6 Additives: Design additive injection systems as per manufacturer guidelines. Designing the system to handle water contamination will help mitigate most operational additive related contamination problems.

3.8 Construction Considerations Regarding Contaminants:

To ensure fuel quality, the jet fuel handling, storage, and distribution system shall be constructed per the construction documents and per the recommendations of the equipment manufacturers. Keeping the interiors of the piping, tanks and vessels free of particulate matter and water are of supreme importance.

3.9 Operational Practices:

The Owner shall be responsible for ensuring that jet fuel quality control operator training and task evaluation programs are implemented per ATA SPEC 103.

4. SYSTEM PLANNING:

4.1 General:

4.1.1 Planning for aviation fueling facilities must comply with industry codes and standards and meet all applicable Federal, State, and Local laws and regulations. Further requirements should include Owner's specific objectives as well as insurance requirements.

4.1.2 Planning for facilities shall comply with FAA airspace and airfield clearance restrictions and Local and FAA security requirements. Compliance with these requirements should also be considered when planning renovations of existing facilities.

4.1.3 The engineer should consider the Owner's need for system expansion based on future growth predictions to meet operational requirements.

4.1.4 Owner's scope and budget limitations are key issues that should be addressed as part of the planning phase of the project. The engineer should consider if the Owner's objective is to minimize long-term ownership costs or to minimize initial construction or operating costs or some combination thereof.

4.1.5 The facility design should be consistent with the airport master plan and must comply with project lease and land use restrictions imposed by adjacent jurisdictions. Changes to the master plan shall be thoroughly documented and coordinated with applicable agencies.

4.1.6 The Owner's policies concerning custody receipt requirements, inventory control procedures, handling of bonded fuel and special handling needs to include additive injection equipment should be considered.

4.1.7 Determination of current and future fuel consumption needs is critical and requires thorough analysis of historical fuel use data from all users of the facility. Take into consideration average daily fuel consumption by grade, peak uplift data, simultaneous servicing requirements, and peak flow data as well as receipt and transfer capability. General planning information used in this analysis includes aircraft information including flight schedule, aircraft mix, load factors, flight duration, aircraft fuel consumption factors and aircraft characteristics including length, wingspan, and location and height of the fueling receptacles.

4.1.8 Verify availability of all necessary utilities such as electrical power, water, and communications to meet current and future facility requirements.

4.1.9 Planners shall consider building redundant capacity in critical system components such as pumps, filters, and emergency power to minimize and/or eliminate system down time.

4.1.10 Assure compliance with fuels quality requirements of ATA SPEC 103 or applicable military criteria. Coordinate with Owner to identify additional quality requirements exceeding industry standards.

4.1.11 Provide corrosion protection for piping, equipment and tanks consisting of coatings and cathodic protection.

4.2 Facility Siting Issues:

4.2.1 Conduct a geotechnical survey and incorporate the resulting information into the planning process when available.

4.2.2 Coordinate the design concept review with responsible fire official and/or other Authority Having Jurisdiction.

4.2.3 Locate existing and site future utilities to minimize impact on current operations.

4.2.4 Evaluate emergency vehicle access/egress routes to provide adequate emergency response.

4.2.5 Evaluate existing airport industrial and commercial traffic to develop safe entry and exit routes for petroleum delivery vehicles.

4.2.6 Comply with necessary security requirements including fencing, surveillance equipment, and security communications equipment. Considerations should be given to the Owner's risk management program.

4.3 Fuel Receipt:

4.3.1 The engineer should thoroughly analyze existing receipt capabilities to assure optimization of facilities in use and consider enhancements to increase existing fuel receiving and transfer rates. Obtain anticipated changes to the current demand rate to assess facilities' capability to meet future needs. New facilities should be designed to meet anticipated growth or to accommodate future expansion.

4.3.2 Consider the following for development of new or expanded receipt facilities: type of existing and possible future receipt mode(s); space to accommodate new equipment; existing and future fuel consumption; land use and airspace clearance constraints, Owner quality requirements, cost constraints, facility access, vehicle traffic flow, environmental issues, installation security, and specific insurance considerations of the Owners.

4.3.3 Incorporate Owner's specific accounting and automation requirements and custody transfer procedures.

4.4 Tank Truck Delivery:

4.4.1 Tank truck receipt facilities typically require more area than pipeline receipt facilities. Commercial tank trucks normally exceed 56 ft (17.1 m) in length. Typically spacing for multiple unload positions is 80 ft (24.4 m) apart, allowing trucks to maneuver into and out of the area. Verify the size(s) of fuel delivery vehicles and consider parallel off-loading positions.

4.4.2 Determine the number of off-loading positions required to meet demand. Planning factors should consider space, available manpower, weather, safety, traffic congestion, access and egress routes for both delivery and emergency vehicles, etc.

4.4.3 Provide inbound filtration.

4.4.4 Evaluate the method of truck off-loading. Consider hydrostatic, environmental, cost, safety, and total storage requirements. Provide secondary containment.

4.4.5 Consider a staging area for parking full trucks that are waiting for an off-loading spot to open up.

4.4.6 Consider the use of underground tanks to allow for gravity off-loads.

4.5 Pipeline Delivery:

4.5.1 Bulk transfer of aviation fuel is typically delivered via pipeline where receipt volumes, time, manpower, and space limitations may preclude tank truck operations. When planning a pipeline receipt facility, key design considerations include: storage tank capacity limitations, transfer flow rates and operating pressures of the pipeline, batch quantities, breakout tankage, multi-product pipeline cycles, and future consumption requirements.

4.5.2 Provide inbound filtration and automatic bypass capability protection for excessive differential pressure build-up during receipts from cross-country pipelines.

4.5.3 Review and comply with the pipeline operating agreement. Plan for adequate pressure control transition into the airport fuel storage and provide communications protocol to interface with the pipeline pump station. Include emergency shutdown capability in the system design.

4.5.4 Provide for adequate security of the pipeline receipt facility to preclude unauthorized personnel from entering the area.

4.6 Tank Capacity:

4.6.1 Determine total fuel storage requirements based upon current and projected fuel use and resupply methods and capability. The amount of storage available should meet the daily demand or issue rates as well as peak or surge issue rates, whichever is greater. The engineer should specify both nominal and useable tank capacities.

4.6.2 Critical issues impacting the amount of fuel storage for a particular airport include the historic fuel receipt quality, the delivery mode, the frequency and size of delivery, reliability of the supplier, the need to handle bonded fuel, quality control testing requirements, fuel settling time, and operations and maintenance schedules.

4.6.3 Verify the Owner's operational parameters for tank usage and dispensing. A minimum of three tanks per product is recommended to maximize operational flexibility, allowing simultaneous receipt, settling, and issue of product. Options for tank configurations are described in Chapter 5.

4.6.4 Bulk and operating storage tanks should be located as close to the active aircraft fueling operations area as possible and still meet airfield clearance, safety, and security requirements in order to minimize construction costs and reduce hydraulic surges.

4.7 Refueler Truck Loading:

4.7.1 All airports have truck refueling capability as either a primary means of servicing aircraft, provide supplemental servicing capability at locations with hydrant fueling systems, or accommodate aircraft parked at various locations on the airport without hydrant outlets. Provide a minimum of two loading positions per grade of product at the truck refueling facility. Additional truck loading positions are determined based upon operational needs.

4.7.2 Access to and from the facility is a critical consideration. Locate the refueler truck loading area as close to the aircraft parking areas as possible to minimize transit time. Unobstructed access for both fuel servicing and emergency response vehicles is absolutely critical. Since these vehicles have access to the entire parking apron, security of the vehicles and loading area is essential and shall be designed to preclude unauthorized entry. Verify with the Chief of the Airport Security Program all requirements and assure compliance with FAR Parts 107 and 108.

4.7.3 Verify Owner's requirements for custody transfer control, automation, and data transmission to meet accounting and inventory control needs.

4.7.4 Provide issue filtration.

4.7.5 Where two or more refueler trucks are located in a straight line, provide sufficient spacing to allow the refuel vehicles space to enter and exit.

4.8 Hydrant Systems:

4.8.1 Hydrant fueling systems are normally found at airports with a large number of fueling operations or when large frame aircraft with large volume requirements are the norm. Factors influencing the selection of this dispensing mode include the daily number of aircraft servicing operations, peak servicing requirements, amount of fuel issued per aircraft, number of simultaneous servicing operations and safety considerations.

4.8.2 Hydrant fueling systems include operating storage tankage, pumps, filter/separator vessels, pressure and flow control valves, discharge piping, and hydrant and isolation valve pits on the aircraft parking apron.

4.8.3 Determine required pump system flowrate capacity based on the peak demand and reserve capacity requirements. Factors influencing the peak demand include aircraft mix, number of simultaneous servicing operations, volume of fuel issued per aircraft, and acceptable system diversity factor.

4.8.4 Include provisions for future expansion by allowing for increases in future pump and filtration capacity, and strategically located blind flanges and isolation valves for extending the system.

4.8.5 Determine number and the location of hydrant outlet positions based on the aircraft-parking plan, the specific type of aircraft, and in consideration of ground support and servicing equipment requirements around the aircraft.

4.8.6 Verify with Owner the need to provide aircraft defuel capabilities. If fuel is permitted to be removed from the aircraft and returned into the hydrant fueling system, assure that the hydrant valve has the necessary features to accommodate reverse flow. The Owner must have equipment capable of performing the defuel operation and adequate filtration.

4.8.7 Perform an initial estimate of the pipe size and configuration necessary to support the operation. See Section 5 for sizing parameters.

4.8.8 Develop an emergency fuel shut-off system consistent with Local requirements, NFPA 407 and other applicable requirements. Obtain approval from the Authorities Having Jurisdiction.

4.8.9 Coordinate fueling hydrant outlet locations with applicable fire/safety clearance criteria such as NFPA and Local building codes.

4.8.10 Provide positive isolation valves (double block and bleed type) for maintenance, emergency operations, and spill or leak detection.

4.9 Product Systems Other Than Jet Fuel:

4.9.1 While not within the scope of this document, facilities should be planned to accommodate other products in addition to jet fuels. These products include various grades of aviation gasoline, automotive gasoline, and diesel fuel. Additionally, some locations have systems for injecting additives into fuels. Airports may also receive, store, and issue glycol for deicing aircraft.

4.9.2 These systems require careful planning and design to ensure that they comply with applicable industry codes and standards. Particular attention should be given to packaged systems to ensure compliance with accepted industry standards.

4.10 Environmental Considerations:

4.10.1 Provide secondary containment and spill containment for all aboveground tanks, truck loading and unloading areas, and permanent fuel vehicle and servicing equipment parking areas. Design includes providing individual spill containment areas with drains to oil/water separators or by using retention basins or ponds. Assure compliance with Federal, State, County, City, and Local airport rules and regulations and coordinate the facility design with applicable environmental authorities.

4.10.2 Review environmental requirements to determine special handling procedures for stormwater with hydrocarbons present.

4.10.3 Consider management of lead and asbestos when modifying existing systems.

4.10.4 Review requirements of applicable air quality regulatory agencies and the airport authority to assure compliance with product emission limitations.

4.10.5 Coordinate with the Owners and Local, State, and Federal environmental agencies to determine the extent of leak detection requirements.

4.11 Other Items for Consideration:

4.11.1 Maintenance facilities including repair shops for fuel servicing equipment and system components. These facilities are generally located adjacent to equipment parking areas, tank farms and/or operations areas.

4.11.2 Fuel servicing equipment parking areas and cold weather storage facilities, i.e., heated parking building, provisions for engine block heaters, etc.

4.11.3 Operations buildings to including office space for supervisory personnel, a dispatch office or control center, a ready room for operator personnel, a fuels laboratory, necessary comfort facilities, and a break room for operators.

4.11.4 Adequate employee parking consistent with installation security plans.

4.11.5 Lighting for work areas.

5. DESIGN:

This section discusses design issues associated with the systems and sub-systems that deal with the receipt, storage, and dispensing of aviation fuel. Design of these systems should follow good engineering practices and meet the requirements of all Local, State, and Federal codes and regulations.

5.1 General:

Information contained within "General" is applicable to all of the systems and sub-systems described in this chapter.

5.1.1 Overall Design Standards: The piping design standard for aviation fuel piping is Process Piping ASME Code for Pressure Piping. ANSI/ASME B31.3.

5.1.2 System Pressure Rating: Generally, aircraft fuel system piping and components are designed using an ANSI Class 150 pound pressure rating. For purposes of this document, and for most design purposes, this is defined as 275 psig maximum allowable working pressure at 100 °F (1896 kPa at 37.8 °C. Factors to consider in determining the pressure rating of the system are system hydraulics, relative elevations, pump head, thermal relief pressure, and the potential for surges. In some instances, use of pressure ratings higher than ANSI Class 150 pound may be necessary. Conversely, the use of lower pressure rated components such as meters and filter vessels, may be justifiable for lower pressure loading and unloading operations. In addition, several common components in aircraft fuel systems such as underwing nozzles and adaptors are not available at 275 psig (1896 kPa) maximum allowable working pressure.

NOTE: The pressure rating of an ANSI Class 150 flange varies with the flange material and ambient temperature.

5.1.3 Materials:

5.1.3.1 Overall Materials:

a. Fuel quality and operational safety are of primary importance. Consequently, piping, equipment and other component materials used in aviation fueling systems must be selected considering potential impacts on fuel quality. An improperly designed system can impact fuel quality with contaminants such as rust, dirt, water, and construction debris.

b. To protect the thermal stability properties of aviation turbine fuels, materials in contact with fuel should not include copper, copper alloys, light metal alloys containing more than four percent copper, zinc, zinc alloys, cadmium, lead, or lead alloys. Bronze hose couplers are permitted. Minimize contact between the fuel and ferrous materials such as ductile iron and carbon steel through the use of plating, coatings, and non-ferrous materials such as stainless steel and aluminum.

c. Natural rubber, neoprene and EPDM are not compatible with aviation turbine fuels. Teflon, nylon, and urethane are generally considered suitable for use with aviation fuels as well. Compatible elastomers for valve/equipment seals and other related uses include Buna-N (nitrile) and Viton.

5.1.3.2 Piping Materials: To protect fuel quality and extend the life of the piping system, all piping that comes in contact with the aviation fuel should be either internally lined carbon steel piping or stainless steel piping. To protect piping from corrosion, all piping shall be externally coated. The use of fiberglass reinforced plastic (FRP) and aluminum for piping systems is not recommended.

5.1.3.3 Valve Materials: Consideration should be given to preventing fuel contamination resulting from wetted ferrous valve surfaces, such as use of cast ductile iron or cast carbon steel valves with chrome plating, nickel plating, or epoxy-coating. Another alternative is stainless steel or aluminum.

5.1.4 Underground Piping Arrangement:

a. Spacing between parallel fuel piping is typically set to allow for adequate pipe bedding compaction between the pipes.

b. Spacing between fuel liner and water and sanitary sewer lines will be per code.

c. Separation distances from other utility piping should horizontally be a minimum of 36 in (914 mm), and vertically no less than 12 in (305 mm). A vertical separation of 18 in (457 mm) is preferable. Provide insulating material if these cannot be met.

d. Consider cathodic protection as well, especially shorting to other systems, piping, utilities, and structures.

5.1.5 Testing: Testing of fuel piping is recommended to be performed in accordance with ANSI/ASME B31.3 and the engineer shall determine the applicability of the code. All new temporary and permanent piping shall be tested in the following steps.

a. All underground welds and a minimum of 10% of aboveground welds on fuel systems shall be radiographic inspected. Acceptable criteria shall be based upon serve cyclic conditions.

b. Initial Leak Test: An initial pneumatic leak test shall be performed on all temporary and permanent fuel piping prior to filling with fuel. Test pressure should not exceed 25 psig (172 kPa) and the test medium shall be dry compressed air or nitrogen. During this test all joints shall be checked for leaks using the “soap” test method.

c. Pneumatic Pressure Test: A pneumatic pressure test may be performed after the “initial leak test” on all temporary and permanent fuel piping prior to filling with fuel. For permanent piping the recommended test pressure is typically 50 to 100 psig (345 to 690 kPa) with a test duration of 24 hours and monitored with a dual temperature/pressure recorder. For temporary piping the recommended test pressure is typically 50 psig (345 kPa) with a test duration of 2 hours and may be monitored visually. The test medium for all pneumatic testing shall be dry compressed air or nitrogen.

d. Hydrostatic Pressure Test: A hydrostatic test must be performed on all permanent piping systems fuel as the test medium. The recommended test pressure shall be 150% of the maximum design system operating pressure, not to exceed 275 psig (1896 kPa) for Class ANSI Class 150 systems. Higher test pressures are sometimes selected; if so, additional precautions such as removing equipment not rated beyond 275 psig (1896 kPa) must be taken. The hydrostatic test duration shall be a minimum of 4 hours and shall be monitored with a temperature/pressure recorder.

e. Testing of Protective Coatings: Perform tests with an approved silicone rubber electric wire brush or an approved electric spring coil flaw tester. Tester shall be equipped with an operating bell, buzzer, or other audible signal which will sound when a holiday is detected. Areas where arcing occurs shall be repaired by using material identical to original coating or coating used for field joints. Upon completion of installation, retest the exterior surfaces, including field joints, for holidays. Promptly repair holidays.

f. In the event that a test fails, the leaks shall be identified, repaired and the system retested in accordance with the procedures as outlined above.

5.1.6 Environmental Considerations:

5.1.6.1 Spill Prevention:

a. Oil Pollution Act:

1. The Oil Pollution Act (OPA) was signed into law in August 1990. The OPA improved the nation's ability to prevent and respond to oil spills by establishing provisions that expand the Federal government's ability, and provide the money and resources necessary, to respond to oil spills.

2. The OPA provides requirements for contingency planning both by government and industry. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) has a three-tiered approach: the Federal government is required to direct all public and private response efforts for certain types of spill events; Area Committees are composed of Federal, State, and Local government officials who must develop detailed, location-specific Area Contingency Plans; and owners or operators of vessels and certain oil facilities that pose a serious threat to the environment must prepare their own facility response plans.

b. SPCC Regulations:

1. The SPCC (Spill Prevention, Control, and Countermeasures) 40 CFR 112 regulations, administered by the U.S. EPA, establish comprehensive procedures, methods and equipment requirements to prevent the discharge of oil from “non-transportation-related” onshore, inland and offshore facilities, including those with aboveground storage tanks (ASTs), into or upon the navigable waters or adjoining shorelines of the U.S., and to contain such discharges when they occur.

2. The SPCC regulations require development of a plan that would address the Owner’s and Operator’s prevention and control of project releases.

3. Current SPCC guidelines require that plans for tank and pipeline integrity assessments and pipeline tightness testing be developed and executed.

5.1.6.2 Spill Containment:

a. At each location where fuel is received, stored, transferred, loaded or offloaded, provide an impermeable retention and controlled drainage system leading to a containment or treatment system. Provide a controlled drainage system if possible to preclude the influx of surrounding stormwater drainage.

b. Loading/Offloading Facilities: Pave the spaces between truck positions, and on each side of the outer positions, with concrete pitched a minimum of one percent toward catch basins or trench drains. Design containment per the most stringent of Federal, State or Local regulations. Maximum slope should not exceed 8.0 % for vehicle entry and exit containment curbing. “Speed bumps” should not be used due to potential damage to rigid chassis equipment. Do not use asphalt within a containment area.

c. Equipment Pads/Enclosures: Provide secondary containment for equipment pads and enclosures to prevent the migration of dripped or spilled fuel into the surrounding environment. This should include any equipment or piping connections that are not sealed by welding and can potentially leak. Pads or slabs may be drained to a controlled drainage system. Also consider the use of walkway gratings within curbed containment areas to allow access above potential ponding of liquids.

d. Tank Diked Areas:

1. Types: Concrete, steel, or earth berm dike walls for containment. Constructed material to protect adjacent property in the event of a spill. Spill and concrete dike walls are commonly 6 ft maximum height to allow ease of emergency access. Provide stairways and ladders for personnel access/egress and consider providing vehicle access.

2. Containment volume requirements: per NFPA-30, environmental regulations, or determined by more Owner stringent requirements. Consider also the accumulation of precipitation that cannot be easily removed, and for the degradation of earthern dikes over time, reducing its effective height.

3. Liner systems: Common fuel resistant materials to “temporarily impound” potential spills including concrete and synthetic compound liners. Exposed liner materials shall be UV and continuous fuel (and associated additives) immersion resistant.

4. Drainage systems: Drainage system for containment areas to use exterior valve to release water following a storm event after checking for presence of fuel. Valves to be normally closed and locked to preclude inadvertent release.

5. Dike system shall prevent migration of fuel at a rate greater than that prescribed by Local or State regulations.

e. Remote impoundment: Per NFPA 30, another option for spill containment is remote impounding. This option controls spillage by means of drainage to a remote impounding area, so that impounded liquid will not be held against tank(s). The impounding area must have a capacity of not less than the largest tank that can drain into it plus an allowance for precipitation.

5.1.6.3 Product Recovery Systems:

a. General Criteria: Include one or more tanks or other collection system equipment to collect fuel and fuel/water mixtures from tank and equipment sumps, equipment drains, product saver tanks, thermal relief valves, automatic air vents, fuel sampling, high point vents, low point drains, and any other equipment from which fuel or fuel/water mixtures can be collected.

b. Types and Configuration:

1. Product Recovery Tank: Typically a large tank located in a fuel farm. Typically one tank receives the fuel and fuel/water discharges of the entire facility. It usually includes a pump for off-loading and may be installed either above or below ground. At the discretion of the Owner this tank will be configured to: (1) Transfer its contents directly into a waste oil truck or facility, or (2) Separate its contents into fuel and oily water and deliver the fuel back into storage through filtration and the water to a waste product tank, truck or facility, or (3) Deliver its contents to a filtration system for separation into usable fuel and oily water. A separate waste product tank may be provided for collection of oil/water mixtures that are not considered suitable for recovery.

2. Product Saver Tank: Also called a water draw-off tank or a sump separator, this is a small (less than 100 gallons (380 L)) aboveground tank located adjacent to an aboveground storage tank or filtration bank and piped and valved to allow for the drawing of water from the bottom of a storage tank or filter vessel and returning the product to the storage tank or filtration system after the water has separated and been sent to the product recovery or waste product tank. These are typically equipped with an electric pump (a hand pump is acceptable but less desirable) and a full size opening in the top to allow for inspection, cleaning and a way to manually return fuel samples to the system.

3. Water Stripping System: A small packaged filtration system (typically located adjacent to a storage tank) that continuously removes fuel from the storage tank, circulates it through a filter/separator and then returns the clean, dry fuel to the tank while it either stores or transfers the water to the product recovery or waste product tank. It is used in situations where traditional product saver tanks are overwhelmed by the amount of water they are required to handle.

5.1.6.4 Automated Leak Detection Systems for Pressurized Piping:

a. General Criteria: Leak detection for aviation product piping for refueler loading and aircraft hydrant systems should be a fixed or mobile assembly of components capable of detecting product leaks from pressurized piping. This can be accomplished by means of a periodic manual test or as an automatic system depending on Local requirements and the Owner's instructions. The technology and manufacturer should be one that is reviewed and listed by the National Work Group on Leak Detection Evaluations (NWGLDE). The leak sensitivity and frequency must be consistent with Federal, State, and Local environmental regulations. The leak detection system technology utilized should be specifically designed to address the physical size, piping configurations, operating conditions, flow rates and pressure variations common to refueler loading and aircraft hydrant systems. If a leak detection system is not included initially, provisions for future installation should be considered such as capped pipe connections, isolation valves and thermowell connections. Consideration should also be given to minimizing the volume of the system to be tested that is aboveground. The Engineer should coordinate early in the planning process with regulatory authorities.

b. Leak Detection Methodologies:

1. Leak detection systems are available in both the static and dynamic modes. A static system requires a hydrant system to be isolated for the duration of the test. This is usually accomplished by closing valves at the test envelope end, by using motor operated valves. Dynamic leak test systems utilize a variety of methodologies to look at fluid in and fluid out of a continuous pipeline. Hydrant systems, by the nature of having a variety of exit paths by design and purpose, are not candidates for dynamic leak detection. It must be noted that high technology leak detection, although an available concept for over 12 years, is still in a state of flux with new and better technology emerging at frequent intervals. Maximum flexibility should be built into a system to accommodate future upgraded leak detection systems and technology.

2. Visual Observation: Where possible, locate piping aboveground. Most environmental regulations will not require any further type of leak detection.

3. Hydrostatic Testing: Using product, the piping is placed under pressure for some period of time. Water shall not be used. All air must be removed from the line, and very accurate temperature measurements must be taken to compensate for thermal expansion or contraction of the fuel. The sensitivity of the test is a function of time (for thermal equilibration), pipe volume, and temperature measurement sensitivity. The piping needs to be blind flanged or terminated using double block and bleed valves, and surge arrestors should be isolated. This technology will not locate a leak other than in the section of piping tested. Internal valve leakage can compromise test results. An operational test may be built into the fuel distribution system as an automated part of the pump and valve control. Frequently repeating the test using a statistical algorithm can improve the sensitivity of this automated version of a hydro test.

4. Dual Pressure, Temperature Neutralizing Method: This type of test or monitoring system conducts a pressure test on a segment of the system at two different pressures in rapid succession in order to eliminate thermal affects as they “neutralize” the effect of temperature change. The two pressure changes versus time curves are analyzed. Parallel curves usually indicate the change is temperature related. Non parallel curves indicate a possible leak. Statistical analysis using multiple tests may be applied on a specific piping segment to improve sensitivity. This is essentially similar to a hydrostatic test, except temperature measurement is not required.

5. Dual Pressure, Volume Method: This type of test or monitoring system first maintains the system pressure at a upper pressure, and measures liquid in or out, then uses a lower pressure and measures liquid in or out. As the test is of relatively short duration, if temperature changes are causing the liquid addition or removal, the volumes should be the same. In the event the volumes are the same, adjusted for the different pressure, a leak may be determined.

6. Chemical Marker: A volatile chemical marker or inoculant is added to the product, followed by analysis of air surrounding the buried pipe. Location of the marker indicates leakage. This is effective for precise leak location, but not easily adaptable to automated monitoring. Standards governing the composition of jet fuels limit additives to jet fuel, so coordination with Owners and Users is imperative before inoculating fuel.

7. Hydrocarbon Detection: There are many electronic, optical, cable, and float type hydrocarbon sensors available for detecting product or hydrocarbon vapor outside a piping system. While many of the sensors will detect hydrocarbons under ideal conditions, site geology, product volatility, and water table can have dramatic impact on the ability of these detectors to “see” product or vapor. Since jet product is a high flash point hydrocarbon, vapor sensors may have a reduced ability to detect all but the largest leaks. Hydrocarbon monitoring works best on a closed interstitial space which is typical in a double wall piping system, but has difficulty when contaminated with fuel or water.

c. Application Guidelines: To obtain proper test performance from any leak detection technology or system, specific components and construction methods must be integrated into the piping system.

1. Isolation Valves: To obtain a successful test the piping must maintain a pressure within the parameters of the test. To accomplish this, the piping system must have isolation valves with positive shut-off characteristics to isolate segments of the system. General practice utilizes double block and bleed plug valves. The isolation valves should be strategically located within the system to optimize isolation of segments and maximize test performance. These valves are motorized when automatic leak detection is provided.

2. High Point Vents: To obtain leak tests without a bias from vapor pockets, it is imperative that the piping be properly sloped and include vent valves at high point locations in the piping system. In some cases however, care must be exercised in placing remote high point vents because the environmental risks may outweigh the leak detection benefits. In system where it is impractical or impossible to provide vents, design and operate the system to minimize the introduction of air.

3. Set-up Calibration: To establish a testing program with acceptable accuracy, the leak detection system must be modeled and calibrated to the specific piping system. Issues such as isolation segments, surge absorbers, control devices, potential thermal spots where the above grade piping can be exposed to the sun, and elevation changes throughout the system, must be modeled and accounted for in the calibration process.

5.1.6.5 Storm Water Discharge:

a. General Criteria: Fuel facilities should be designed to handle stormwater discharge in accordance with all Federal, State and Local environmental regulations. Allowable discharge limits are typically imposed by the governing authority, defining the maximum concentration of fuel/oil contamination allowed in a stormwater discharge stream.

b. Oil/Water Separators: Storm water runoff from facility areas which could potentially yield fuel/oil contamination is often passed through an oil/water separator. A separator is designed to remove fuel/oil contaminants prior to the stormwater being discharged to a waterway or public storm drainage system. They are less effective in cold climates. Provisions should be made for pump out of the collected fuel/oil from the separator to enable removal offsite to a proper waste disposal/reclaim facility.

c. Collection Tanks: These tanks may be used at locations where use of oil/water separators is not feasible or desirable. This may be due to restrictive regulations regarding allowable effluent hydrocarbon concentrations, the lack of suitable maintenance capabilities or risk assessment issues. Provisions should be made for pump out of the collected water/fuel/oil from the tank to enable removal offsite to a proper waste disposal/reclaim facility.

d. Retention Ponds: The collection of surface runoff to an open basin is desirable in some cases. The collected water can then be observed and/or tested prior to discharge. Consideration should be given to utilizing an impervious liner in the design of these basins.

5.1.6.6 Air Emissions:

a. General Criteria: Federal, State or Local regulations may require that measures be taken to limit the amount of hydrocarbon air emissions generated by a jet fuel system or facility. Restrictions are more prevalent in regions defined as “non-attainment areas,” where concentrations of airborne pollutants exceed acceptable levels.

b. Measures: Items such as tank pressure-vacuum vents and/or tank internal floating roofs with high quality double seals are commonly used to limit emissions as well as to limit the loss of fuel due to evaporation. The connection of automatic air vents to a closed piping reclaim system or the use of emission limiting pump seals are some other measures which can be used to limit hydrocarbon emissions.

5.1.7 Operational Issues:

5.1.7.1 Protective Structure: Evaluate protecting loading, off-loading, or equipment areas by a cover designed for severe weather conditions. The cover must be justified by severe environmental conditions impacting operations (extreme temperatures, blowing sand, snow, etc.) or economically justified by reducing stormwater runoff and reducing or eliminating the need for stormwater collection and treatment. If the protective structure is included in the design, ensure the underside of the roof is high enough to maintain equipment and provide operator headroom when walking on top of platforms or trucks. Fire protection may be required for these structures as determined by the authorities having jurisdiction.

5.1.7.2 Maintainability: Consider equipment maintainability when designing facility layouts, protective structures, vaults and pits. This may include the use of bridge cranes, monorails, access hatches, and vehicle and equipment access ramps.

5.1.7.3 Vaults and Pits: Wherever possible, locate valve vaults and pits in areas that are readily accessible for maintenance and in emergency situations. Ensure that vaults are not located under parked aircraft wheel locations and do not interfere with normal aircraft servicing. Consider effects of adjacent traffic and weather conditions on accessibility. Note that all low point drains and high point vents must be flushed or bled on a frequent basis per ATA SPEC 103 and other governing criteria.

5.1.8 Life Safety Issues:

5.1.8.1 OSHA, NIOSH, NFPA and others have produced life and safety standards and regulations that must be addressed in the design of facilities. Criteria which should be considered includes, but is not limited to, the following:

a. Proper identification of product piping and equipment.

b. Adequate signage and advisory information concerning safety, proper operational procedures, and emergency provisions and procedures.

c. Adequate access and egress capabilities in all facility areas, tanks, and underground vaults.

d. Design of platforms and stairways to include guardrails and adequate clearance.

e. Design/construction of paved and other surfaces to prevent slippage.

f. Proper location of emergency showers and eyewash stations.

g. Hazardous areas classifications in accordance with NEC.

h. Ensure proper identification and placement of emergency fuel shut-off stations.

5.1.8.2 Fire Protection: The extent of desired and mandated fire protection for fuel storage tanks, adjacent exposures, and other fuel system facilities should be determined.

a. Water fire protection: Fire hydrants are typically required in the immediate vicinity of fuel storage, equipment and handling facilities per requirements of NFPA 30, NFPA 24, and other governing criteria unless other specific provisions are required per Local jurisdiction.

b. Foam suppression systems: May be required for storage tanks and other enclosed structures which contain or handle fuel. Follow the requirements of NFPA 11, NFPA 30, and other governing criteria unless other specific provisions are required per Local jurisdiction. Currently, the military does not require these systems.

5.1.9 Electrical Design Minimum Requirements:

5.1.9.1 Provide an electrical design that meets the minimum requirements of NFPA 30, NFPA 70, NFPA 77, NFPA 407, and NFPA 780. State or Local regulations may impose additional requirements.

5.1.9.2 All aboveground fuel system equipment, piping and tanks should be electrically grounded in accordance with applicable standards and regulations. Consideration should be given to the grounding of platforms and stairs.

5.1.9.3 Consider the fuel flash point and auto-ignition when selecting motors and other electrical equipment.

5.1.9.4 Cathodic protection is needed to protect system components which are in contact with soil from corrosion. Typically included are aboveground storage tank bottoms, underground storage tanks and buried piping systems. The cathodic protection systems shall be designed by a NACE certified corrosion engineer. Provide electrical isolation where appropriate, particularly where piping goes underground.

5.1.9.5 Lightning protection may be desirable or required to provide lightning protection for a fuel facility. Older, aboveground storage tanks are typically inherently protected due to the thickness of the steel used and attached grounding system. Newer aboveground storage tanks resting on impermeable membranes for leak detection may not be adequately grounded for lightning protection. Refer to NFPA 780 for further discussion regarding tank grounding.

5.1.9.6 All piping, equipment, tanks, etc., shall be bonded and grounded for static charge dissipation per NEC. Provide vehicle bonding and/or grounding at all locations where fuel is transferred into, out of, or between vehicles such as aircraft, tank trucks or hydrant servicers in accordance with NFPA 407 and NEC.

5.1.10 Piping:

5.1.10.1 Sizing: Equipment and piping should be sized to accommodate anticipated flow rates, pipe cleanliness, and static relaxation. Particular care must be paid to system hydraulics and surge control. Typical designs have a velocity of 5 to 10 ft/s (1.5 to 3 m/s). Pump suction lines are typically designed for a velocity of 3 to 7 ft/s (1 to 2 m/s). Piping velocities below 3 ft/s are not recommended due to the potential for sediment accumulation and difficulty in removing water. Delivery rates from pipelines vary widely depending on the source.

5.1.10.2 Piping Layout: Consider suitable equipment access, piping expansion/contraction, ground settlement concerns, seismic design, etc.

a. Provide positive slope in piping systems to promote removal of free water and air. A commonly used minimum slope is 0.5%.

b. Although their use should be kept to a minimum in fuel systems, flexible connections or pump vibration isolators should be considered for connection to vertical turbine and horizontal centrifugal pumps to minimize alignment strain and potentially extend bearing and seal life.

c. Non-welded piping connections (e.g., flanges, valves, threaded connections) shall not be installed below grade unless located in access vault/pit.

d. When directed by the Owner, provide “pigable” system capabilities including barred tees, fully installed pig barrels or provisions for pig barrels and full port valves in pigable sections.

5.1.10.3 Thermal Expansion: Excessive pressures (above the rating of the piping system) can be developed in blocked-in piping segments as the fuel temperature increases. Relief valves need to be provided to prevent excessive pressure build-up. Relief valve discharge should be piped and/or contained. Consider cascading effects of multiple thermal relief valves in series when selecting between the balanced and non-balanced types. Verify that pressure ratings of existing and new equipment and piping elements are consistent with the system design.

5.1.10.4 Air Elimination: Provisions for removal of air from the fuel system need to be included in all piping segments for venting during initial filling and on a periodic maintenance basis. Filter vessels should be provided with both manual and automatic air vents. The discharge of automatic air vents shall go to an appropriate container. Design of unloading operations should include provisions for removal of gross amounts of air ingested during and at the end of a receipt.

5.1.10.5 Low Point Drains: All system low points should be provided with a means of draining the piping system as well as removing any accumulated water, sediment and debris. Water in solution with the fuel will precipitate and must be removed from these low points. This is a required preventative maintenance activity to prevent potential microbial growth contamination as well as prevent water introduction into downstream system components. Recommended minimum drain size is 2 in (50 mm).

5.1.10.6 High Point Vents: All system high points should be provided with a means of venting for filling and draining operations and to allow periodic removal of trapped air. Recommended minimum vent size of 1 in for equipment pads and 1.5 in (40 mm) for underground transmission piping.

5.1.10.7 Fuel Sampling: Provide fuel sampling connections where necessary, consistent with the Owner's fuel quality acceptance criteria and/or in accordance with ATA SPEC 103 requirements.

5.1.10.8 Relaxation: If the fuel does not have a static dissipater additive which provides a conductivity level greater than 50 conductivity units (50 picosiemens per meter), and a 30 second retention time is not provided in piping between the filter/separator and dispensing point (as required by NFPA 407), provide a relaxation tank downstream of the filter/separator to ensure a combined 30 second retention time.

5.1.11 Filtration:

5.1.11.1 Inbound Filtration: Fuel delivery system should include inbound filtration for aviation fuels, preferably at the entrance to the storage facility. The selection of filtration depends on anticipated impurities, the source of fuel, and the shipping methods. Caution should be exercised in the design of inbound filtration systems where fuel is transferred to the fuel system operating tanks from barges or pipelines that handle more than one product. Align equipment to allow gross filtration before fine filtration, in the direction of flow. A typical sequence for pipeline receipt, where there could be particulate, water, and surfactant contamination, would consist of a prefilter, water coalescer, clay treater and filter/separator. For truck receipts, only a filter/separator is typically used. Where surfactants may be present in truck receipts, a clay treater is added upstream of the filter/separator.

5.1.11.2 Issue/Recirculation Filtration: Issue/recirculation filtration is required and typically consists of filter/separators.

5.1.11.3 Filtration Types in Typical Order of Use From Gross to Fine Filtration:

a. A prefilter filter, commonly referred to as a micronic filter, is normally used for removal of fine solids. It has a relatively inexpensive element, which is easy to change.

b. A water high rate coalescer vessel (also known as a hay pack) is used to remove large slugs of water.

c. A clay treater can be placed upstream of a filter/separator to protect it by removing surfactants that could affect water separation performance.

5.1.11.4 Receipt filtration for military turbine fuels is usually by filter/separators meeting latest API/IP SPEC 1581 requirements. Clay filters are not used because they strip additives from the fuel. When necessary, prefilters are used as discussed above.

5.1.11.5 Receipt Filtration Considerations:

a. Redundant filters.

b. Flow/pressure control.

c. Differential pressure indication/monitoring.

d. Automatic switching to redundant filter banks.

e. Alarm signals upon high differential pressure, water build-up, or automatic bypass of filter banks.

f. When relatively high levels of surfactants, particulate, or other contamination can be present in receipts, consider receiving into receipt tankage and then filter when transferring to operating storage.

g. Avoid the use of an automatic closing water slug valve when closure of the valve may cause unacceptable pressure surges. This is of most concern in pipeline receipts.

5.2 Receiving:

Fuel is normally received at fuel storage by pipeline or tank truck. At facilities with pipeline or water transport as their principal supply source, it may be wise to provide for tank truck deliveries as a secondary supply source.

5.2.1 Tank Truck Off-Loading Facilities:

5.2.1.1 Mechanical Design Requirements: A method of off-loading trucks and rail cars must be selected from the numerous available typical options:

a. Off-Loading Drop Process Tanks. Since trucks are designed to be off-loaded by gravity, one method is to off-load into an underground tank or into a specially designed low profile above ground tank. For facilities with the capability to off-load several tank trucks at once or where newer tank trucks with multiple hoses are connected to multiple isolated compartments, consider providing an underground, gravity-type, receiving tank with submersible or vertical turbine transfer pumps and level controls. For smaller systems of one or two tank trucks, consider a low profile, aboveground, receiving tank with a centrifugal transfer pump. For either case, receiving tank level sensors and automatic tank high level shut-off devices should be provided.

b. Direct Pump Off-Load. The other common method of off-loading is to draw the fuel from trucks/rail cars using pumps. Typical performances for this type of system are a maximum of 300 gpm (18.9 L/s) for a single outlet truck and up to 600 gpm (37.9 L/s) for a truck and pumping system with multiple connections. The drawback of this approach versus gravity off-loading is that the process could introduce air into the fuel receiving system, which can pose fire and/or explosion hazards and also affect metering accuracy. Hazards are compounded when an air/fuel mixture is compressed by a positive displacement pump, or is passed through filter/separators, where static electricity is generated and ignition could occur if oxygen is present. Where tank trucks or rail cars are directly off-loaded into aboveground tanks, provide a pumping system configured to provide automatic air elimination and proper relaxation. Effective automatic air elimination typically requires specialized air eliminator vessels with high rate vents, sometimes with automatic controls to prevent air or vapor from passing downstream of the air eliminator. Suggested pump types are low-profile in-line centrifugal, self-priming centrifugal or positive displacement. Typically provide one pump for each tank truck or rail car that is to be off-loaded simultaneously. Consideration should be given to redundancy to allow continued operations if a pump or associated off-loading equipment is out of service. When fuel is pumped from trucks/rail cars, the preferred pump location is at the off-load point, as opposed to a remote location, to reduce suction losses. Provide flow control and check valves on all off-load pumps except positive displacement types. Typically flow control is provided through a self-contained, hydraulically operated diaphragm or piston control valve.

5.2.1.2 Major Components:

a. Unloading Hose: Typical off-loading hoses are 4 in diameter lightweight reinforced vacuum rated suitable length. The number of hoses connected to each truck varies, but as it is common for an over-the-road tank truck to have five compartments, five hoses are typically provided. Use of delivery truck provided hoses is not recommended due to cleanliness concerns.

b. Pantographs: In lieu of hoses, flexible pantographs consisting of a combination of swivel joints and liquid piping may be used. An arrangement where the pipe swivels out horizontally is preferable to a vertical scissors type.

c. Truck Grounding: It is recommended that each tank truck off-loading position be equipped with an automatic, self-monitoring ground verification unit with a lockable bypass. Include a separate grounding reel to accommodate vehicles without grounding equipment.

d. Fuel Sampling Connections: Provide fuel sampling connections for collecting test samples.

e. Meter and meter Proving Connections: Provide a positive displacement or turbine meter, with meter proving connections, when required by the Owner, and where desirable for inventory management.

5.2.2 Pipeline Receiving Facilities:

5.2.2.1 General Criteria: Prior to designing any features into the system that might affect the flow from a pipeline, contact the operator of the pipeline to ascertain the current operating conditions and evaluate the impact of any proposed changes on the pipeline operations. A hydraulic analysis of the pipeline may be necessary to determine whether the use of pressure reducing valves is needed to reduce pipeline pressures to the design pressure of the facility’s piping and equipment. If a pressure-reducing valve is required, provisions for pipeline relief, collection of relieved fuel, pressure class change points, and block valve locations need to be considered.

5.2.2.2 Design Considerations: Flow Rates: Receipt pipeline flow rates are normally determined by the fuel supplier for commercial pipelines, with future anticipated fuel throughput taken into account. An exception to this is when the pipeline is “dual” mode, with only a portion of the passing fuel diverted to the receiving facility.

5.2.2.3 Equipment:

a. Interface Tank (multi-product pipeline): When receiving from a multi-product pipeline, consider providing an interface tank to receive mixed products/water at the beginning and end of a shipment unless the commercial pipeline company can provide this service satisfactorily.

b. Breakout Tank: Based on an agreement with the pipeline company, a breakout (or relief) tank is needed if pipeline flow cannot be stopped suddenly due to pipeline operational requirements. To prevent pipeline over pressurization from a transient surge or from deadheading a pipeline, provide valves to divert the flow of fuel from the receipt tank to a breakout/relief tank should a manual or automatic valve within the fuel system block fuel transfer. Provide appropriate tank overfill alarms and alarm breakout/relief operation so fuel facility operators can take necessary steps to stop pipeline flow. Provide a means of transferring fuel out of the breakout tank back to the fuel systems after a breakout event. Conduct a thorough review with the pipeline operator and perform a transient surge analysis to determine if surge pressure reduction methods are required to avoid damage to the pipeline.

c. Controls Interface Concerns: Coordinate fuel facility and supply pipeline control systems interface with the pipeline company. Parameters that should be addressed include emergency shutdown, tank high level, monitoring of valve positions, flowrates, pressures, and custody transfer metering, if needed.

d. Provide a means for sampling each pipeline product receipt to allow sampling in accordance with applicable standards.

e. Pigging: Provisions for supply pipeline pigging should be considered. This would typically consist of a permanent pig receiver/launcher or provisions for temporary connection of a pig receiver/launcher to the system for pigging. Arrange pig-receiving connections to avoid introducing pipeline sludge and sediment into the tanks. The use of three to five diameter sweeps or long radius bends, and full port valves must be considered where pigging is to be performed.

5.3 Storage Facility:

5.3.1 General Criteria: A number of basic design issues should be considered when designing a fuel storage facility. These include, but are not necessarily limited to, the following criteria:

5.3.1.1 Tank Capacity: An adequate “usable” storage capacity should be provided in accordance with the facility user requirements. The actual usable quantity of fuel stored in a tank is less than the tank gross capacity (shell capacity). This is due to required fluid level clearances from tank vents and roof structure, unusable tank bottoms, etc. Consult with the Owner to determine if a pre-established method of calculating “usable” volume exists.

5.3.1.2 Tank Types: Depending on the storage facility size and application, the use of aboveground versus underground tanks and/or piping may need to be analyzed. Issues such as code or user requirements, security concerns, cost factors, soil conditions, and climate could influence these decisions.

5.3.1.3 Geotechnical: Geotechnical characteristics such as soil load bearing capacity, cathodic protection soil resistivity, seismic zone design factors, and anticipated ground settlement shall be investigated and determined.

5.3.1.4 Spill Containment: Spill containment criteria such as product containment volume safety factors, extent of shared containment areas or segregation between tanks in multiple tank systems, dike liner materials, and diked area stormwater/waste fuel drainage systems should be evaluated.

5.3.1.5 Security: Security issues such as fencing, controlled gate access, closed circuit video, and manned versus unmanned mode of operation should be evaluated. Refer to Section 4.

5.3.2 Design Considerations:

5.3.2.1 Site Requirements:

a. Distance from Buildings and Property Lines: Shall be in accordance with Authority Having Jurisdiction, local building codes, NFPA-30, UBC/IBC or other adopted codes, facility insurer standards, and adjacent land use requirements. The military has their own standards, which are typically more stringent than commercial ones.

b. Tank Spacing: Based on tank volume and per criteria given in NFPA-30, facility insurer standards and State or local restrictions. Consideration should be given to strategically locating tank service valves and equipment to facilitate ease of maintenance. The military has their own standards, which are typically more stringent than commercial ones.

c. Fire/Emergency Response Access: Provide roadways for emergency vehicle access to tank areas, fire hydrants, and AFFF connections.

d. Maintenance Access: Vehicle access to tank secondary containment areas should be considered where feasible. Make provisions to protect the containment liner.

e. Personnel Access: Provide a minimum of two separate means of egress per dike containment area for emergency situations. Consider providing access across aboveground piping with the dike area.

5.3.2.2 Other Considerations:

a. Seismic design requirements must be considered per site specific locally accepted building code.

b. Consider installing activation alarm/annunciation for Emergency Eyewash/Shower Stations.

5.3.2.3 Major Components:

a. Storage Tanks:

1. Aboveground Vertical Tanks:

(a) These are the most commonly used in medium to large fuel storage facilities. Vertical tanks greater than 12 ft in diameter are typically field-erected; smaller tanks are typically shop-fabricated. Field-erected tanks should be designed and constructed in accordance with API STD 650. Shop-fabricated aboveground tanks should be designed and constructed in accordance with UL 142.

(b) Vertical storage tanks are typically provided with a concrete foundation. A solid mat or ring-wall foundation may be provided depending on the tank size, soil conditions, and/or user preference. Piles may be required. Anchor bolts may be required depending on the tank diameter/height aspect ratio and seismic design constraints.

(c) This storage tank type may be equipped with a single or double bottom, depending on code or user requirements. Several variations of tank bottom secondary containment have been used, ranging from a single bottom with impervious liner installed below, to a full double steel bottom with interstitial space and impervious liner installed below. Provide means of draining interstitial space and leak detection capability or monitoring.

2. Aboveground Horizontal Tanks:

   (a) Horizontal tanks may be used in smaller fueling systems and are typically limited to 50,000 gallon individual capacity. Either single-wall, self-diked, or double-wall construction may be used depending on Owner preference and/or Local and State code requirements. Horizontal tanks are shop-fabricated and should be designed and constructed in accordance with UL 142. See spill containment requirements for aboveground tanks.

   (b) Self diked or double-wall tanks may not require a diked spill containment area. NFPA 30 allows for this exception for tanks of 12,000 gallon capacity and smaller. The actual requirements will depend on local code requirements.

3. Underground Storage Tanks (USTs):

   (a) This tank type is also used in smaller fueling systems. These tanks are typically limited to 50,000 gallon individual capacity. Either single-wall or double-wall construction can be used. These tanks are shop-fabricated in either steel or fiberglass. Fiberglass tanks should be designed and constructed in accordance with UL 1316. Double-wall tanks are recommended for underground fuel storage.

   (b) A variation of an underground tank used primarily by the military is the mounded or “cut and cover” tank, also called a BFCUST (Bulk Field-Constructed Underground Storage Tank). These tanks are basically similar in configuration to an aboveground vertical steel tank, but contained within a concrete encasement and mounded over with earthen backfill.

   (c) Valves should be provided on all tank piping nozzles for isolation. In selecting the types of isolation valves to be used, consideration should be given to reliability, durability and safety of operation. Double block and bleed valves are recommended for this service as they permit hydro testing of pipelines up to the shell of a tank and can prove they have no seat leakage by opening the cavity drain. Safe closure in the event of a fire external to the tank also needs to be considered. Valves should be “firesafe” meeting the requirements of API STD 607. The use of fire-rated motor actuators or self-closing fire safety valves should be investigated and local fire authority requirements defined. The use of conventional double block and bleed valves on bottom water draw-offs versus use of inherent non-freeze valves must be considered. Determine the need for independent hydraulically operated or electric operated valves to stop tank filling to prevent overfilling the tank. U.S. military systems require an independent, mechanically pilot operated, diaphragm type, overfill protection valve.

5.4 Dispensing:

5.4.1 General: The two common methods of dispensing fuel to aircraft are into refueler trucks, and directly into the aircraft via a direct fueling system (hydrant system).

5.4.2 Hydrant Fueling Systems:

5.4.2.1 General:

a. Provide a pressurized hydrant system with automatic pressure and flow control systems. Coordinate with the Owner for the level of automation of other systems such tank level controls, leak detection, emergency fuel shut-off, fire protection, etc. Pump controls and system monitoring equipment are generally located adjacent to the pump equipment pad. Typical hydrant fueling systems operate by pressure and flow controls. The system is normally pressurized to a predetermined pressure and this pressure is maintained throughout the hydrant system until a demand for fuel occurs at a hydrant outlet. When the hydrant valve is opened and flow into the aircraft is initiated, the system pressure drops. When the system pressure drops to a predetermined point, the control system starts the first or lead pump. Subsequent pumps are then started based on increased demand and stopped in reverse order based on a decreased demand.

b. Fueling aircraft via a hydrant system utilizes buried distribution piping to connect remote fuel receiving and storage with the aircraft fuel hydrants located in hydrant pits in the apron pavement near the aircraft. A hydrant servicing vehicle (either self-propelled truck or towed cart) or a pantograph (fixed or towed) is used to complete the link between distribution piping and the aircraft. Pressurization is supplied by the pumps at the fuel storage facility.

c. The hydrant servicing vehicle is equipped with a meter to measure fuel quantity, a filter/separator or fuel monitor to maintain fuel quality, and a primary and secondary pressure control valve.

d. Hydrant fuel pits are typically single wall fiberglass pits with aircraft load-rated covers that are set in the aircraft parking apron. These pits are equipped in commercial systems with a “hydrant” valve with a standard poppet type adapter hose/pantograph connection. Within the pit, an isolation valve is typically provided upstream to allow hydrant valve maintenance and replacement while the system is active.

e. Pantographs predominantly are used for military fueling and serve to convey the fuel directly from the hydrant pit to the aircraft. The location of the apron placed hydrant pit is critical since the extended length from pit to aircraft fuel service point can be in excess of 50 to 75 ft. Hot fueling of aircraft can be accommodated as well using pantographs since the equipment is not motorized and has no potential for generating sparks.

5.4.2.2 Transmission/Distribution Piping:

a. Fuel is distributed from the local fuel storage complex to the hydrant outlets at the aircraft parking apron through a piping network. For sizing the main fuel header piping, economic evaluation of both present flow requirements as well as future fuel distribution demands must be considered. For large systems, dual pipe mains are often installed to provide flexibility for long-term maintenance (periodic downtime for testing or connection/modification) and aid in testing and flushing during initial installation.

b. Fuel distribution piping should be sloped to low point drains to provide locations for the removal of water that has settled out in the system and to facilitate line draining when required for maintenance and future modifications. Fuel mains, hydrant system loops or branches and laterals are typically sloped 0.5 to 1.0%.

c. High point vents should be installed at system high points to permit venting during line filling and draining operations and allow for the periodic for the removal of trapped air.

d. Although system low point drains and high point vents should be minimized because they represent points of long-term maintenance, they are a necessity to maintaining fuel quality and must be exercised periodically as required by ATA SPEC 103.

5.4.2.3 Branched System: Fuel piping that is connected to the “transmission/distribution piping” and distributes fuel to major aircraft fueling areas such as terminals, concourses, and hardstands.

5.4.2.4 Loop System:

a. Some fuel distribution systems are designed in a looped manner that will encircle a major fueling area with a continuous pipeline. This system design has the benefits of providing flow from two directions thus reducing pipe size, minimizing system surges due to valve closing operations and providing more continuous fuel movement through the pipe for the removal of water and other potential contaminants. Additionally, dual feed directions provide more flexibility in the shut-off of system segments for emergency situations, maintenance and modifications.

b. The disadvantage of a loop system is the additional pipe lengths that are required at initial installation and each time the system is extended or modified: however, the system flexibility is generally considered to be more desirable.

5.4.2.5 Lateral Piping: Lateral piping connects the main line (from branched or loop) to the hydrant valve pits; the diameter is typically 6 in. The smallest diameter possible is chosen possible since it keep fuel velocities within the desired range so that the lines can be self flushing of any accumulated water and debris. The piping should be pitched to allow drainage back to the main lines.

5.4.2.6 Military System: For military facilities, the standard designs for all services require the supply and return piping to be arranged in a loop configuration. The supply and return piping loop configuration reduces the magnitude of hydraulic shock and surge, adds reliability and flexibility to the operation of the system, and contributes to product cleanliness by making recirculation possible.

5.4.2.7 Design Requirements:

a. Code Compliance:

- NFPA 407
- NFPA 415
- Airport criteria
- Local Code Authorities and Requirements

b. Hydrant Pit Placement: Due to the relatively expensive installation cost, proper hydrant pit placement is critical for efficient aircraft fueling. Whenever possible, horizontal distance from hydrant pit to aircraft fueling point should be minimized to help reduce potential hazards associated with fueling the aircraft. Aircraft mix, actual fueling point location, and a finalized aircraft parking plan are required information items to allow proper placement of hydrant pits.

1. The top elevation of the hydrant pit should be set higher than surrounding grade (crowned with a maximum of 5% slope) to reduce the amount of surface stormwater that commonly collects in the pits. The amount that the pit rises above standard grade will vary depending on the climate and ground service equipment at the airport. In climates having snow removal, one inch is typical.

2. Positioning of hydrant pits is a critical aspect of the design requiring coordination with a variety of elements such as pavement joints, existing underground utilities, aircraft parking plan and positioning of other ground service equipment.

c. Surge Analysis: A hydraulic surge analysis of system operating conditions should be conducted using a computer simulation program for all systems with quick closing valves and for aircraft hydrant and direct fueling systems with more than two outlets. Give consideration to the causes and effects of hydraulic shock. This is especially important in closed fueling systems such as aircraft fueling systems where the receiving tanks or dispensing equipment may be damaged by shock pressure. Reduce the possibility of shock by limiting flow velocity and avoiding the use of quick opening/closing valves except where required for system operation such as hydrant pit valves. Every reasonable effort should be made to control hydraulic surge or shock within acceptable limits by the design of the piping system rather than by the use of surge suppressors. For military hydrant system designs, the loop backpressure control valve is critical in preventing excessive hydraulic shock.

1. Suggested analysis criteria are as follows: For all complex piping systems (main header, several laterals, mobile equipment), employ computer modeling techniques to determine if surge suppression is required. Conduct a run at steady state flow conditions to establish system flow rates for the scenario being modeled. After that, conduct a transient surge analysis imposing worst-case operating conditions on the system. For military hydrant systems incorporating the use of a back pressure control valve, simulate this valve as an active modulating valve. If acceptable peak pressures are exceeded, discuss the results with the Owner to review parameters used and consider alternatives. If this consultation produces no workable solution, perform a second surge analysis to model the use of surge suppressors in the system. This analysis should indicate that damaging peak pressures are not exceeded.

d. Environmental Considerations:

1. Single wall carbon steel fuel piping with epoxy-coated interior and a coated exterior is predominantly accepted for conveying jet fuel. For military installations, stainless steel fuel piping between fixed filtration and aircraft is required.

2. Double wall fuel piping is not recommended but is required in some states or regions to convey aircraft fuel. Special containment methods are required to control potential interstitial accumulation of liquid and ultimately monitor for leak detection.

e. Systems Accessories:

1. Emergency Fuel Shutoff System: Shutoff stations should be provided within access of and visible from each fuel loading position. The station should have a sign identifying it and a continuously lit indicator light above it and a flash (or strobe) light when the station has been activated. The shut-off system can be designed to initially shut valves supplying the problem area or simply shut down the fuel pumps.

5.4.2.8 Equipment Required:

a. Hydrant Pit: Hydrant pits are typically provided as a complete assembly to be installed in the apron pavement and suitable for access by a hydrant fueling vehicle (or pantograph, as utilized by the military).

b. Isolation Valves: The placement of isolation valves in the lines is important to provide the ability to stop flow in a particular section without halting fueling operations at the entire airport. The need to stop fuel flow could be caused either by activation of an emergency stop control in the event of a spill or fill problem or it might be required for normal maintenance on the system. A rule of thumb for valve isolation varies with the particular philosophy of the airport or airline but the installation of valves every four to eight gates is common. These valves should be double block and bleed type to provide positive shut-off and to facilitate pressure testing.

5.4.3 Refueler Truck Fill Stands: Flight schedule and turn-around times will establish the number of fill positions, with two being the minimum.

5.4.3.1 General Criteria:

a. Location and Access: Locate the refueler truck loading facility as close as practical or permissible to the location of the aircraft to be fueled. NFPA and other code restrictions should be followed in providing adequate clearances from aboveground storage tanks, buildings, overhead power lines, or public roads.

b. Aircraft Hydrant Fueling Systems: The fuel supply piping to the refueler truck loading facility may be an extension from a hydrant fueling system. In such case, the filter/separator (and fuel quality monitor if used), are not required since they are provided as part of the aircraft hydrant fueling system.

c. Arrange fuel loading equipment on one or more concrete islands configured for refueling on one side only. Make the direction of traffic appropriate for the location of the loading connections on the refueler, typically located on the driver's side. When more than one island is required because of the volume, arrange them in a parallel fashion with approximately 15 ft (4.6 m) between adjacent sides. Arrange the islands and approaches to allow forward motion for all trucks at all times with ample room for turning. Allow for egress and entrance of emergency response vehicles.

d. Loading Refueler Trucks: Load aircraft refueler trucks by bottom loading only. Top loading of any refueler truck is not permitted.

5.4.3.2 Design Requirements: See the design requirements paragraph for Hydrant Fuelling Systems.

5.4.3.3 Equipment Required: Provide separate piping, pumps, loading connections, and controls for each different type or grade of fuel. Provide an individual block valve for each fill connection. Suggested equipment for each refueler truck fill stand includes the following:

a. Shutoff valves for servicing equipment. Provide self-closing fusible link actuated valves where required by the authority having jurisdiction.

b. Filter/separator unless fill stand is supplied from a hydrant fueling system with issue filter/separator(s).

c. Relaxation tank or provisions when the time between the filter/separator and truck being filled is less than 30 seconds and there is no anti-static additive in the fuel.

d. Flow meter with rated capacity equal to the maximum flow of the loading station. At custody transfer points, provide a custody transfer metering system. Consider ability to measure fuel temperature for compensation to standard temperature. Consider current or future application of centralized inventory management with remote readout or recording of issue meter.

e. A hydraulically operated control valve with the following functions:

1. Rate of flow control (optional).

2. Control valve to fail closed.

3. Dead-man control, electric or hydraulic.

4. Compatibility with electronic high-level shut-off device.

f. Fuel hose or mechanical arm.

g. Quick disconnect fueling nozzle.

h. When directed by the Owner, an automatic, high-level shut-off system with a lockable bypass. Provide a single cable connection to the refueler, which incorporates overfill shut-off, grounding, and grounding verification.

i. Emergency fuel shut-off stations.

j. Grounding/bonding reel (if combination automatic high-level shut-off/grounding system is not provided).

k. Surge arrestors (if required).

l. Thermal relief system resulting in a maximum pressure less than the nozzle or adapter rating, which is typically lower than the rest of the system.

5.4.4 Hydrant Hose Truck and Pantograph Flushing and Calibration Stands:

5.4.4.1 General Requirements: Provide a facility that meets the needs of specific fuel handling equipment for flow testing, flushing, and calibration. Such systems should include the following suggested features:

Connection to the actual hydrant system with appropriate block value and hydrant control valve to simulate an actual hydrant pit.

A suitable fuel acceptance system with typical underwing nozzle and ability to impose a backpressure.

Metering system if calibration of truck metering is to be performed.

Method of returning test fuel back to an appropriate operating tank (through a filter) or bulk storage tank.

6. EQUIPMENT DESCRIPTIONS:

6.1 General:

6.1.1 Piping, fittings, valves and equipment used in the fueling system shall be capable of meeting the design pressures and shall be constructed of materials compatible with jet fuel and with their external environment.

6.1.2 Fabricated pressure vessels such as relaxation chambers, air eliminators, filter/separators and surge suppressors shall be constructed in accordance with ASME Boiler and Pressure Vessel Code Section VIII and Code stamped with the allowable maximum working pressure. Vessels are normally constructed of carbon steel and internally epoxy coated. Internal coating is not required if the vessel is constructed of aluminum or stainless steel.

6.1.3 Except where otherwise noted, end connections shall be flanged or butt welded for pipe sizes larger than 2 in (50 mm), and flanged, butt welded, socket welded or threaded for pipe sizes 2 in (50 mm) and smaller. Equipment such as filters, meters, pumps, and other inline devices that are larger than 0.5 in (15 mm) shall have flanged ends. Due to the wicking properties of jet fuel, threaded connections should be minimized especially in stainless steel or aluminum piping. Groove joint couplings shall not be permitted.

6.2 Piping:

6.2.1 Except in systems constructed of non-ferrous materials (in many military systems for example), piping material shall be carbon steel, ASTM A 53, Grade B or ASTM A 106, Grade B. API SPEC 5L pipe is not recommended.

6.2.2 Fitting materials shall be carbon steel, ASTM A 105 for fittings 2 in (50 mm), and larger and ASTM A 234 Grade WPB for pipe sizes 2 in (50 mm) and smaller.

6.2.3 Cold temperature metal steel such as ASTM A 333 is required for cold climates.

6.2.4 Carbon steel piping shall be interior and exterior coated. Stainless steel piping shall be exterior coated.

6.2.5 Piping and fittings larger than 2.5 in (50 mm) shall be interior epoxy lined with a fuel resistant material.

6.2.6 Minimum wall thickness of piping and fittings shall be Weight Class STD (Standard) for pipe sizes larger than 2 in (50 mm), Weight Class XS (Extra-Strong) for pipe sizes 2 in (50 mm) and smaller.

6.2.7 All fittings, including welding branch outlet connections, in underground service shall be buttwelded and radiographicable.

6.2.8 Make changes in piping direction with fittings. Branch outlets shall be made with either forged tees or forged-welded branch outlet connections. Elbows shall be long radius. Angles or turns that cannot be assembled from 45 degree and 90 degree fittings shall be constructed by cutting down an elbow to the required angle, but retaining a minimum crotch length of 2 in.

6.2.9 Flanges shall be forged steel welding neck type. When circumstances require and with the permission of the Owner, slip-on welding flanges may be specified provided the piping is welded at each end of the flange. Lap joint flanges shall not be used.

6.3 Valves:

6.3.1 All Manual Valves: Valves shall be rated Class VI, bubble-tight shut-off, as determined by ANSI B16.104, shall be bi-directional with the same flow characteristics in either direction, and shall be firesafe as determined by an API STD 607 partial burn test. Valves shall be full port when required, and should be indicated as such in the design documents. Typically, the body is carbon steel, the trim is stainless steel, and the elastomers are Buna-N, Viton or Teflon except where graphite packing is required to maintain fire ratings.

6.3.2 Butterfly Valves: Valves shall be high performance type, lug style. Dimensional standards shall per API STD 609.

6.3.3 Ball Valves: Valves shall meet the requirements of API SPEC 6D. Provide trunnion-mounted balls in 14 in and larger valves.

6.3.4 Double Block and Bleed Plug Valves: Valves shall meet the requirements of API SPEC 6D, non-lubricated, resilient, double seated, taper lift plug supported on upper and lower trunnions. Provide a manual bleed valve and a body cavity thermal relief valve discharging upstream of the valve throat or as shown. An integral bypass thermal relief valve may also be provided to relieve line pressure around a closed valve.

6.3.5 Control Valves (Except Commercial System Hydrant Valves): Provide control valves that are self powered, hydraulically operated, field adjustable, and pilot controlled to provide modulating control. The most common style is a diaphragm style globe valve. Typically, the body is ductile iron or carbon steel and the internals, control tubing, pilots and auxiliary devices are stainless steel.

6.3.6 Commercial System Hydrant Valves: The hydrant valve/coupler assembly shall provide pressure control to limit the pressure at the skin of the aircraft and, deadman control to shut off flow when released. A defuel feature is optional. Typically, the body is epoxy coated and lined or plated ductile iron and the trim is stainless steel. Valves shall be built with two parts and shall be designed such that the upper half can be removed while the system is still under pressure. Valves shall have a four inch API STD 1584 adapter outlet flange. The inlet flange is typically a four or six inch ANSI Class 150 flange. An option is a six inch, ANSI Class 300 outlet flange to conform to the IP Standard pit.

6.3.7 Check Valves: Valves shall be globe or butterfly style, soft seated, bubble tight shut-off, with a spring loaded check device. Swing checks with closure dampening are permitted on suction lines only. Lug pattern recommended over wafer style to reduce status charge build up across flange bolting.

6.3.8 Thermal Relief Valves: Valves shall be angle pattern, direct acting, with a pressure rating suitable for the service. Valves may be ASME code stamped type or a backpressure regulator type. Caution must be exercised in a valve selection between balanced and unbalanced type.

6.3.9 Motorized Actuators: Motorized actuator shall be compatible with the valve type and manufacturer. The entire unit shall be NEMA 4, 6 and 7 rated.

6.4 Tanks:

6.4.1 Vertical Aboveground Storage Tanks: Materials, design, fabrication, welding, erection, testing, and appurtenances shall be in accordance with API STD 650, latest edition. Tanks shall be internally coated with an epoxy coating system or other fuel resistant material.

6.4.1.1 Tank Bottom: Tank bottom shall be built in a cone down configuration, minimum 1 in 20 slope, with a sump at the bottom. Joints shall be lap welded on the upper side with laps in the direction of the sump. Provide isolation material between the tank bottom and the top of the ringwall and seal the interface with a mastic sealer.

6.4.1.2 Fixed Tank Roof: Roof shall be cone up with lap-welded joints in a reverse shingle arrangement.

6.4.1.3 Tank Accessories:

a. Tank Foundation: API STD 650, latest edition, Appendix B.

b. Fill and Suction Lines: When locating the suction line consider the impact of obstructions such as columns on the flow of fuel to the suction. For floating suctions, provide floats as necessary to ensure floatation of swing line, position floats on a pivot to ensure that fluid inlet is always below the surface of the liquid and provide a means of determining if the floating suction if floating properly. For the fill line, provide means to limit velocity at discharge of inlet to 3 ft/s (0.91 m/s). This is typically done with a flared inlet bell.

c. Tank level gauging should be included. A manual gauging port should be provided as a minimum, or in addition to an automatic gauging system if provided. Engineer shall review with the Owner the requirement for automatic tank level gauging (ATG) systems. Appropriate tank nozzles need to be provided for gauge installation.

d. Tank calibration charts indicate product volume based on measured fill height in fractions of an inch increments, typically 0.125 in (3.175 mm). These shall be furnished by the tank manufacturer or installer. The tank Owner should determine what level of accuracy is needed. Field-erected tanks (and in some situations shop-fabricated tanks) should be “strapped” (volume calibrated) per API 2003 MPMS Chapter 2 by a qualified tank strapping company and an incremental volume chart provided to the end user. Incremental volume calibration charts for shop-fabricated tanks are available from the tank manufacturer.

e. Level Alarms: Various level alarms are required for overfill protection and to assist with tank operation and indication. At a minimum, level alarms should occur at the following levels:

- High-High Level - imminent overfill, shall be provided by a system independent of the ATG.

- High Level - alarm level, may be provided by ATG.

- Low Level - Set such that air is not allowed into system, allows warning time to operator. If internal floating roofs are present, consider setting low level alarm at point where floating roof sets on support legs, may be provided by ATG.

- Low-Low Level - Set at lowest point at which air is not allowed into system to prevent pump cavitation, shall be provided by a system independent of the ATG.

f. Overfill protection is required for all fuel storage tanks. It is recommended, and required in some areas, that multiple means of overfill protection be provided. It shall be set at the high-high level point or between the high and high-high level alarms. Alarm setpoints from an ATG system and associated annunciation shall not be used for overfill prevention. Independent overfill protection devices include:

- Float or displacer type switches.

- Optical switches.

- High level control/shut-off valves installed in tank fill lines. Coordinate controls with receipt pipeline where applicable to prevent excessive surges.

- High-high level control function may be used to provide to inlet valve closure.

g. Internal floating roofs (pans) are commonly installed in vertical fuel storage tanks. These roofs can present advantages from both fire protection and vapor emission aspects and are required by code in some areas and by the military. Internal floating roof shall be naturally buoyant and suitable for operation with liquids having a specific gravity of 0.70, have full surface contact with the fuel, be equipped with a seal at each penetration, and meet the requirements of API STD 650 Appendix H. Typical construction for the aviation fueling industry is aluminum sandwich-panel or aluminum pontoon. Factors to consider in the use of a floating roof:

- Perimeter seals.
- Access manway.
- Stilling wells.
- Access ladder from fixed roof.
- Support leg height(s), high and low in some cases.
- Shell overflow openings to protect roof from floating pan.

h. Adequately sized manways, 36 in (900 mm) diameter recommended, should be provided in the lower shell ring and roof of vertical storage tanks and on top of horizontal tanks.

i. On larger diameter vertical tanks, it may be preferable to provide two opposing shell manways for adequate safety and ventilation.

j. Consideration should be given to providing access ladders inside roof manways of vertical tanks with internal floating roofs and in horizontal tank manways.

k. Floating or fixed suction piping should be installed inside fuel storage tanks. This piping is extended from a flanged tank nozzle and should be satisfactorily supported. Military aviation fueling systems typically incorporate fixed suction piping. A common commercial aviation fueling industry practice (see ATA SPEC 103) is to provide floating suction piping, consisting of a swing joint and suction pipe arm equipped with floats, which draws pump suction from the upper level of stored fuel. Where conditions permit and favorable quality of received fuel exists, a waiver may potentially be obtained and fixed suction piping provided.

l. Water draw-off/sampling connections and piping should be provided to allow the accumulated water in the bottom of a fuel tank to be drained on a frequent basis and fuel sampling to occur. Small bore internal tank piping is typically routed to a low point sump within the tank. External piping from the draw-off nozzle is typically routed to a “product saver” tank or “sump separator” which allows water to be separated and disposed of and fuel returned to the storage tank or reclaim system.

m. Tank stripping provisions should be included, consisting of a suction pipe extended into the low point sump and a suitable drain pump connection outside the tank. Larger fuel storage systems may be equipped with a fixed stripping system consisting of permanent site tank drain piping and stripper pumping.

n. Tank vapor emission controls for commonly used, less volatile, aviation turbine fuels typically consist of simple pressure-vacuum venting. For tanks equipped with internal floating roofs, pressure-vacuum venting is installed in the floating roof itself, with open vents provided on the fixed roof and at the top of tank shell perimeter. Additional vapor emission controls and vapor recovery systems may be required per code requirements in the installation vicinity.

o. Corrosion prevention coating systems are required to be installed on all exposed surfaces of aviation fuel storage tanks, both internally and externally. Aviation fueling industry practice is to internally coat fuel tanks and internal piping and accessories with a compatible coating system. Epoxy-based coatings are the most commonly used.

p. Stairs and Access Platforms: Suitable access and safety systems (i.e., handrails) should be provided to the tops of all tanks to allow access to manways, gauging equipment and other top-mounted accessories. The stairway shall be supported completely on the shell of the tank with ends of the stringers clear of the ground. In addition, a handrail system for the entire tank top for safety should be considered. The railing should be at all stairways, landings, walkways, catwalks, and 360 degrees around the periphery of the roof. Catwalks, walkways, or platforms may be desirable for horizontal aboveground tanks.

q. Low Point: Provide a low water draw-off with a pump and a means of returning product to the tank.

r. Vents: Provide vents for fill and withdraw, to allow tanks to breathe, and for emergency venting (per API STD 2000). Provide breathing, fill and withdrawal vents separate from emergency venting. Typical vents are open type with raincap and bug screen. Pressure/vacuum vents are sometimes requested by the Owner or required to obtain Air Quality permits, but are not used when a tank shell has an overflow port due to the presence of a floating pan.

6.4.2 Horizontal Aboveground Storage Tanks:

6.4.2.1 Materials, design, fabrication, welding, erection and testing shall be in accordance with local code and standards requirements such as UL 142. Provide coating system, such as epoxy, for the entire tank interior.

6.4.2.2 Tank Accessories:

a. Low Point: Slope tanks a minimum of 1% with a low point drain. Provide a low point sump, a low point drain and a low point drain pump.

b. Vents: Provide emergency venting as per API STD 2000. Manholes with long bolts shall not be used for emergency venting. Provide fill and withdrawal vents separate from emergency venting. Typical vents are open type with raincap and bug screen. Pressure/vacuum vents are sometimes requested by the Owner or required to obtain air quality permits.

c. Manholes: Provide at least one 36 in (900 mm) manhole with ladder for ingress and egress and at least one more manhole (preferably 36 in as well) for air circulation.

d. Stairway and Platform: Provide for access to roof nozzles and manholes.

e. Fill and Suction Lines: Design the pipe inlet for maximum velocity of 3.5 ft/s (1.07 m/s) for the specified suction flow rate. When locating the suction line consider the impact of obstructions on the flow of fuel to the suction. For floating suctions, provide floats as necessary to ensure floatation of swing line, position floats on a pivot to ensure that fluid inlet is always below the surface of the liquid and provide a means of determining if the floating suction if floating properly. For the fill line, provide means to limit velocity at discharge of inlet to 3 ft/s (0.91 m/s). This is typically done with a flared inlet bell.

f. Provide with other features such as wear plates, gauge hatches, manual level gauging, automatic level gauging, level alarms and an overfill protection valve.

6.4.3 Horizontal Underground Storage Tanks:

6.4.3.1 There are multiple design variations of underground cylindrical steel tanks. The most common types include single-wall or Type I or II double wall. For all of these variations, the primary tank shell should be designed and constructed in accordance with UL 58. The external coating system for these tanks should be in accordance with UL 1746. Common external coating systems meeting this criterion are STi-P3, ACT-100, and ACT-100U. Approved use of any of these variations should be confirmed with local code authorities.

6.4.3.2 A Type I double-wall UST consists of a primary steel tank encapsulated completely by a “wrap” of steel or acceptable alternate material, without a significant interstitial space.

6.4.3.3 A Type II double-wall UST consists of a primary steel tank, encapsulated completely by a secondary shell of steel, with an interstitial space between the two shells.

6.4.3.4 Tank Accessories:

a. Low Point: Slope tanks a minimum of 1%. Provide a low point sump, combination low point pump out and sample/gauge well, and a low point drain pump.

b. Vents: Provide emergency venting as per API STD 2000. Fill and withdrawal vents may be combined with emergency venting. Typical vents are open type with raincap and bug screen. Pressure/vacuum vents are sometimes requested by the Owner or required to obtain air quality permits.

c. Manholes: Provide at least one 36 in (900 mm) manhole with ladder for ingress and egress and at least one more manhole (preferably 36 in as well) for air circulation.

d. Fill and Suction Lines: When locating the suction line consider the impact of obstructions on the flow of fuel to the suction. For floating suctions, provide floats as necessary to ensure floatation of swing line, position floats on a pivot to ensure that fluid inlet is always below the surface of the liquid and provide an means of determining if the floating suction if floating properly. For the fill line, provide a drop tube.

e. Provide accessories such as wear plates, gauge hatches, manual level gauging, automatic level gauging, level alarms and an overfill protection valve.

6.5 Pumps:

6.5.1 Centrifugal Pumps: Pumps shall be API STD 610, latest edition. Casings are typically carbon steel with 12% chrome or stainless steel impellers in trim with an unbalanced mechanical seal. The pump/motor combination shall be non-overloading at every point on their curve using a unity service factor. Pumps shall be suitable for the fluid temperature and suction head conditions required. Total dynamic head shall be a maximum at no flow and decrease continually from no flow to design flow. Motors may be constant or multi- or variable speed drive depending on the application. Motor classification shall be adjusted for the service it is designed to perform and the location in which it performs it.

6.5.2 Positive Displacement Pumps: Pumps shall be self-priming, sliding vane rotary positive displacement type. Impeller shall be constructed to handle 0.25 in (6.4 mm) diameter spherical solids. Casings are typically ductile iron with steel, ductile iron or cast iron impellers and internal trim, stainless steel shaft and a self-lubricated, unbalanced mechanical seal. Motors may be constant or multi- or variable speed drive depending on the application. Motor classification shall be adjusted for the service it is designed to perform and the location in which it performs it.

6.6 Filters:

For each filter vessel the accessories provided shall include a manual air vent, an automatic air vent with check valve, a relief valve, a differential pressure gauge, inlet and outlet sampling connections, and a drain connection or connections. Provide a service platform when indicated or specified. When a platform is provided, furnish with access ladder and handrails. In cold climate areas, provide a means of protecting water sumps and water drain piping from freezing.

6.6.1 Filter/Separators: Filter/separators are used to remove water and particulate matter contamination from jet fuel. The vessel shall be a two-stage design with separate coalescer and separator cartridges for removal of solids and undissolved water from jet fuel. Coalescer cartridges shall be designed for both particulate and water removal and shall be configured to flow from inside to outside. Separator cartridges shall be designed for water removal and shall be configured for flow from outside to inside. The vessel, coalescer cartridges and separator cartridges shall be the product of one manufacturer and shall meet the performance requirements of the latest edition of API/IP SPEC 1581, and for the category and type suitable for the application.

6.6.2 Fuel Quality Monitors: Fuel quality monitors are used to remove water and particulate matter contamination from jet fuel. The vessel shall be a equipped with monitor cartridges that are designed to absorb all free and emulsified water and remove solids from jet fuel; surfactants or additives shall not affect them. All fuel flow shall be shut-off when a sufficient amount of water has been absorbed. The vessel and cartridges shall be the product of one manufacturer and shall meet the performance requirements of the latest edition of API/IP SPEC 1583.

6.6.3 Clay Treatment Vessels: Clay treatment vessels are used to remove surfactants from jet fuel. The vessel shall be furnished with bags or cartridges of very fine-grained attapulgite clay arranged concentrically in the vessel. The vessels shall have a vertical cylindrical configuration with a swing-bolt top closure. An access platform is required to remove and replace the very heavy clay bags or canisters.

6.6.4 High Rate Water Coalescer Vessel (Haypack): Haypack vessels are used when large amounts of water are expected during fuel receipts. The vessel shall be furnished with wafers composed of either excelsior or synthetic hay-like material, capable of coalescing water into larger droplets that fall to the collection sump and are removed. The vessel shall be furnished in a horizontal cylindrical configuration, with an extended water collection sump and a swing-bolt end closure.

6.6.5 Prefilter Vessels: Prefilter vessels are used to remove particulate matter contamination in fuel receipt operations. The prefilter is installed upstream of the filter/separator to extend the life of the more expensive coalescer filtering elements in the filter/separator vessel. The vessel shall be furnished in a vertical or horizontal cylindrical configuration with a swing bolt top closure. Provide with pleated paper type cartridges sized for the indicated or specified nominal particle size. Often labeled as “micronic filters.”

6.6.6 Cyclonic Filters: Cyclonic filters are used where large amounts of particulate or sediment are expected to be present in off-loading barges or tankers. Their use is not common in the aircraft fueling industry. The vessel shall be furnished in a vertical cylindrical configuration. Flow enters the vessel tangentially with centrifugal force providing the means to separate sediment/particulate from the fuel. The particulate is removed through a centrally located bottom drain connection.

6.7 Pre-Fabricated Aircraft Rated Pits:

Pits shall be prefabricated units that are the standard products of a firm regularly engaged in their manufacture and shall consist of continuously formed fiberglass walls and floors with a cast aluminum hinged top pit cover with a lip ring design. The cover assembly shall be removable, including the ring. Cover shall open 180 degrees with 25 lb (12 kg) maximum lift and shall close flush. Provide cover with latching device for holding cover in the closed position. The pit cover shall be designed to support an aircraft wheel load of 50,000 lb (22,680 kg) on a contact area of 200 in^2 (1,290 cm^2) with a safety factor of 4:1. Except for the electrical hand-hole pits, pipe penetrations through the pit shall be sealed by means of a Buna-N boot and shrink-sleeve seal. For aircraft fueling hydrant pits, the fuel line shall enter the side of the pit; bottom entry shall not be allowed.

6.8 Meters:

Meters provide either gross or net volume measurements. Net volume is calculated by measuring fuel temperature and correcting the measurement to a standardized temperature and pressure. Gross volume is a “raw” measurement that does not take into account the change in density (mass per unit volume) of the fuel with temperature.

6.8.1 Positive Displacement Meters: Commonly referred to as PD meters, these can be configured for either gross or net volume throughput measurement. Provide with double case construction with rotary vane, bi-rotor, or other lobed measuring. PD meters maximum allowable working pressures range from 150 to 275 psi (1034 to 1896 kPa) and higher.

6.8.2 Turbine Meters: Can be configured for either gross or net volume throughput measurement. Consider reducing the pipeline size, providing straight upstream and downstream sections of pipe, or providing flow straighteners to provide greater accuracy and turndown capabilities. They are available in all pressure classes. Turbine meters typically are equipped with one or more pulse transmitter(s) connected to a flow computer or other microprocessor signal conditioning equipment.

6.8.3 Venturi Meters: Uses a differential pressure device to measure flow and are typically configured for gross flow measurement. Consider reducing the pipeline size, providing straight upstream and downstream sections of pipe, or providing flow straighteners to provide greater accuracy and turndown capabilities.

6.8.4 Ultrasonic Meters: Typically configured for gross flow measurement, they work by measuring the variation in sound wave transit time from point to point through a fluid, which is dependent on fluid velocity.

6.8.5 Mass Coriolis Meters: Typically configured for net volume measurement.

6.9 Oil/Water Separators:

Oil/water separator shall be either rectangular API type or inclined parallel plate type. Where possible, design the separator as a rectangular vessel with a fully open top with lid for ease of inspection and cleaning. If a parallel plate type is provided, the plates shall be constructed of a non-oleophilic material such as fiberglass and arranged in either a downflow or crossflow mode so that the oil collects in the high point of the corrugations and rises to the top without clogging from settleable solids. Materials designed to absorb oil, commonly called coalescer media, shall not be allowed.

6.10 Accessories:

6.10.1 Strainers: Baskets shall be stainless steel, 7 mesh with 0.108 in (2.74 mm) openings for strainers in front of centrifugal pumps and 40 mesh with 0.016 in (0.40 mm) openings elsewhere. Provide pressure gauges on both sides of all strainers or a differential type gauge across the strainer. Where a strainer is upstream of a pump, the pump suction gauge may function as the strainer downstream gauge.

6.10.2 Pressure Gauges: Liquid filled type. Consider ambient temperatures when choosing liquid type.

6.10.3 Hoses: Loading hoses shall be API BUL 1529 aviation fueling hose with a working pressure rating of 300 psig (2068 kPa, gauge) and with end connections of with brass, aluminum, or stainless steel fittings. Hose shall be conductive in accordance with NFPA 407. Off-loading hose shall be smooth bore, corrugated tank truck hose with static wire, vacuum rated brass, aluminum or stainless steel fittings. Fuel hoses are typically 3 or 4 in (75 or 100 mm) nominal diameter. A spiral protective device (slinky) may be installed around the hose. Provide swivels as required for ease of hose manipulation and connection. A hose storage rack should be provided for each position.

6.10.4 Mechanical Arm: A device that can be used in lieu of hoses. It is made of aluminum or stainless steel and is counterbalanced to ease of use.

6.10.5 Swivel Joints: Non-lubricated and constructed of stainless steel or aluminum.

6.10.6 Underwing Nozzles and Adaptors: The nozzle shall be AS5877, 2.5 in (65 mm) with an integral swivel joint, quick disconnect coupling, strainer and sample connection tap. The adapter shall be 2.5 in (65 mm) nozzle adapter with self-closing valve in accordance with flange mounting and metal dust cap.

6.10.7 Surge Suppressors: Bladder type with a dry nitrogen gas precharge in a vertical steel vessel with a removable top. Provide with means of preventing extrusion of the bladder and absorbing kinetic energy as flow enters or leaves, and with an energy dissipation device designed to provide unrestricted flow in and restricted flow out.

7. CONSTRUCTION:

7.1 General:

The best designed system will not operate satisfactorily unless constructed properly. Without proper construction, the ability to accomplish the mission of the facility will be diminished and the safety of aircraft and personnel may be compromised. The primary focus of this chapter will be on the role of the engineer in the construction process.

7.2 Design Phase:

The primary involvement of the engineer in this phase is to design the system properly and to ensure that the specifications provide clear and concise quality assurance requirements for the Contractor.

7.2.1 Overall System Design: The system shall be designed with constructability, testing, flushing and maintenance in mind.

7.2.2 Defining Contractor Interface: The engineer shall consider specifying, indicating or detailing the following in the contract documents.

a. Phasing and Scheduling: General project schedule, allowable system outages/shutdowns, special working restrictions, etc.

b. Staging Area: Available contractor's lay-down areas, equipment trailer locations, mobilization areas, etc.

c. Site Access/Security: Contractors will be required to comply with specific AOA requirements. Contractor's haul routes, personal vehicle parking, location of allowable utility tie-ins, access gates, construction entrance details, FOD regulations, security checkpoints, etc.

d. Environmental: Project requirements for erosion control, stormwater management, hazardous material spill prevention and management, etc.

7.2.3 Defining Construction Quality Assurance: Project quality assurance requirements including third party independent inspection agencies unrelated to the Contractor. Such agencies may include inspections for the following:

a. API STD 653 tank inspector for tank erection.

b. Helium leak testing for site erected tank bottoms.

c. Weld radiographers for pipe and tank weld inspection.

d. NACE certified inspectors for tank and pipe coatings.

e. NACE certified inspectors for cathodic protection.

f. Geotechnical Engineers for soil compaction or pile testing.

g. Owner/airline fuel quality control representative.

h. Concrete strength testing.

7.2.4 Defining Start-up Assistance: Consider specifying that certain manufacturer personnel be present during the start-up period. Recommended personnel include manufacturer technical assistance for control valve adjustment, control panel checkout and commissioning, and special manufactured systems startup.

7.2.5 Safety Practices: Specify that the Contractor submit a safety plan including confined space, fall protection, asbestos and lead abatement, and trenching and shoring plans.

7.2.6 As-Built Drawings: As-built drawings are important for the long-term operation, maintenance, modification and improvement of fuel systems. Accurate as-built drawings of all underground installations including elevations and project coordinates must be maintained throughout the construction of the job. All as-built information should be provided after the completion of each project phase with complete as-built documentation upon final project completion.

7.2.7 System Testing, Flushing and Commissioning: Ensure that the materials, equipment, procedures and planning items described in Section 8 are specified. These include detailed testing, flushing, tie-in and commissioning plans as well as the required personnel, equipment and manufacturer's representatives.

7.3 Contractor Selection Phase:

In a design-bid-build style project, the Owner may contract with a design engineer to assist in the selection of the Contractor. The role of the Engineer in this phase will be determined by the Owner, who may require the Engineer to assist in such tasks as the selection of pre-qualified bidders, the development of project criteria, preparation of bid documents and review of the proposals submitted.

7.4 Construction Phase:

In the construction phase of a design-bid-build style project, the Owner will determine the role of the Engineer who may be tasked to provide services as described herein. A brief list of things to consider (i.e., construction lessons learned) is included as Appendix A.

Construction phase services provided by the Engineer typically include the following levels of support. The Owner is responsible for determining the level of support services to be provided by the Engineer.

7.4.1 Office Support: Representative(s) of the design firm may provide project support from their office for contractor shop drawing submittal review, response to technical questions from the Contractor, and to provide additional services requested by the Owner.

7.4.2 Periodic Site Visits: Representative(s) of the design firm may make periodic site visits of one or more times throughout the construction phase to observe the work in progress, witness system testing, perform final system observation, assist in the preparation of punch-lists, and attend project meetings as requested by the Owner.

7.4.3 Engineering Technical Representative: Representative(s) of the design firm may reside onsite throughout all or part of the construction phase to perform some or all of the duties as described above in "Office Support" and "Periodic Site Visits."

8. SYSTEM COMMISSIONING:

8.1 General:

System flushing and commissioning may occur throughout the construction process of a new or modified fuel system depending on phasing, system activation, and operational requirements. Its purpose is to validate the ability of the system to deliver fuel of an acceptable quality to aircraft, fuel servicing vehicles, and bulk/operating storage tanks. The commissioning or start-up phase also determines the adequacy of the design and assures all components are properly operating. The flushing and commissioning process for aircraft fuel systems consists of the following.

NOTE: Weld inspections and pneumatic and hydrostatic testing of the piping systems shall be completed and accepted prior to system commissioning.

a. Flushing:

- Prepare detailed flushing plans including tie-ins to existing systems.
- Procure temporary materials and equipment.
- Coordination of flushing and tie-in work with the appropriate parties.
- Develop a detailed safety plan.

b. Commissioning (Startup):

- Evaluate pump performance.
- Verify control valve operation and specific settings.
- Validate the pump control operational sequence.
- Check the accuracy of level controls and gauging systems.
- Verify the operation of the cathodic protection system.
- Test the Emergency Fuel Shutoff System.

8.2 Preparation of the Commissioning Plan:

The Contractor is typically responsible for preparing a commissioning plan that will provide detailed procedures and schedules to accomplish the start-up process.