

Preparing Activity: USACE

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2016

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DIVISION 33 - UTILITIES

SECTION 33 09 55

AVIATION FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (CUT-N-COVER TANKS)

02/10

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USACE / NAVFAC / AFCEC / NASA UFGS-33 09 55 (February 2010)

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2016

SECTION 33 09 55

AVIATION FUEL PUMP CONTROL AND ANNUNCIATION SYSTEM (CUT-N-COVER TANKS) 02/10

NOTE: This guide specification covers the requirements for the Pump Control and Annunciation System for aircraft refueling systems constructed to the requirements of the DOD Cut-N-Cover Hydrant Refueling System Standards.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

NOTE: DoD Type III systems shall conform to Standard Design 078-24-28 PRESSURIZED HYDRANT FUELING SYSTEM (TYPE III). DoD Type IV/V systems shall conform to Standard Design 078-24-29 AIRCRAFT DIRECT FUELING SYSTEM (TYPE IV) DESIGN

The Cut-N-Cover style of tanks are primarily used in OCONUS. Therefore this standard was prepared using metric units that would apply to most OCONUS projects. 120 volts at 60Hz is used for control power. Adjust all units to meet local requirements.

1.1 SUMMARY

The Hydrant Fueling System consists of fueling pumps that pump fuel to a Hydrant Hose Truck Check-out Pad, Truck Fill Stands, and fuel pits located on the airfield apron. Automatic pump starts and stops are based on system pressure and flow. Programmable Logic Controllers (PLCs) receive information from pressure transmitters and other devices to control the pumps and control valves. There are two PLCs that are connected in a redundant configuration, to assure continued operation of the Hydrant Fueling System even if either PLC (but not both) fails. The Hydrant Fueling System also includes Cut-N-Cover fuel storage tanks and a product recovery tank. The pump control panel, personal computer, graphic display panel, and annunciator are located in the Control Room of the Filter Separator Building.

1.2 GENERAL REQUIREMENTS

Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM applies to this project, with the additions and modifications specified herein. The control system shall be furnished by a single supplier. See Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT for other required components of the control system. The control system supplier is responsible for providing a fully functional control system, in accordance with the drawings and specifications, including the field devices. Install in accordance with NFPA 70.

1.3 REFERENCES

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.90 (2005; R 2011) Standard for Relays and Relay Systems Associated With Electric Power Apparatus

IEEE C62.41 (1991; R 1995) Recommended Practice on

Surge Voltages in Low-Voltage AC Power
Circuits

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 18.1 (1979; R2004) Annunciator Sequences and
Specifications

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250 (2014) Enclosures for Electrical Equipment
(1000 Volts Maximum)

NEMA IA 2 (2005) Programmable Controllers - Parts 1
thru 8

NEMA ICS 1 (2000; R 2015) Standard for Industrial
Control and Systems: General Requirements

NEMA ICS 2 (2000; R 2005; Errata 2008) Standard for
Controllers, Contactors, and Overload
Relays Rated 600 V

NEMA ICS 4 (2015) Terminal Blocks

NEMA ICS 6 (1993; R 2011) Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2014; AMD 1 2013; Errata 1 2013; AMD 2
2013; Errata 2 2013; AMD 3 2014; Errata
3-4 2014; AMD 4-6 2014) National
Electrical Code

U.S. FEDERAL COMMUNICATIONS COMMISSION (FCC)

FCC Part 15 Radio Frequency Devices (47 CFR 15)

UNDERWRITERS LABORATORIES (UL)

UL 1012 (2010; Reprint May 2014) Power Units Other
than Class 2

UL 1449 (2014; Reprint Mar 2015) Surge Protective
Devices

UL 508 (1999; Reprint Oct 2013) Industrial
Control Equipment

1.4 SUBMITTALS

**NOTE: Review submittal description (SD) definitions
in Section 01 33 00 SUBMITTAL PROCEDURES and edit
the following list to reflect only the submittals
required for the project.**

**The Guide Specification technical editors have
designated those items that require Government**

approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

An "S" following a submittal item indicates that the submittal is required for the Sustainability Notebook to fulfill federally mandated sustainable requirements in accordance with Section 01 33 29 SUSTAINABILITY REPORTING.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submittals with an "S" are for inclusion in the Sustainability Notebook, in conformance to Section 01 33 29 SUSTAINABILITY REPORTING. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Shop Drawing; G[, [_____]]

SD-03 Product Data

Pump Control Panel (PCP) and Components; G[, [_____]]
Programmable Logical Controller (PLC) Hardware and Software; G[, [_____]]
Personal Computer (PC); G[, [_____]]
Laptop Computer; G[, [_____]]
FCC Computer; G[, [_____]]
Printer; G[, [_____]]
Graphics Display Panel; G[, [_____]]
Graphics Display Screen; G[, [_____]]
Control Wiring Data Lists; G[, [_____]]

SD-06 Test Reports

Testing Plan; G[, [____]]
Certified Pump Control Panel (PCP)
Record of Test

SD-07 Certificates

Experience and Qualifications; G[, [____]]

SD-10 Operation and Maintenance Data

Plan for Instructing Personnel; G[, [____]]
Operation and Maintenance Manuals; G[, [____]]
Tools and Spare Parts

1.5 OPERATION AND MAINTENANCE MANUALS

1.5.1 Schedule and Content

Submit 6 copies of operational and maintenance manuals, within 7 calendar days following the completion of factory tests. As a minimum, include the following in the manuals:

- a. Pump Control Panel including interior and exterior equipment layout.
- b. All documents previously submitted and approved with all comments and field changes annotated.
- c. Complete description of the sequence of operation including that described in Paragraphs 3.6 through 3.13 of this specification and any subsystems not controlled by the PLC (e.g. annunciator panel, EPDS, etc.)
- d. Complete listing of all programming of the PLCs, laptop computer, and Personal Computer.
- e. Complete relay ladder logic diagrams, PLC input/output diagrams and control power distribution diagrams for the complete control system.
- f. Complete guide outlining step-by-step procedures for system startup and operation.
- g. Complete troubleshooting guide, which lists possible operational problems and corrective action to be taken.
- h. Complete maintenance and installation manual for all equipment supplied.
- i. Spare parts data, which provides supplier name, current cost, catalog order number, and a recommended list of spare parts to be stocked.
- j. The above shall incorporate all as-built conditions.

1.5.2 Assembly

Bind documents in a suitable binder adequately marked or identified on the spine and front cover. Include a table of contents page and mark with pertinent contract information and contents of the manual. Provide tabs to separate different types of documents, such as catalog ordering information, drawings, instructions, and spare parts data. Index sheets shall be provided for each section of the manual when warranted by the

quantity of documents included under separate tabs or dividers.

1.6 TOOLS AND SPARE PARTS

Provide the following:

- a. Any special tools necessary for maintenance of the equipment
- b. One spare set of fuses of each type and size
- c. Recommended manufacturer list of spare parts. Include part number, current unit price, and source of supply.
- d. One spare power supply module
- e. One spare I/O module (for discrete devices)
- f. One spare I/O module (for analog devices)
- g. Two PLC RAM back-up batteries
- h. Two complete sets of ink cartridges for the laser printer
- i. Minimum of ten spare lamps for the Alarm Annunciator
- j. Minimum of ten spare lamps of each type of non-LED lamps used on the Pump Control Panel

[k. [_____]]

1.7 EXPERIENCE AND QUALIFICATIONS

Submit the following data demonstrating experience and qualifications:

- a. Certification stating that the manufacturer has manufactured, installed, and successfully completed at least three PLC-based systems for automatic cycling of pumps based upon varying dispensing demands ranging from 0 to 150 L/s 2400 gallons per minute utilizing multiple pumps. At least one of the three PLC-based systems must be for dispensing jet fuel into a pressurized, constant pressure, flow demand aircraft hydrant system.
- b. Certification that the proposed control systems have successfully operated over the last 2 years and are currently in service.
- c. Project names, locations, and system description of these installations. Include user point-of-contact and current telephone numbers.

1.8 WARRANTY

Warrant the Pump Control and Annunciation System including devices, hardware and software for a period of 1 year from the date of acceptance of the system by the Government. This warranty service shall include parts and labor service for equipment supplied under this specification. Upon notification by the Government of system or component failure, respond at the site with necessary parts within 48 hours of notification.

PART 2 PRODUCTS

2.1 PUMP CONTROL PANEL (PCP) AND COMPONENTS

2.1.1 Enclosure

NEMA ICS 1, NEMA ICS 6, NEMA 250, and UL 508. The PCP enclosure shall be a freestanding NEMA Type 12, smooth, gasketed enclosure constructed of 12 gauge steel. All seams shall be continuously welded and there shall be no drilled holes or knockout prior to delivery to the job site. The pump control panel dimensions shall be a maximum of 2300 mm 90 inches high, maximum 1830 mm 72 inches wide, and a maximum of 610 mm 24 inches deep and shall have removable lifting eyes. The interior surfaces of the panel shall be properly cleaned, primed, and spray painted with white high-gloss enamel. Exterior surfaces shall have standard factory finish. Access for the PCP shall be front only and shall consist of hinged doors having 3-point latching mechanisms. The doors shall open approximately 120 degrees. Rack mounting angles, swing-out panels and other component mounting hardware shall be installed such that servicing of one component shall not require removal or disconnection of other components. No clearance shall be required between the back of the panel and the room walls. Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure.

2.1.2 Ventilation System

Two supply fans, single phase, 115 volt, shall be provided. Each fan shall supply a minimum of 2.8 cubic meters/minute 100 CFM. The supply and exhaust grill shall contain a filter that is easily removed from the exterior of the enclosure. Three thermostats with an adjustable set point range of 21 degrees C 70 degrees F to 60 degrees C 140 degrees F shall also be provided. Locate the thermostats near the top in the interior of the PCP.

2.1.3 Ground Bar

The control panel shall have a tin plated copper equipment ground bar. The bar shall have a minimum of twenty grounding screws.

2.1.4 Standard Indicator Lights

NEMA ICS 1, NEMA ICS 2, and UL 508. Lights shall be heavy duty, NEMA 13, 22.5 mm mounting hole, round indicating lights operating at 120 volts ac/dc or 24 volts ac/dc. Long life bulbs shall be used. Indicator lights shall have a legend plate with words as shown on drawings. Lens color as indicated on the drawings. Lights shall be "push to test (lamp)" type. LED type lamps of comparable size and color may be substituted for standard indicator lights.

2.1.5 Selector Switches

NEMA ICS 1, NEMA ICS 2, and UL 508. Non-illuminated lever operated selector switches shall be heavy duty, NEMA 13, round, and utilize a 22 mm 7/8-inch mounting hole. They shall have the number of positions as indicated on the drawings. Switches shall be rated 600 volt, 10 amperes continuous. Provide legend plates with each switch with words as indicated on the drawings.

2.1.1.6 Pushbuttons

NEMA ICS 1, NEMA ICS 2, and UL 508. Non-illuminated pushbuttons shall be heavy duty, NEMA 13, round, utilize a 22 mm 7/8 inch mounting hole, and have the number and type of contacts as indicated on the drawings or elsewhere in the specifications. The emergency stop switch shall be a red mushroom head, 38 mm 1.5 inch diameter, momentary contact type. Pushbuttons shall be rated 600 volt, 10 amperes continuous. Provide legend plates with each switch with words as indicated on the drawings.

2.1.1.7 Relays

IEEE C37.90, NEMA ICS 2, UL 508.

2.1.1.8 Nameplates

Provide laminated plastic nameplates with black outer layers and a white core. Edges shall be chamfered. Fasten the nameplates with black-finished round-head drive screws or approved nonadhesive metal fasteners.

2.1.1.9 Transient Voltage Surge Suppression Devices

IEEE C62.41 for Category "B" transients, UL 1449.

2.1.1.10 Terminal Blocks

NEMA ICS 4. Terminal blocks for conductors exiting the PCP shall be two-way type with double terminals, one for internal wiring connections and the other for external wiring connections. Terminal blocks shall be made of bakelite or other suitable insulating material with full deep barriers between each pair of terminals. A terminal identification strip shall form part of the terminal block and each terminal shall be identified by a number in accordance with the numbering scheme on the approved wiring diagrams.

2.1.1.11 Circuit Breakers

UL 508. Provide individual, appropriately sized, terminal block mounted, circuit breakers for all 120 volt PCP mounted equipment and for the 120 volt terminal boards shown on the drawings.

2.1.1.12 Uninterruptible Power Supplies

UL 1012. Input voltage shall be 120 volts (nominal), 1 phase, 60 Hertz. Output voltage regulation shall be +/-5.0 percent for the following conditions:

- a. 20 percent to 100 percent load on output.
- b. Input voltage variation of -15 percent to +10 percent.
- c. Constant load power factor between 80 percent and 100 percent.

Response time shall be 1.5 cycles or less. Battery capacity shall be such as to provide an orderly shut down of operating programs or as a minimum 10 minutes.

2.1.1.13 Miscellaneous Power Supplies

UL 1012. Certain field devices may require power other than 120VAC (i.e. 24VDC). The power supplies shall be convection cooled, have fully isolated

independent outputs, have constant voltage, have short circuit and overvoltage protection, and have automatic current limiting.

2.1.14 Alarm Annunciator

UL 508 and ISA 18.1. The Alarm Annunciator shall provide visual annunciation, local and remote monitoring, constant or flashing visual and audible alarm as specified herein. The annunciator shall be completely solid state with no moving parts. Furnish the annunciator with cabinet and hardware appropriate for flush mounting on the control panel. A power supply either integral or separately mounted shall operate on 120 volts, 60 Hertz. The annunciator shall have windows arranged in a matrix configuration (rows and columns). Each window shall be at least 25 mm 1 inch high by 40 mm 1-5/8 inches wide and shall have rear illuminated translucent engraved nameplate. Lettering shall be at least 4 mm 5/32 inches high. System lamp voltage shall be 24 to 28 volts dc.

2.1.15 Alarm Horns

UL 508. The alarm horns shall consist of 2-vibrating horns and 1-resonating horn. One vibrating horn is to be mounted in the PCP, and one vibrating and one resonating horn shall be mounted outside of the control room as shown on the drawings. The exterior horns shall each produce 100db at 3 m10 feet and shall be provided in a weather proof housing. The PCP horn shall produce 70db at 3 meters 10 feet.

2.1.16 Laptop Computer

2.1.16.1 Hardware

The following are the minimum hardware requirements for the laptop computer:

- a. Latest Pentium CPU operating at 2 GHz or faster
- b. 1 GB RAM
- c. 100 GB hard drive
- d. 16X Read-Write DVD drive
- e. Color XGA LCD screen 360 mm 14 inches
- f. Keyboard
- g. Pointing device (e.g. mouse, track ball)
- h. Parallel communication port
- i. Serial communication port compatible with PLC (e.g. RS-232-C, RS-485)
- j. 120VAC and Battery power supply
- k. All cables and connectors for interfacing with PLC and personal computer
- l. Modem compatible for remote troubleshooting of the system
- m. Two USB 2.0 communications ports
- n. Provide a carrying case for the Laptop Computer

2.1.16.2 Software

The following is the minimum software to be loaded on the laptop. The software shall be the most current versions and compatible with each other to make a complete and usable system. All software needs to be fully site licensed and come with all disks to allow a full restore or reload of software in the event of a harddrive crash.

- a. Operating system (e.g. the latest commercially available MS Operating System)
- b. Software for programming the PLC

- c. Software for programming the personal computer

2.1.17 Personal Computer (PC)

2.1.17.1 Hardware

The following are the minimum hardware requirements for the personal computer:

- a. Latest Pentium CPU operating at 2.4 GHZ or faster
- b. 2 GB RAM
- c. 250 GB hard drive
- d. 16X Read-Write DVD drive
- e. Color 430 mm 17 inches flat screen monitor
- f. Keyboard
- g. Pointing device (e.g. mouse)
- h. Parallel communication port
- i. Serial communication port compatible with PLC (e.g. RS-232-C, RS-485)
- j. 120VAC operating power
- k. All cables and connectors for interfacing with PLC and Laser Printer
- l. Provide a modem capable of remote troubleshooting of the system. The modem will not be permanently connected to the System.
- m. Two USB 2.0 communications ports

2.1.17.2 Software

The following is the minimum software to be loaded on the personal computer. The software shall be the most current versions and compatible with each other to make a complete and usable system. All software shall be fully site licensed and come with all disks to allow a full restore or reload of software in the event of a hard drive crash.

- a. Operating system (e.g. the latest commercially available MS Operating System)
- b. Software for programming the PLCs
- c. The personal computer shall communicate with the PLCs to display system status and change system set points. The personal computer shall have run-time graphical software to display the graphical screens described later and to change set points.
- d. Software for recording, tracking, trending, and printing out the pressures, flows, and operational status of all monitored components of the fueling system on a real time basis.
- e. MS Office Professional with Excel shall be provided to allow the trending data described above to be imported to Excel where it can be studied, manipulated, graphed, and easily sent electronically.

2.1.18 Printer

The alarm/report printer shall be a color laser jet printer. The unit shall print in black at a minimum speed of twelve pages per minute. It shall print in color at a minimum speed of ten pages per minute. It shall as a minimum be capable of printing color graphs of various system pressures, issue flow, and return flow vs. time in seven colors. Provide one set of spare replacement ink cartridges.

2.1.19 FCC Computer

2.1.19.1 Hardware

The FCC computer shall be a copy of the personal computer so that upon failure of the personal computer it could be relocated to the pumphouse to assume the personal computers duties. The normal duties of the FCC computer shall be to serve as a remote monitor only of the screens that are available on the personal computer. The following are the minimum hardware requirements for the FCC computer:

- a. Latest Pentium CPU operating at 2.4 GHZ or faster
- b. 2 GB RAM
- c. 250 GB hard drive
- d. 16X Read-Write DVD drive
- e. Color 430 mm 17 inches flat screen monitor
- f. Keyboard
- g. Pointing device (e.g. mouse)
- h. Parallel communication port
- i. Serial communication port compatible with PLC (e.g. RS-232-C, RS-485)
- j. 120VAC operating power
- k. All cables and connectors for interfacing with PLC and Laser Printer
- l. Provide a modem capable of remote troubleshooting of the system. The modem will not be permanently connected to the System.
- m. Two USB 2.0 communications ports

2.1.19.2 Software

The following is the minimum software to be loaded on the FCC computer. The FCC computer shall be capable of replacing the Personal computer in the pumphouse if the personal computer fails. It will be set up initially to serve only as a remote monitor of the system while located at the FCC. Should the personal computer fail, the FCC computer will be relocated to the pumphouse and then assume the role of the personal computer. The computer software shall have a built in command to tell the computer whether it is serving as the personal computer or as the remote monitor only. The software shall be the most current versions and compatible with each other to make a complete and usable system. All software shall be fully site licensed and come with all disks to allow a full restore or reload of software in the event of a hard drive crash.

- a. Operating system (e.g. the latest commercially available MS Operating System)
- b. Software to tell the computer which mode it is to operate in, i.e. (personal computer or remote monitor)
- c. Software to run as a remote monitor
- d. Software for programming the PLCs
- e. The personal computer shall communicate with the PLCs to display system status and change system set points. The personal computer shall have run-time graphical software to display the graphical screens described later and to change set points.
- f. Software for recording, tracking, trending, and printing out the

pressures, flows, and operational status of all monitored components of the fueling system, on a real time basis.

- g. MS Office Professional with Excel shall be provided to allow the trending data described in e. above to be imported to Excel where it can be studied, manipulated, graphed, and easily sent electronically.

2.2 PROGRAMMABLE LOGICAL CONTROLLER (PLC) HARDWARE AND SOFTWARE

2.2.1 General

- a. NEMA IA 2. Each PLC shall be able to receive discrete and analog inputs and through its programming it shall control discrete and analog output functions, perform data handling operations and communicate with external devices and remote I/O racks. The PLCs shall be a modular, field expandable design allowing the system to be tailored to the process control application. The capability shall exist to allow for expansion to the system by the addition of hardware and/or user software. At a minimum the PLCs shall include mounting backplanes, power supply modules, CPU module, communication modules, and I/O modules.
- b. Each PLC provided shall be designed and tested for use in the high electrical noise environment of an industrial plant. The PLC modules shall comply with the FCC Part 15 Part A for radio noise emissions. The programmable controller processor shall be able to withstand conducted susceptibility tests as outlined in NEMA ICS 2, IEEE C37.90.
- c. The PLCs shall function properly at temperatures between 0 and 50 degrees C 32 and 122 degrees F, at 5 to 95 percent relative humidity non-condensing and have storage temperatures between -40 and 60 degrees C -40 and +140 degrees F at 5 to 95 percent relative humidity non-condensing.
- d. The PLCs shall have manufacturer's standard system status indicators (e.g. power supply status, system fault, run mode status, back-up battery status).

2.2.2 Central Processing Unit Module

The CPU shall be a modular self-contained unit that provides time of day, scanning, application (ladder rung logic) program execution, storage of the application program, storage of numerical values related to the application process and logic, I/O bus traffic control, peripheral and external device communications and self-diagnostics.

2.2.3 Power Supply Module

- a. The power supply module shall be plugged into the backplane not separately mounted. The power supply shall be wired to utilize 120 VAC, 60 Hz power, the system shall function properly within the range of -10 percent to +15 percent of nominal voltage. The power supply shall provide an output to the backplane at a wattage and voltage necessary to support the attached modules. A single main power supply module shall have the capability of supplying power to the CPU module and local communication and I/O modules. Auxiliary power supplies shall provide power to remote racks.
- b. Each power supply shall have an integral on/off disconnect switch to

the module. If the manufacturers standard power supply does not have an on/off disconnect switch a miniature toggle type switch shall be installed near the PLC and clearly labeled as to its function.

- c. The power supply shall monitor the incoming AC line voltage for proper levels and have provisions for both over current and over voltage protection. If the voltage level is detected as being out of range the system shall have adequate time to complete a safe and orderly shutdown.

2.2.4 Program Storage/Memory Requirements

- a. The PLC shall have the manufacturers standard nonvolatile executive memory for the operating system. The PLC shall also have EEPROM (Electrically Erasable Programmable Read Only Memory) for storage of the user program and battery backup RAM for application memory. The EEPROM shall be loaded by use of the laptop computer or the personal computer.
- b. Submit a calculation of the required amount of EEPROM and RAM (random access memory) needed for this application plus an extra 50 percent.
- c. The number of times a normally open (N.O.) and/or normally closed (N.C.) contact of an internal output can be programmed shall be limited only by the memory capacity to store these instructions.

2.2.5 Input/Output (I/O) Modules

- a. Provide all required I/O modules (analog input, analog output, discrete input, discrete output, and isolated discrete output) to manipulate the types of inputs and outputs as shown on the drawings and to comply with the sequence of operations. Also provide a minimum of 20 percent (round up for calculation) spare input and output points of each type provided, but not less than two of each type.
- b. I/O modules shall be a self-contained unit housed within an enclosure to facilitate easy replacement. All user wiring to I/O modules shall be through a heavy-duty terminal strip. Pressure-type screw terminals shall be used to provide fast, secure wire connections. The terminal block shall be removable so it is possible to replace any input or output module without disturbing field wiring.
- c. During normal operation, a malfunction in any remote input/output channel shall affect the operation of only that channel and not the operation of the CPU or any other channel.
- d. Isolation shall be used between all internal logic and external power circuits. This isolation shall meet the minimum specification of 1500 VRMS. Provide optically isolated I/O components which are compatible with field devices.
- e. Each I/O module shall contain visual indicators to display ON/OFF status of individual input or output points.
- f. Discrete output modules shall be provided with self-contained fuses for overload and short circuit protection of the module.
- g. All input/output modules shall be color coded and titled with a distinctive label.

2.2.6 Interfacing

The PLC shall have communication ports and communication modules using the manufacturers standard communication architecture for connections of the Personal computer, Laptop Computer, remote I/O racks and interconnections between SYS 1 PLC and SYS 2 PLC for the redundant backup system of the PLCs.

2.2.7 Program Requirements

- a. The programming format shall be ladder diagram type as defined by NEMA IA 2.
- b. There shall be a means to indicate contact or output status of the contact or output on the CRT (of the personal computer) or LCD screen (of the laptop computer). Each element's status shall be shown independently, regardless of circuit configuration.
- c. The program shall be full featured in its editing capabilities (e.g. change a contact from normally open to normally closed, add instructions, change addresses, etc.).

2.2.8 Diagnostics

The CPU shall continuously perform self-diagnostic routines that will provide information on the configuration and status of the CPU, memory, communications and I/O. The diagnostic routines shall be regularly performed during normal system operation. A portion of the scan time of the controller should be dedicated to perform these housekeeping functions. In addition, a more extensive diagnostic routine should be performed at power up and during normal system shutdown. The CPU shall log I/O and system faults in fault tables, which shall be accessible for display. When a fault shuts down a CPU, a sequence shall be initiated that will automatically switch over to the other CPU. When a fault affects I/O or communication modules the CPU shall shut down only the hardware affected and continue operation by utilizing healthy system components. All faults shall be annunciated on the alarm annunciator.

2.3 GRAPHICS DISPLAY PANEL

2.3.1 Enclosure

The Graphics Display Panel (GDP) shall be a minimum 1100 mm 42 inch LED Panel Display suitable for wall mounting and capable of accepting input from the Personal Computer. The Personal Computer shall be set up to normally display it's screen number four on the graphic Display Panel, but it shall be capable of sending any of its other screens to the display panel. Any combination of the screens shall be capable of being displayed on the Personal Computer and the Graphic Display Panel.

2.3.2 Display Presentation

The process schematic graphic representation shall be as shown on the drawings. Display Red, green, amber, etc. colors on the screen as indicated on the drawings. The indicated lights on the drawing shall display approximately 12 mm 1/2 inch in diameter.

2.3.3 Digital Net Flow, Pressure and Level Indicators

Digital indicators as shown on the drawings shall also be displayed on the

Graphics Display Panel to provide the net, issue, and return flow in liters per secondGPM and pressure in kPapsi of the system and the level in the operating tanks and product recovery tank. The digital indicators shall display the indicated number of digits as shown on the drawings. Each digit shall be approximately 15 mm 5/8 inch high.

PART 3 EXECUTION

3.1 PUMP CONTROL PANEL (PCP) AND COMPONENTS

3.1.1 General

- a. Where two or more pieces of equipment performing the same function are required, they shall be exact duplicates produced by the same manufacturer. All display instruments of each type shall represent the same outward appearance, having the same physical size and shape, and the same size and style of numbers, characters, pointers, and lamp lenses.
- b. The PCP shall include all required resident software programs and hardware to provide the specified sequence of operation. All software R/W optical discs including programming manuals shall be turned over to the Government at the completion of start-up so modification can be done in the field with no outside assistance.
- c. It is intended that process controlling devices except field devices, and motor controllers be attached to or mounted within the PCP enclosure and all interconnecting wiring installed prior to shipment to the job site. This is to allow shop testing of the system and to decrease field labor requirements.
- d. The PCP shall be shipped fully assembled in one piece after the completion of the shop tests and all defects corrected.

3.1.2 Wiring

3.1.2.1 Methods and Practices

Wiring methods and practices shall be in conformance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 4 and NEMA ICS 6 recommendations as applicable. All wiring to instruments and control devices shall be made with stranded wire, and wiring shall be permanently labeled with conductor/wire numbers within 25 mm 1 inch of termination points. Labels shall be tubular heat-shrinkable wire markers that remain legible after exposure to industrial fluids and abrasion. Position markers so that wire numbers can be read without disturbing or disconnecting wiring. Use of individual character-markers placed side-by-side is not acceptable. Numbers shall match approved shop drawings. All wiring shall be neatly laced from point of entry into enclosures to termination points with nylon lacing cord or plastic lacing ties. Lacing within wiring channels is not required.

3.1.2.2 Control Wiring Data Lists

Provide typed Control Wiring Data Lists within each terminal cabinet and the PCP. The data lists shall include: conductor identification number, wire gauge, wire insulation type, "FROM" terminal identification, "TO" terminal identification, and remarks. Submit the preliminary lists and update to As-Built conditions.

3.1.3 Shop Tests

The manufacturer shall shop test the Certified Pump Control Panel (PCP), Personal computer, and lap top computer. Include simulation of field components and provide for fully testing the pump control and annunciator system as a unit before delivery to the project site. The test shall, reveal system defects, including, but not limited to, functional deficiencies, operating program deficiencies, algorithm errors, timing problems, wiring errors, loose connections, short circuits, failed components and misapplication of components. Perform the test prior to shipment to the site and correct problems detected. Repeat the final testing and correction sequence until no problems are revealed and then perform two additional successful tests. Submit certified test report within 15 days after completion of the test. The report shall include a statement that the Pump Control Panel performs as specified. Notify the Governments Contracting Officer and the Command Fuels Engineer 30 days prior to the final shop testing date. The Contracting Officer may require a Government witness at the final test before the PCP is shipped to the site.

3.1.4 Ventilation System

Thermostat T-1, shall control fan F-1 and thermostat T-2 shall control fan F-2. T-1 and T-2 shall be set at 27 degrees C 80 degrees F to maintain interior air temperature to 11 degrees C 20 degrees F above ambient. Thermostat T-3, set at 38 degrees C 100 degrees F, shall provide a non-critical PCP HIGH TEMPERATURE alarm to the alarm annunciator.

3.1.5 Grounding

The PCP ground bar shall be connected to the building counterpoise via a #10 AWG conductor. Within the enclosure all I/O racks, processor racks, and power supplies, etc. shall be grounded to meet the manufacturer's specifications.

3.1.6 Indicator Lights, Switches, and Pushbuttons

Mount indicator lights, switches, and pushbuttons through the PCP enclosure and arrange to allow easy vision and operation of each device. Provide each device with a nameplate and/or legend plate as indicated on the drawings. Nameplate wordings shall be as indicated on the drawings.

3.1.7 Transient Voltage Surge Suppression Devices

Transient voltage surge suppression (TVSS) devices shall be installed in the PCP to minimize effects of nearby lightning strikes, switching on and off of motors and other inductive loads. TVSS shall be provided for each control circuit ladder. Each ladder may contain any combination of the following devices: PLCs, power supplies (e.g., 24 volt), fans, relays, lights, switches etc. TVSS shall also be provided for PLC I/O originating outside of the building.

3.1.8 Terminal Blocks

As a minimum, any PCP device that connects to a field device (devices not located in the PCP) shall be connected to a terminal block. A connection diagram similar to the drawings shall be provided to the field contractor for field connections to the PCP.

3.1.9 Circuit Breakers

As a minimum, any 120 volt PCP device i.e. (fans, lights, power receptacles, 24 VDC power supplies, PLC CPUs, PLC I/O racks) shall be provided with an individual circuit breaker. Additionally 120 volt terminal boards connecting to field devices (devices not located in the PCP) shall be protected by a 120 volt circuit breaker.

3.1.10 Uninterruptible Power supplies

The Pump Control Panel (PCP) shall contain three uninterruptible power supplies (UPS) each connected to a dedicated circuit. As shown on the drawings one UPS shall supply PLC System 1, one UPS shall supply PLC System 2, and the third UPS shall supply the miscellaneous device power. The UPSs output capacity shall be sufficient to drive all the equipment connected plus 25 percent. The UPSs shall be mounted on shelves near the bottom of the PCP but not rest on the floor of the PCP.

3.1.11 Power Supplies

Provide and install all 120VAC and 24VDC power supplies as required. Size the power supplies for the load plus 25 percent. Supply all field devices, which require power and are controlled or monitored from the PCP, from power supplies in the pump control panel. Provide a 120V receptacle in the PCP for use by the Laptop computer. Completely install interconnecting wiring between UPSs and PLC power supplies prior to shipment to the job site.

3.1.12 Alarm Annunciator and Horns

Initiate signals by hardwired field contacts or by PCP outputs as required. The annunciator shall energize alarm horns, both an integral panel mounted vibrating horn and remote horns, and flash the appropriate annunciator lamp. The minimum number of windows shall correspond to the number of alarm points, plus 15 percent spare. The drawings indicate panel layout and the alarms to be annunciated.

3.1.12.1 Non-critical Alarms

Non-critical alarm windows shall be white with black lettering and shall sound the PCP mounted vibrating horn and the exterior mounted vibrating horns.

3.1.12.2 Critical Alarms

Critical alarm windows shall be red with white lettering and shall sound the PCP mounted vibrating horn and the exterior mounted resonating horns. Critical alarms shall also cancel all automatic pump starts in the PLC.

3.1.12.3 Alarm Sequence

Alarm sequence for each alarm shall be as follows (ISA 18.1 sequence 'A').

- a. For a normal condition, visual indicator and horns will be off.
- b. For an alarm condition, visual indicator will flash and horns will sound (this condition will be locked in).
- c. Upon acknowledgment of the alarm condition, visual indicator will

be steady on and the horns will be off.

- d. If, after acknowledgment of an alarm condition, another alarm condition is established, the new alarm will cause the appropriate window to flash and the horn to sound.
- e. When condition returns to normal after acknowledgment, the visual indicator and the horn will be off.

3.1.13 Personal Computer

The personal computer shall be a stand alone, desk top mounted unit. The personal computer shall download system parameters from the PLCs for display. The personal computer shall also upload new set point values that the operator has changed using the personal computer keyboard, after a password has been entered.

3.1.13.1 Screen Number 1

The general opening screen shall as a minimum display the name and location of the installation (e.g. Seymour Johnson Air Force Base, North Carolina), name of the project (e.g., Type III Hydrant Fueling System) and screen navigation information.

3.1.13.2 Screen Number 2

At a minimum display the following items. Continuously update the values; a 2 second delay maximum between updates is acceptable.

System Issue Rate	xxxx L/sGPM
System Return Rate	xxxx L/sGPM
System Net Flow	xxxx L/sGPM
System Pressure	xxxx kPaPSI
System Operation Mode	Auto/Off/Flush/Tightness test
Active System	Sys-1/Sys-2
Lead Pump in Tank 1	1/2/3/4/5
Fuel Pump #1	On/Off xxxxx.x HOURS
Fuel Pump #2	On/Off xxxxx.x HOURS
Fuel Pump #3	On/Off xxxxx.x HOURS
Fuel Pump #4	On/Off xxxxx.x HOURS
Fuel Pump #5	On/Off xxxxx.x HOURS
Backpressure Control Valve	Closed/Enabled

Pressure Control Valve	Closed/Enabled
Defuel/Flush Valve	Closed/Enabled
Lead Pump in Tank 2	6/7/8/9/10
Tank 1 Outlet Valve I11	Open/Closed
Tank 2 Outlet Valve I12	Open/Closed
Receipt Bypass Valve	Open/Closed
Manifold Setup Valve I34	Open/Closed
Manifold Setup Valve I35	Open/Closed
Manifold Setup Valve R10	Open/Closed
Manifold Setup Valve R11	Open/Closed
Lead Tank	1/2
Fuel Pump #6	On/Off xxxxx.x HOURS
Fuel Pump #7	On/Off xxxxx.x HOURS
Fuel Pump #8	On/Off xxxxx.x HOURS
Fuel Pump #9	On/Off xxxxx.x HOURS
Fuel Pump #10	On/Off xxxxx.x HOURS
Only one of the words separated by a slash (/) shall be displayed. The xxxxx.x HOURS is the fuel pumps elapsed run time and the value shall not be lost when the lead PLC is switched. The pump and valve status words shall be color coded to match the colors used on the graphic display screen.	

3.1.13.3 Screen Number 3

Display the following table. The table lists the set points that can be adjusted using the operator interface. A password shall be entered before the "current value" can be adjusted. The value entered can only be a number within the "set point range". The "default value" is the value held in the program that is loaded into EEPROM memory (This screen may require more than one display screen.).

SET POINT DESCRIPTION	SET POINT RANGE	DEFAULT VALUE	CURRENT VALUE
Lead pump starting pressure	205 to 1035 kPa30 to 150 psi	415 kPa60 psi	xxx KpApsi
Issue flow to start second pump in the sequence	25 to 40 L/s450 to 650 gpm	35 L/s560 gpm	xxx L/srpm
Issue flow to start third pump in the sequence	65 to 80 L/s1000 to 1300 gpm	73 L/s1160 gpm	xxx L/srpm
Issue flow to start fourth pump in the sequence	100 to 120 L/s1600 to 1900 gpm	111 L/s1760 gpm	xxx L/srpm
Return flow to enable next pump in sequence to start	0.5 to 6 L/s10 to 100 gpm	2.5 L/s40 gpm	xxx L/srpm
Return flow to stop fourth third, and second pump in the sequence (lag pump)	30 to 50 L/s500 to 800 gpm	44 L/s700 gpm	xxx L/srpm
Return flow to initiate lead pump shutdown sequence	30 to 50 L/s500 to 800 gpm	35 L/s560 gpm	xxx L/srpm
Timer to enable start-up of lead pump	0 to 120 seconds	0 seconds	xx seconds
Timer to enable second, third and fourth pumps to start	0 to 120 seconds	10 seconds	xx seconds
Timer to stop fourth, third, and second pumps	0 to 120 seconds	15 seconds	xx seconds
Timer to stop first pump	0 to 60 seconds	2 seconds	xx seconds
Timer to disable Back Pressure Control Valve	0 to 360 seconds	60 seconds	xx seconds
Timer to establish fueling pump failure	5 to 30 seconds	15 seconds	xx seconds

SET POINT DESCRIPTION	SET POINT RANGE	DEFAULT VALUE	CURRENT VALUE
System pressure to stop lead pump	895 to 1310 kPa130 to 190 psig	965 kPa140 psig	xxx kPapsig
Operating Tank No. 1 Low-Low Level Indication	0 to 2 m0 to 6 feet	500 mm1 foot 8 inches	x.x mfeet
Operating Tank No. 2 Low-Low Level Indication	0 to 2 m0 to 6 feet	500 mm1 foot 8 inches	x.x mfeet
Operating Tank No. 1 Low Level Indication	0 to 2 m0 to 6 feet	600 mm2 feet	x.x mfeet
Operating Tank No. 2 Low Level Indication	0 to 2 m0 to 6 feet	600 mm2 feet	x.x mfeet
Operating Tank No. 1 High Level Indication	5 to 7.5 m18 to 24 feet	6.5 m21 feet 3 inches	x.x mfeet
Operating Tank No. 2 High Level Indication	5 to 7.5 m18 to 24 feet	6.5 m21 feet 3 inches	x.x mfeet
Operating Tank No. 1 High-High Level Indication	5 to 7.5 m18 to 24 feet	6.7 m22 feet	x.x mfeet
Operating Tank No. 2 High-High Level Indication	5 to 7.5 m18 to 24 feet	6.7 m22 feet	x.x mfeet

3.1.13.4 Screen Number 4

Duplicate the Graphic Display Drawing showing a schematic of the process flow. Refer to this screen as the graphical display. Display many operating parameters here as required in later paragraphs of this specification.

3.1.13.5 Screen Number 5

This screen is a duplicate of the Alarm Annunciator and shall be superimposed over the current active screen on the personal computer when an alarm is activated.

3.1.13.6 Screen Number 6

This screen is designed solely for assisting the testing team during initial start up to watch all of the significant parameters of the systems operation simultaneously on one screen. Include the system parameters i.e. (flows, pressures, and status) from screen 2, the set points from screen 3, and timers for all of the actions that will take place following a delay function.

3.1.13.7 Screen Number 7

This screen is designed solely for displaying the seven graphs as described in Section 33 08 53, AVIATION FUEL DISTRIBUTION SYSTEM START-UP. Display the following values concurrently against time: Issue flow, Issue pressure, Return flow, Pump #1 discharge pressure, Pressure upstream of BPCV, Pressure downstream of BPCV, and Hydrant Pit Pressure. The personal computer shall be capable of storing up to 1 week of data corresponding to the above values. The system shall be able to produce graphs on the screen of this data and print the data in seven colors on the laser printer.

3.1.13.8 Screen Number 8

This screen is an alarm history screen, referred to as the Alarm History Display. This screen shall be capable of storing and displaying all alarms that have occurred in the system for at least a period of 30 days.

3.1.13.9 Screen Number 9

This screen is designed solely for displaying the parameters and process involved in the Tightness Test as described in this specification and on the drawings. Display the following values concurrently against time: Pressure (as sensed by PIT3). The system shall be able to produce graphs on the screen of this data and be able to print the data in color on the laser printer.

3.1.14 Laptop Computer

The Laptop computer is used to create, edit, and load the ladder logic program into the PLCs and the operator interface graphics control program into the personal computer. The Laptop shall also be used to monitor the PLCs memory and ladder logic program. Store the computer in a lockable cabinet provided and located within the Pump Control Panel.

3.2 PROGRAMMABLE LOGICAL CONTROLLER (PLC) HARDWARE AND SOFTWARE

3.2.1 General

NOTE: The pressure indicating transmitters and the differential pressure transmitters are the only devices that the PLC can monitor for a possible failure. Failures shall be defined in the following manners: When the pressure indicating transmitters differ with each other by more than 70 kPa 10 psig after a 10 second delay, assume the lower reading transmitter has failed. When the issue differential pressure transmitters differ from each other by more than 2 L/s 30 gpm after a 10 second delay, assume the lower reading transmitter has failed. When the return differential pressure transmitters differ from each other by more than 1.2 L/s 20 gpm after a 10 second delay, assume the lower reading transmitter has failed.

The basic operation of the redundant PLC system is (Reference "Control System Block Diagram" on the drawings):

- a. CPU-1 and it's associated I/O rack (I/O-1) sends system outputs to appropriate devices and receive input signals from System-1 redundant field devices (PIT-1, DPT-1, DPT-3, flow switches, valve limit switches), System-2 redundant field devices (PIT-2, DPT-2, DPT-4, flow switches, valve limit switches), and all nonredundant field devices as listed on the drawings.
- b. CPU-2 and it's associated I/O rack (I/O-2) sends system outputs to appropriate devices and receive input signals from System-1 redundant field devices (PIT-1, DPT-1, DPT-3, flow switches, valve limit switches), System-2 redundant field devices (PIT-2, DPT-2, DPT-4, flow switches, valve limit switches), and all nonredundant field devices as listed on the drawings.
- c. Within each rack (I/O-1 and I/O-2) System-1, System-2, and nonredundant inputs and outputs shall not be mixed on the same input/output module.
- d. Under normal operation: The system input select switch is in the "SYS-1" position. CPU-1 is controlling the system using System-1 and nonredundant inputs from I/O-1 and any set point changes from the personal computer. CPU-2 is being updated by CPU-1 or concurrently monitoring System-1 inputs from I/O-2.
- e. If under normal operation CPU-1 recognizes that a System-1 input has failed (see note below) it shall change over to the System-2 redundant input on I/O-1 and report the failure to the personal computer alarm screen.

Note: The pressure indicating transmitters and the differential pressure transmitters are the only devices that the PLC can monitor for a possible failure. Failures shall be defined in the following manners: When the pressure indicating transmitters differ from each other by more than 70 kPa 10 psig after a ten second delay, assume the lower reading transmitter has failed. When the issue differential pressure transmitters differ from each other by more than 2 L/s 30 gpm after a ten second delay, assume the lower reading transmitter has failed. When the return differential pressure transmitters differ from each other by more than 1.2 L/s 20 gpm after a ten second delay, assume the lower reading transmitter has failed.

- f. During normal operation there are two ways for CPU-2 to take control of the system: 1) CPU-1 identifies its own internal fault and hands over control to CPU-2. 2) CPU-2 identifies a fault in CPU-1 and takes control from CPU-1. When CPU-2 is in control of the system it shall annunciate the fault condition and shall be using any updated inputs from the personal computer and shall use System-1 inputs. If CPU-2 senses a fault on a System-1 input it shall then switch over to the appropriate System-2 input. If power is lost to System-1 inputs then CPU-2 shall use all of the System-2 inputs.
- g. CPU-2 shall also report any of its internal faults to CPU-1 and CPU-1 shall report any faults it detects in CPU-2.
- h. When the operators think the system is not working and the PLCs do not detect any faults the operator can move the system input select switch from the "SYS-1" position to the "SYS-2" position. With the switch in the "SYS-2" position the PLCs are using System-2 inputs.

3.2.2 Programs

- a. Provide two copies of all working programs (i.e. PLC logic, personal computer) on read only CD or DVD as well as a printed program listing.
- b. The Contractor (programmer) shall provide rung comments (documentation) in the ladder logic program. Each device, on the ladder, shall be identified as to the type of device, i.e. limit switch XX, flow indicator XX, motor starter XX, etc. Rung comments shall be provided for input and output rungs. The programmer shall also provide a comment describing the function of each rung or group of rungs that accomplish a specific function.

3.3 GRAPHICS DISPLAY PANEL (GDP)

Ship the graphic display panel fully assembled in one piece after it has been shop tested as an integral part of the pump control panel and all defects corrected. The graphic display panel must be able to depict the same screens as the personal computer displays. The default screen on the GDP shall be the graphic display screen. The other screens that the personal computer can display shall also be able to be chosen from the personal computer to be displayed here.

3.4 GRAPHICS DISPLAY SCREEN

3.4.1 General

The graphic display screen shall be capable of being displayed on the personal computer and the GDP.

3.4.2 Display Presentation

Depict the process fuel flow schematically as indicated on the drawings. Integrate red, green, and amber symbols integrated with the process schematic to provide current equipment status graphically. Locate the symbols immediately adjacent to related equipment symbol.

3.4.3 Process Schematic

The process schematic graphic representation shall utilize conventional symbols when possible. Size and space symbols and flow lines so as to provide a clear representation of the system process. The Graphic Display shall be suitable for supervised field modification when future items are added. Minor changes may be incorporated to allow proper line width and spacing. Component arrangement, piping routing, and location of valves shall match the flow diagram.

3.4.4 Digital Flows, Pressures, and Level Indicators

Provide digital displays for the flows, pressures, and levels as indicated on the drawings.

3.5 INSTALLATION

Installation shall conform to the manufacturer's drawings, written recommendations and directions.

3.5.1 Shop Drawing

The shop drawing shall be clear and readable and preferably drawn using a computer aided drafting package. At the conclusion of the project the diagram drawings shall be redrafted to include all as-built conditions. These updated drawings shall be included in the O&M Manuals and appropriate section of the drawings placed in a data pocket located in each of the enclosures. The shop drawing at a minimum shall show:

- a. Overall dimensions, front, side and interior elevation views of the PCP showing size, location and labeling of each device.
- b. Overall dimensions, front elevation of the GDP showing graphical layout and size, location and labeling of each device.
- c. Power ladder diagram indicating power connections between TVSS, power conditioners, PLCs, power supplies and field and panel devices. Any terminal block connection numbers used shall be indicated.
- d. Control ladder diagram indicating control connections between field and devices and PLC I/O modules. Terminal block connection numbers and PLC terminal numbers shall be indicated.
- e. Communication connections between PLCs and I/O racks. Communication channel numbers shall be indicated.
- f. Bill of materials.
- g. Written control sequence covering all inputs, outputs, and control scheme.

3.5.2 System Start-Up and Testing

- a. At PCP start-up and testing provide personnel, on site, to provide technical assistance, program fine tuning, and to start-up and test the system. Start-up and testing shall be coordinated with the overall fueling system start-up test specified in Section 33 08 53, AVIATION FUEL DISTRIBUTION SYSTEM START-UP. Prior to this test, all connections shall have been made between the PCP, the personal computer, the motor control center, and all field devices. In addition, check wiring for continuity and short circuits. Adjust set point values, timing values, and program logic as required to provide a functional hydrant fuel control system. Once the system has been fine tuned and passed the system test, load the new system default values into the PLC EEPROM and adjust the personal computer screens to indicate the new values.
- b. Submit a step-by-step testing procedure of the PCP, Testing Plan. Design the test to show that every device (lights, switches, personal computer display screens, alarms, etc.) on the PCP and personal computer is in working order and that the PLC program controls the system per specifications. Perform the test in conjunction with Section 33 08 53 AVIATION FUEL DISTRIBUTION SYSTEM START-UP. Include a place for the contractor and Government representative to initial each step of the plan after satisfactory completion and acceptance of each step. Certify and submit the complete initialed testing plan, Record of Test.

3.5.3 Training Plan for Instructing Personnel

Upon completion of the system start-up a competent technician regularly employed by the PCP manufacturer shall hold a training class for the instruction of Government personnel in the operation and maintenance of the system. Provide both classroom type theory instruction and hands-on instruction using operating equipment provided. The period of instruction shall be a minimum of three 8-hour working days. The training shall be designed to accommodate 8 operators, four maintenance personnel, and two programmers. The Government shall receive written notice (via Contracting Officer) a minimum of 14 days prior to the date of the scheduled classes.

- a. Furnish a written lesson plan and training schedule for Government approval at least 60 days prior to instructing operating, maintenance and programming personnel. Concurrently submit above to the MAJCOM for their input into the review process. Approval of lesson plan will be based on both Government and MAJCOM concurrence. This plan shall be tailored to suit the requirements of the Government. The training shall be divided into three separate classes. Each class shall be tailored to a specific group of personnel. The groups are: 1) Operators, those that will use the control system on a day to day basis; 2) Maintenance personnel, those that will perform routine and non-routine maintenance and trouble shooting of the control system; 3) Programmers, those that will make changes to and trouble shoot the PLC and personal computer programs. The training program shall provide:
 - (1) a detailed overview of the control system including the complete step-by-step procedures for start-up, operation and shut-down of the control system.
 - (2) a general overview of programmable logic controllers
 - (3) the maintenance of equipment installed
 - (4) the programming of the PLC and Personal Computer
 - (5) trouble shooting of the system
- b. Use the complete approved Operation and Maintenance manuals for Section 33 09 54 PUMP CONTROL AND ANNUNCIATION SYSTEM (CUT-N-COVER TANKS) and 26 20 00 INTERIOR DISTRIBUTION SYSTEM (specifically pertaining to the motor control center and its relay ladder diagrams) for instructing operating personnel. Include both classroom and hands-on field instruction. Record the class in DVD format.
- c. Also provide training courses in DVD format covering system overview, operation, maintenance, trouble shooting, and programming. Produce these DVDs off-site using the supplied Pump Control Panel as the teaching aid, or commercially produced DVDs by the PLC manufacturer or third party who specializes in training on PLC systems. In conjunction with the DVDs, provide workbooks, which follow along with the DVDs.

3.6 PLC CONTROL SYSTEM SEQUENCE OF OPERATION

The following describes general functions of the fueling system components.

3.6.1 Abbreviations

- a. SYS-1: components of System #1 including UPS#1, power supplies, CPU-1, I/O-1, and system #1 input and outputs.
- b. SYS-2: components of System #2 including UPS#2, power supplies, CPU-2, I/O-2, and system #2 input and outputs.
- c. CPU-1: SYS-1 PLC CPU.

- d. CPU-2: SYS-2 PLC CPU.
- e. I/O-1: SYS-1 PLC input/output modules.
- f. I/O-2: SYS-2 PLC input/output modules.
- g. PCP: Pump Control Panel.
- h. PC: Personal Computer.
- i. UPS: Uninterruptible Power Supply.
- j. GDP: Graphic Display Panel

3.6.2 Operating Tanks

**NOTE: Use the following paragraphs for level alarms
as electronic level switches are used for
determining tank level alarms.**

3.6.2.1 Level Alarms

Each CUT-N-COVER tank has two level switches to monitor its fuel level. Connect the switches to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. The following alarms shall be reported.

3.6.2.1.1 Low-Low Level

When the low-low level elevation is attained the associated tank's GDP low-low level light shall light. The alarm annunciator's critical alarm sequence activates, the tank's fueling pumps running in automatic mode shall be disabled and these pumps shall not be allowed to start automatically. If both tanks are at low-low level, no fueling pumps shall start automatically.

3.6.2.1.2 Low Level

the low level elevation is attained the associated tank's GDP low level light shall light. The alarm annunciator's non-critical alarm sequence activates.

3.6.2.1.3 High Level

When the high level elevation is attained the associated tank's GDP high level light shall light and the alarm annunciator's non-critical alarm sequence activates.

3.6.2.1.4 High-High Level

When the high-high level elevation is attained the associated tank's GDP high-high level light shall light, the alarm annunciator's critical alarm sequence activates, fueling pumps running in automatic mode shall be disabled and no pump shall be allowed to start automatically. Additionally the pump control panel shall de-energize the solenoid on the tank's high level shutoff valve to force it closed.

3.6.2.2 Tank Outlet Valves

Each operating tank's outlet valve (I11 & I12) has two limit switches to indicate valve position. The closed limit switch is connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. Close the closed limit switch when the valve is fully closed. When the closed limit switch is closed the associated tank's valve graphic display

closed light shall activate. When the valve is fully open, the open limit switch is closed. At this time the associated tank's valve graphic display open light shall activate.

3.6.2.3 Level Annunciation

Each CUT-N-COVER tank has a level indicator/ATG (Automatic Tank Gauge) to measure its fuel level. Connect the ATG directly to the installation FAS System and additionally be connect to the PCP as shown on the drawings. Display the tank levels on the Graphic Screen.

3.6.3 Product Recovery Tank

3.6.3.1 Fuel Transfer Pump (FTP)

The pump's motor controller has a status relay to indicate the on/off status of the pump. Connect the status relay to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. When status relay is open the pump's graphic display off light shall light. When the status relay is closed the pump's graphic display on light shall light. Also use the status relay state to start and stop the pumps elapsed run time timer.

3.6.3.2 Overfill Valve (OV)

NOTE: The automatic starting and stopping of the fuel transfer pump is accomplished by the actuation of tank float switches connected to the control circuit in the motor control center. The PLC system does not control the starting and stopping.

The tank's overfill valve has a limit switch to indicate valve position. Connect the switch, SPST, to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. The switch shall close when the valve is fully closed. When the limit switch is closed the tank's graphic display valve closed light shall light and the alarm annunciator's non-critical alarm sequence activates. When the limit switch is open the tank's graphic display valve open light shall light.

3.6.3.3 High Level Alarm

The tank has a high level alarm float switch. Connect the switch, SPST, to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. When the high level alarm float is activated the tank's graphic display high level light shall light and the alarm annunciator's critical alarm sequence activates.

3.6.3.4 Leak Detection

The tank has a leak detection system. Connect the leak detection systems alarm relay to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. When the leak alarm is activated the alarm annunciator's non-critical alarm sequence activates.

3.6.4 Fueling Pumps (FP)

There are ten fueling pumps with five being in each tank. A maximum of four fueling pumps could run concurrently from one tank. A lead tank

selector switch determines which tanks pumps are active. The lead pump selector switches shall select the pump starting sequence in each tank. Each pump's motor controller has a status relay to indicate the on/off status of the pump. Connect the status relay to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. When status relay is open the associated pump's graphic display off light shall activate and screen number 2 shall indicate on. When the status relay is closed the associated pump's graphic display on light shall activate and screen number 2 shall indicate off. The status relay state shall also be used to start and stop the pumps elapsed run time timer and shall be displayed on screen number 2.

3.6.5 Flow Switch, Fueling Pump

On the discharge side of each pump is a flow switch to indicate positive flow (fail safe feature). The flow switch is DPDT for redundancy and each pole shall be connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. If the PLC has given a signal to start a pump and the flow switch has not closed before the set point timer expires or if the flow switch opens after the pump has been running then the pump shall be in a failure state and it shall be disabled (taken out of the starting sequence), the alarm annunciator's non-critical alarm sequence shall also be activated, and the next pump in the start sequence started. After the PLC has stopped all of the pumps, any failed pump shall be added back into the start sequence.

3.6.6 Transmitters

3.6.6.1 Pressure Indicating Transmitter (PIT)

The PIT's measure system pressure in kiloPascals pounds per square inch. There are two PITs for redundancy. PIT-1 and PIT-2 are connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. The system pressure is sent to personal computer display. PIT-3 is connected directly to the Tightness Test Panel.

3.6.6.2 Differential Pressure Transmitter (DPT)

The DPT's measure flow in liters per second gallons per minute. There are two issue DPTs (DPT-1 and DPT-2) and two return DPTs (DPT-3 and DPT-4) for redundancy. The DPTs are connected to both SYS-1 and SYS-2 as indicated on the Terminal Block Connection drawing. The net flow is sent to the personal computer display. The issue rate, return rate and net flow shall be displayed on the personal computer.

3.6.6.3 Pressure Sensors (PS)

The PS measure system pressure in kiloPascals pounds per square inch. There are three PS installed on the system and there are PCP preparations made for a fourth PS to be temporarily wired in from a Hydrant Pit. PS-1, PS-2, PS-3, and PS-4 are connected to SYS-1 only as indicated on the Terminal Block Connection drawing. These sensors shall report various system pressures to the personal computer to be used for the system pressure test and for the creation of the system graphs as required for screen 7 and described in Section 33 08 53 AVIATION FUEL DISTRIBUTION SYSTEM START-UP.

3.6.7 Control Valves

3.6.7.1 Defuel/Flush Valve (D/FV)

Connect the D/FV to I/O-1, I/O-2 and UPS#3 as indicated on the Terminal Block Connection drawing. Activate the graphical display open and closed lights and screen number 2 status based on the PLC's output status for the valve. Base the valve status on the table listed below.

Defuel/Flush Valve Operation - Two Solenoids				
Fueling Mode per PCP Selector Switch	Valve Action	Solenoid A	Solenoid B	Graphical Display
Flush Mode	Open	De-energized	Energized	Open
Automatic Mode Pump(s) On	Closed	De-energized	De-energized	Closed
Automatic Mode Pumps Off	Enabled	Energized	De-energized	Closed
Off Mode Pump(s) On	Closed	De-energized	De-energized	Closed
Off Mode Pumps Off	Enabled	Energized	De-energized	Closed
Tightness Test	Closed	De-energized	De-energized	Closed

3.6.7.2 Pressure Control Valve (PCV)

Connect the PCV to I/O-1, I/O-2 and UPS#3 as indicated on the Terminal Block Connection drawing. The graphical display enabled and closed lights and screen number 2 status shall activate based on the PLC's output status for the valve. Base the valve status on the table listed below.

Pressure Control Valve Operation - Two Solenoids				
Fueling Mode per PCP Selector Switch	Valve Action	Solenoid A	Solenoid B	Graphical Display
Automatic Mode Pumps Off	Enabled	De-energized	De-energized	Enabled
Automatic Mode Pump(s) On	Closed	Energized	De-energized	Closed
Flush Mode Pumps On	Closed	Energized	De-energized	Closed
Flush Mode Pumps Off	Enabled	De-energized	De-energized	Closed
Off Mode Pump(s) On	Closed	Energized	De-energized	Closed
Off Mode Pumps Off	Enabled	De-energized	De-energized	Enabled
Tight. Test-Hi Pres	Closed	Energized	De-energized	Closed
Tight. Test-Static	Enabled	De-energized	De-energized	Enabled

Pressure Control Valve Operation - Two Solenoids				
Fueling Mode per PCP Selector Switch	Valve Action	Solenoid A	Solenoid B	Graphical Display
Tight. Test-Low Pres	Enabled	Energized	Energized	Enabled

3.6.7.3 Backpressure Control Valve (BPCV)

Connect the BPCV to I/O-1, I/O-2 and UPS#3 as indicated on the Terminal Block Connection drawing. The graphical display enabled and closed lights and screen number 2 status shall activate based on the PLC's output status for the valve. Base the valve status on the table listed below.

Backpressure Control Valve Operation - Two Solenoids				
Fueling Mode per PCP Selector Switch	Valve Action	Solenoid A	Solenoid B	Graphical Display
Automatic Mode Pump Start-Up	Enabled	Energized	De-energized	Enabled
Automatic Mode Prior to Lead Pump Shutoff	Closed	De-energized	De-energized	Closed
Flush Mode	Closed	De-energized	De-energized	Closed
Off Mode Pump(s) On	Enabled	Energized	De-energized	Enabled
Off Mode Pumps Off	Closed	De-energized	De-energized	Closed
Tight. Test-Hi Pres	Enabled	De-energized	Energized	Enabled
Tight. Test-Low Pres	Closed	De-energized	De-energized	Closed

3.6.8 Safety Circuit

3.6.8.1 Emergency Stop Status

Connect the emergency stop circuit status relay (ER1) N.O. contact to I/O-1, I/O-2 and UPS#3 as indicated on the Terminal Block Connection drawing. When the circuit is activated the alarm annunciator's critical alarm sequence is activated and any calls to start fueling pumps shall be canceled and no additional pump start signals shall be sent until the circuit has been reset. The fueling pumps shall actually be stopped by a emergency stop circuit status relay (ER2) N.O. contact in the fuel pump motor control circuit located in the motor control center.

3.6.8.2 Emergency Shutoff Valves (ESO) Status

Connect the ESO status relay (ER2) N.O. contact to I/O-1, I/O-2 and UPS#3 as indicated on the Terminal Block Connection drawing. When the relay is closed the GDP valve open lights shall light. When the relay is open the GDP valve closed lights shall light.

3.6.8.3 Circuit Power Status

Connect the safety circuit power status relay (ER3) N.O. contact to I/O-1, I/O-2 and UPS#3 as indicated on the Terminal Block Connection drawing. When the relay is closed the PCP emergency circuit power on light shall light.

3.6.9 Pump Control Panel

3.6.9.1 CPU Faults

The PCP mounted CPU-1 and CPU-2 on lights are connected to both SYS-1 and SYS-2. The associated CPU light shall light when no system faults are detected. When a fault is detected by the CPU or it's redundant CPU the faulted CPU's on light shall be turned off and the alarm annunciator's non-critical alarm sequence shall be activated.

3.6.9.2 Input Select Switch

The 2-position input select switch shall control which inputs (System-1 or System-2) are being used. Connect each switch position to both SYS-1 and SYS-2. The OI display shall indicate the active system.

3.6.9.3 Mode Select Switch

The 4-position switch selects what mode of fueling is active: automatic, flush, Tightness Test or off. Connect each switch position to both SYS-1 and SYS-2. The screen number 2 status shall indicate the active mode.

3.6.9.4 Lead Tank Selector Switch

The 2-position switch selects which tank shall be the operating tank. The screen number 2 status display shall indicate the operating tank.

3.6.9.5 Lead Pump Selector Switches

The two 5-position switches select which pump shall be the lead pump in a given tank. The switch position shall fix the starting sequence for all pumps. The sequences for tank one shall be 1-2-3-4-5, 2-3-4-5-1, 3-4-5-1-2, 4-5-1-2-3, and 5-1-2-3-4. The sequences for tank two shall be 6-7-8-9-10, 7-8-9-10-6, 8-9-10-6-7, 9-10-6-7-8, and 10-6-7-8-9. The off sequence shall be the reverse of the start sequence; therefore, first on shall be last off. A maximum of four pumps are allowed to run at one time. If a pump fails to start or fails during operation, disable that pump and start the next pump in the sequence. The screen number 2 status display shall indicate the lead pump.

3.6.9.6 PCP Temperature Alarm

The alarm thermostat when activated shall activate the alarm annunciator's non-critical alarm sequence.

3.7 OPERATING PROGRAM REQUIREMENTS

Store the control system's logic program on an EEPROM chip. Permanently store default values of operator adjustable parameters on the chip with the capability of resetting the values in RAM to the values within the range specified below. The default values can be changed through the use of the personal computer (after the correct password has been entered). After

loss of power and battery failure the adjustable settings shall revert back to the default values located on the chip. The default values shown here shall be reset to the values determined during the system start up and test.

SET POINT DESCRIPTION	SET POINT RANGE	DEFAULT VALUE
Lead pump starting pressure	205 to 1035 kPa30 to 150 psi	415 kPa60 psi
Issue flow to start second pump in sequence	25 to 40 L/s450 to 650 gpm	35 L/s560 gpm
Issue flow to start third pump in sequence	65 to 80 L/s1000 to 1300 gpm	73 L/s1160 gpm
Issue flow to start fourth pump in sequence	100 to 120 L/s1600 to 1900 gpm	111 L/s1760 gpm
Return flow to enable next pump in sequence to start	0.5 to 6 L/s10 to 100 gpm	2.5 L/s40 gpm
Return flow to stop fourth, third, and second pump in sequence (lag pump)	30 to 50 L/s500 to 800 gpm	44 L/s700 gpm
Return flow to initiate lead pump shutdown sequence	30 to 50 L/s500 to 800 gpm	35 L/s560 gpm
Timer to enable start-up of lead pump	0 to 120 seconds	0 seconds
Timer to enable second, third, and fourth pumps to start	0 to 120 seconds	10 seconds
Timer to stop fourth, third, and second pumps	0 to 120 seconds	15 seconds
Timer to stop first pump	0 to 60 seconds	2 seconds
Timer to de-energize (close) Back Pressure Control Valve	0 to 360 seconds	300 seconds
Timer to establish fueling pump failure	5 to 30 seconds	15 seconds
System pressure to stop lead pump	895 to 1310 kPa130 to 190 psig	965 kPa140 psig
Operating Tank No. 1 Low-Low level indication	0 to 2 m0 to 6 feet	510 mm1.6773 feet

SET POINT DESCRIPTION	SET POINT RANGE	DEFAULT VALUE
Operating Tank No. 2 Low-Low level indication	0 to 2 m0 to 6 feet	510 mm1.6773 feet
Operating Tank No. 1 Low level indication	0 to 2 m0 to 6 feet	675 mm2.22 feet
Operating Tank No. 2 Low level indication	0 to 2 m0 to 6 feet	675 mm2.22 feet
Operating Tank No. 1 High level indication	5 to 7.5 m18 to 24 feet	6.5 m21 feet 3 inches
Operating Tank No. 2 High level indication	5 to 7.5 m18 to 24 feet	6.5 m21 feet 3 inches
Operating Tank No. 1 High-High level indication	5 to 7.5 m18 to 24 feet	6.85 m22 feet 5-1/2 inches
Operating Tank No. 2 High-High level indication	5 to 7.5 m18 to 24 feet	6.85 m22 feet 5-1/2 inches
Should the operator enter a value not within the range for that parameter, the personal computer shall indicate "INVALID ENTRY" and revert back to the previous value.		
A number inside braces, {x}, in the following paragraphs indicates that the number may be changed by the operator via the operator interface within the Set Point Range listed above.		

3.8 AUTOMATIC MODE - IDLE CONDITION

The fueling system is intended to remain continuously pressurized while in the idle condition. This allows the system to respond immediately to aircraft refueling and defueling requirements. Periodically, in the idle condition, the system will lose minimal pressure. When this occurs, the control system shall automatically repressurize in the following sequence:

- a. Start the lead pump when the system pressure is less than 415 kPA 60 psig continuously for 0 seconds. Reset the timer if the pressure then rises above 415 kPA 60 psig before the timer expires.
- b. After the timer expires:
 - (1) Energize the BPCV solenoid 'A' to enable the valve to modulate the system pressure at it's set point.
 - (2) Energize the PCV solenoid 'A' to close the valve.
 - (3) De-energize the D/FV solenoid 'A' so the valve is closed and

solenoid 'B' is de-energized.

- c. With the lead pump running, 38 L/s 600 gpm flows through the issue venturi. The system pressure upstream of the BPCV shall increase to the BPCV set point of 900 kPa 130 psig. At this pressure the BPCV shall start to open and the valve modulate as required to pass sufficient flow through the return venturi to maintain pressure upstream of the valve.
- d. With the lead pump running and no fueling demand the return venturi flow rate shall equal the issue venturi flow rate. When the return venturi flow rate is greater than 35 L/s 560 gpm a 300 second timer shall start. If the flow rate drops below 35 L/s 560 gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.
- e. After the timer expires:
 - (1) The BPCV solenoid 'A' shall be de-energized to close the valve.
 - (2) The PCV solenoid 'A' shall be de-energized to bleed system pressure to 515 kPa 75 psig.
 - (3) When system pressure rises to 965 kPa 140 psig a {2} second timer shall start. After the timer has expired, the lead pump shall be stopped.
 - (4) The Defuel/Flush valve solenoid "A" shall be energized 30 seconds after lead pump shut down to allow it to open at 550 kPa 80 psig for defuel operations.
- f. The system has now returned to a pressurized and idle condition.
- g. When a fueling pump is called to start, a 15 second timer shall start. If the timer expires before the flow switch closes the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.
- h. If a fueling pumps flow switch opens after the pump has successfully started the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.

3.9 AUTOMATIC MODE - REFUELING CONDITION

To start an aircraft fueling operation, an operator connects fueling equipment such as a hydrant hose truck to an aircraft and to a hydrant control valve. When the operator opens the hydrant control valve by use of an hydraulic operated "Deadman", the following sequence occurs:

- a. The lead pump will start when the PIT senses a pressure less than {415} kPa {60} psig continuously for {0} seconds. If the pressure then rises above {415} kPa {60} psig before the timer expires, the timer shall reset.
- b. After the timer expires:

- (1) The BPCV solenoid 'A' shall be energized to enable the valve to modulate the system pressure at it's set point.
 - (2) The PCV solenoid 'A' shall be energized to close the valve.
 - (3) The D/FV solenoid 'A' shall be de-energized so the valve is closed and solenoid 'B' shall be de-energized.
- c. With the lead pump running, +38 L/s600 gpm will flow through the issue venturi. The system pressure upstream of the BPCV will increase to the BPCV set point of 900 kPa 130 psig. At this pressure the BPCV will start to open and the valve will modulate as required to pass sufficient flow through the return venturi to maintain pressure upstream of the valve.
- d. With lead pump running and a issue venturi flow rate greater than {35} L/s {560} gpm and a return venturi flow rate greater than {2.5} L/s {40} gpm and less than {35} L/s {560} gpm the lead pump will continue to run and the BPCV will modulate to pass flow as necessary to maintain upstream system pressure.
- e. With the lead pump running and a issue venturi flow rate greater than {35} L/s {560} gpm and a return venturi flow rate greater than {35} L/s {560} gpm a {300} second timer shall start. If issue venturi flow rate falls below {35} L/s {560} gpm or the return venturi flow rate falls below {35} {560} before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.
- f. After the timer expires:
 - (1) The BPCV solenoid 'A' shall be de-energized to close the valve.
 - (2) The PCV solenoid 'A' shall be de-energized to bleed system pressure to 520 kPa 75 psig.
 - (3) When system pressure rises to 965 kPa 140 psig a {2} second timer shall start. After the timer has expired, the lead pump shall be stopped.
 - (4) The Defuel/Flush valve solenoid "A" shall be energized 30 seconds after lead pump shut-down to allow it to open at 550 kPa 80 psig for defuel operations.
- g. With the lead pump running and a issue venturi flow rate greater than {35} L/s {560} gpm and a return venturi flow rate less than {2.5} L/s {40} gpm a {10} second timer shall start. If the issue venturi flow rate falls below {35} L/s {560} gpm or the return venturi flow rate rises above {2.5} L/s {40} gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.
- h. After the timer expires: The second pump shall start.
- i. With the lead and second pumps running and a issue venturi flow rate greater than {73} L/s {1160} gpm and a return venturi flow rate of greater than {2.5} L/s {40} gpm and less than {44} L/s {700} gpm the lead and second pumps shall continue to run and the BPCV shall modulate as necessary to maintain system pressure.
- j. With the lead and second pumps running and a issue venturi flow rate

greater than {73} L/s {1160} gpm and a return venturi flow rate greater than {44} L/s {700} gpm a {15} second timer shall start. If issue venturi flow rate falls below {73} L/s {1160} gpm or the return venturi flow rate falls below {44} L/s {700} gpm before the timer expires, the timer shall reset and no changes shall be made to the pump and valve status.

- k. After the timer expires: The second pump shall be stopped.
- l. With the lead and second pump running and a issue venturi flow rate greater than {73} L/s {1160} gpm and a return venturi flow rate less than {2.5} L/s {40} gpm a {10} second timer shall start. If the issue venturi flow rate falls below {73} L/s {1160} gpm or the return venturi flow rate rises above {2.5} L/s {40} gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.
- m. After the timer expires: The third pump shall start.
- n. With the lead, second and third pumps running and a issue venturi flow rate greater than {111} L/s {1760} gpm and a return venturi flow rate of greater than {2.5} L/s {40} gpm and less than {44} L/s {700} gpm the lead, second and third pumps shall continue to run and the BPCV shall modulate as necessary to maintain system pressure.
- o. With the lead, second and third pumps running and issue venturi flow rate greater than {111} L/s {1760} gpm and a return venturi flow rate greater than {44} L/s {700} gpm a {15} second timer shall start. If the issue venturi flow rate falls below {111} L/s {1760} gpm or the return venturi flow rate falls below {44} L/s {700} gpm before the timer expires, the timer shall reset and no changes shall be made to the pump and valve status.
- p. After the timer expires: The third pump shall be stopped.
- q. With the lead, second and third pumps running and a issue venturi flow rate greater than {111} L/s {1760} gpm and a return venturi flow rate less than {2.5} L/s {40} gpm a {10} second timer shall start. If the issue venturi flow rate falls below {111} L/s {1760} gpm or the return venturi flow rate rises above {2.5} L/s {40} gpm before the timer expires, the timer shall reset, and no changes shall be made to the pump and valve status.
- r. After the timer expires: The fourth pump shall start.
- s. With the lead, second, third and fourth pumps running and a issue venturi flow rate greater than 149 L/s 2360 gpm and a return venturi flow rate of greater than {2.5} L/s {40} gpm and less than {44} L/s {700} gpm the lead, second, third and fourth pumps shall continue to run and the BPCV shall modulate as necessary to maintain system pressure.
- t. With the lead, second, third and fourth pumps running and a issue venturi flow rate greater than 149.4 L/s 2368 gpm and a return venturi flow rate greater than {44} L/s {700} gpm a {15} second timer shall start. If the issue venturi flow rate falls below 149 L/s 2360 gpm or the return venturi flow rate falls below {44} L/s {700} gpm before the timer expires, the timer shall reset and no changes shall be made to the pump and valve status.

- u. After the timer expires: The fourth pump shall be stopped.
- v. When a fueling pump is called to start, a 15 second timer shall start. If the timer expires before the flow switch closes the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.
- w. If a fueling pumps flow switch opens after the pump successfully started the pump shall be called off, the alarm annunciator's associated non-critical alarm sequence shall activate and the next pump in the sequence shall be called to start.

3.10 AUTOMATIC MODE - DEFUELING CONDITION

To start an aircraft defuel operation, an operator connects a hydrant hose truck to an aircraft and a fuel sense line and an air sense line to the hydrant control valve. The hydrant hose truck has an on-board defuel pump capable of delivering 19 L/s 300 gpm at 1140 kPa 165 psig. When the operator starts the defuel operation one of the following occurs:

- a. If the fueling pumps are running (D/FV closed) the fuel being removed from the aircraft will either go to the other aircraft(s) connected to the system or be returned to the pumphouse where the BPCV will modulate to control system pressure and the fuel will be returned to the operating tanks. The return venturi flow rate will control the number of pumps that are on as discussed in paragraph "AUTOMATIC MODE - FUELING CONDITION".
- b. If the fueling pumps are off (D/FV enabled) the fuel being removed from the aircraft will be returned to the pumphouse and both the D/FV and the PCV will modulate to return the fuel to the operating tanks.

3.11 FLUSH MODE

This mode shall be used when the system need to be flushed of water or sediment. The operators will first place the manual valve in the desired position to select the appropriate flow path. Placing the selector switch in "flush" the following shall occur:

- a. The BPCV solenoid 'A' shall be de-energized to force it closed.
- b. The D/FV solenoid 'A' shall be de-energized to allow the valve to open and the D/FV solenoid 'B' shall be energized to force it open.
- c. Start the fueling pump(s) manually using the Hand-Off-Auto or Hand-Auto switch to obtain the desired flow rate. The automatic pump starts shall be disabled in this mode.
- d. The PCV solenoid 'A' shall be energized when pump(s) are on and de-energized when the pumps are off.
- e. When a fueling pump is started, a 15 second timer shall start. If the timer expires before the flow switch closes the alarm annunciator's associated non-critical alarm sequence shall activate.
- f. If a fueling pumps flow switch opens after the pump successfully started the alarm annunciator's associated non-critical alarm sequence

shall activate.

3.12 TIGHTNESS TEST MODE

This mode shall be used in conjunction with the Tightness Monitoring Panel provided by Section 33 52 43.11 AVIATION FUEL MECHANICAL EQUIPMENT to perform tightness tests. Placing the selector switch to "TIGHTNESS TEST" the PCP shall send a signal to the Tightness Monitoring Panel telling it that it is ready to perform the tests. At this time it also operates three MOV valves, closing I25 and I26 and opening I27. The PCP then receives signals from the Tightness Monitoring Panel to prepare for High Pressure Test, run High Pressure Test, Prepare for Low Pressure Test, run Low Pressure Test, prepare for Second High Pressure Test, run Second High Pressure Test, and when the test is over. The following PCP actions will occur after the corresponding signal:

3.12.1 High Pressure Test Preparation

- a. The BPCV solenoid "A" shall be de-energized and the BPCV solenoid "B" shall be energized to enable the valve at the 1100 kPa 160 psi value.
- b. The D/FV solenoid "A" shall be de-energized and the D/FV solenoid "B" shall be de-energized to force it closed.
- c. Automatically start the lead fueling pump to obtain pressure.
- d. The PCV solenoid "A" shall be Energized and PCV solenoid "B" shall be de-energized to close the valve.
- e. When a fueling pump is started, a 15 second timer shall start. If the timer expires before the flow switch closes the alarm annunciator's associated non-critical alarm sequence shall activate.
- f. If a fueling pumps flow switch opens after the pump successfully started the alarm annunciator's associated non-critical alarm sequence shall activate.
- g. MOV I32 shall be opened.
- h. The pump will continue to run until such time as the run High Pressure test signal is received. Note: the Tightness Monitoring Panel is monitoring the Loop pressure and when it is satisfied that it is high enough it will instruct the PCP to Run the High Pressure test.

3.12.2 Run High Pressure Test

- a. MOV I32 will be closed.
- b. Fueling pump will be shut off.
- c. The BPCV solenoid "A" shall be d-energized and the BPCV solenoid "B" shall be de-energized to close valve.
- d. The PCV solenoid "A" will be de-energized and the PCV solenoid "B" will be de-energized to enable the valve at the 515 kPa 75 psi value. Note: the Tightness Monitoring Panel will wait for a 10 minute settling time to pass, then it will monitor the loop pressure for 2 minutes. Upon finishing this test it will instruct the PCP to Prepare for the Low Pressure Test.

3.12.3 Low Pressure Test Preparation

- a. MOV I32 will be opened.
- b. The PCV solenoid "A" will be energized and the PCV solenoid "B" will be energized to enable the valve at the 345 kPa 50 psi value.
- c. The system will remain in this status until such time as the PCP receives a Run Low Pressure test signal from the Tightness Monitoring Panel. Note: The Tightness Monitoring Panel will monitor the loop pressure until it reaches the 345 kPa 50 psi value. It will then instruct the PCP to run the Low pressure test.

3.12.4 Run Low Pressure Test

- a. MOV I32 will be closed.
- b. The system will remain in this status until such time as the PCP receives a Prepare for Second High Pressure test signal from the Tightness Monitoring Panel. Note: The Tightness Monitoring Panel will wait for a 10 minute settling period to expire, then it will monitor the loop pressure for 2 minutes. Upon finishing this test it will instruct the PCP to prepare for Second High Pressure Test.

3.12.5 Second High Pressure Test Preparation

- a. The BPCV solenoid "A" shall be de-energized and the BPCV solenoid "B" shall be energized to enable the valve at the 1100 kPa 160 psi value.
- b. The D/FV solenoid "A" shall be de-energized and the D/FV solenoid "B" shall be de-energized to force it closed.
- c. Automatically start the lead fueling pump to obtain pressure.
- d. The PCV solenoid "A" shall be de-energized and PCV solenoid "B" shall be de-energized to close the valve.
- e. When a fueling pump is started, a 15 second timer shall start. If the timer expires before the flow switch closes the alarm annunciator's associated non-critical alarm sequence shall activate.
- f. If a fueling pumps flowswitch opens after the pump successfully started the alarm annunciator's associated non-critical alarm sequence shall activate.
- g. MOV I32 will be opened.
- h. The pump will continue to run until such time as the run Second High Pressure test signal is received. Note: the Tightness Monitoring Panel is monitoring the Loop pressure and when it is satisfied that it is high enough it will instruct the PCP to Run the Second High Pressure test.

3.12.6 Run Second High Pressure Test

- a. MOV I32 will be closed.
- b. Fueling pump will be shut off.

- c. The BPCV solenoid "A" shall be de-energized and the BPCV solenoid "B" shall be de-energized to close valve.
- d. The PCV solenoid "A" will be de-energized and the PCV solenoid "B" will be de-energized to enable the valve at the 515 kPa 75 psi value. Note: the Tightness Monitoring Panel will wait for a 10 minute settling time to pass, then it will monitor the loop pressure for 2 minutes. Upon finishing this test it will instruct the PCP that testing is finished.
- e. The PCP will leave the system as is until such time as the PCP selector switch is placed into a different mode.

3.13 OFF MODE

- a. Automatic starting of fueling pumps shall be disabled. All other functions (GDP, alarm annunciator, operator interface, control valve solenoids, etc.) shall be active to allow manual control of the fueling pumps using the Hand-Off-Auto or Hand-Auto switch.
- b. When the first pump has been started:
 - (1) The BPCV solenoid 'A' shall be energized to enable the valve to modulate the system pressure at it's set point.
 - (2) The PCV solenoid 'A' shall be energized to close the valve.
 - (3) The D/FV solenoid 'A' shall be de-energized so the valve is closed and solenoid 'B' shall be de-energized.
- c. The second, third and fourth pumps maybe started or stopped manually as needed by the operator.
- d. After the last pump has been stopped:
 - (1) The BPCV solenoid 'A' shall be de-energized.
 - (2) The PCV solenoid 'A' shall be de-energized.
 - (3) The D/FV solenoid 'A' shall be energized and D/FV solenoid 'B' shall be de-energized.

3.14 MANUAL OPERATION OF FUELING PUMPS

- a. If the PLC system is still active see paragraph OFF MODE.
- b. If the PLC system has no power or both CPUs have faulted (CPU lights on PCP off) the pumping system will be in a completely manual mode. The safety circuit will need power so that the ESO solenoids on the non-surge check valves will be open and fuel can flow. The solenoids on the other solenoid controlled valves will be de-energized so the valves will have to be manually opened or enabled for the system to run. Other valves may need to be opened or closed manually by the operators for the system to work properly.

3.15 4-VALVE MANIFOLD SUPERVISION

NOTE: The drawing referenced below is from the

DEPARTMENT OF DEFENSE CUT'N'COVER STANDARDS STORAGE
TANK/PUMPHOUSE AND FILTER BUILDING Standard
Drawings. Add the drawing to the design package if
applicable.

- a. Prior to initiating fueling operations in the automatic or in the test mode, the 4-valve manifold valves and the two tank outlet valves must be in the proper positions for successful fueling operations. The PLC shall monitor valve positions of the 4-valve manifold (sensed by position limit switches for fully opened and fully closed status on valves I34, I35, R10, and R11) and by monitoring valve status on the tank outlet valves (sensed by position limit switches for fully opened and fully closed status on valves I11 and I12). Valve position must conform to the valve position table listed on drawing M-204.
- b. If the system is placed in automatic or test mode the valve selections must conform to the position table on sheet M-204. If the valve positions do not conform to this table the PCP will show a 4-Valve manifold error on the alarm annunciator. The alarm can be silenced, but will not reset until such time as the valve positions do conform to the table.

-- End of Section --