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MILITARY HANDBOOK

AIRCRAFT FIXED POINT UTILITY SYSTEMS

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ABSTRACT

This handbook provides basic design guidance for aircraft ground power facilities Category Code 149-15. It has been developed from extensive re-evaluation of facilities and is intended for use by experienced architects and engineers. The contents include preliminary design data for the central utilities supply, distribution and aircraft ground power fixed point (permanently located) service areas. Specific data are given for engine starting air, environmental control system cooling air, preconditioned cooling air for hangar aircraft, compressed air for maintenance operations, 400 Hz and 60 Hz electrical power distribution systems.

FOREWORD

This handbook has been developed from an evaluation of facilities in the shore establishment, from surveys of the availability of new materials and construction methods, and from selection of the best design practices of the Naval Facilities Engineering Command (NAVFACENGCOM), other Government agencies, and the private sector. This handbook was prepared using, to the maximum extent feasible, national professional society, association, and institute standards. Deviations from this criteria, in the planning, engineering, design, and construction of Naval shore facilities, cannot be made without prior approval of NAVFACENGCOM HQ Code 04.

Design cannot remain static any more than can the functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged and should be furnished to Commander, Naval Facilities Engineering Command, Naval Facilities Engineering Command Headquarters, Code 04, 200 Stovall St., Alexandria, VA 22332-2300; telephone (703) 325-0450.

THIS HANDBOOK SHALL NOT BE USED AS A REFERENCE DOCUMENT FOR PROCUREMENT OF FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE OF FACILITIES ENGINEERING STUDIES AND DESIGN (FINAL PLANS, SPECIFICATIONS, AND COST ESTIMATES). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

MAINTENANCE FACILITIES CRITERIA MANUALS

Criteria Manual	Title	PA
MIL-HDBK-1028/1	Aircraft Maintenance Facilities	LANTDIV
MIL-HDBK-1028/3	Maintenance Facilities for Ammunition, Explosives, and Toxins	LANTDIV
DM-28.4	General Maintenance Facilities	WESTDIV
DM-28.5	Environmental Control - Design of Clean Rooms	LANTDIV
MIL-HDBK-1028/6	Aircraft Fixed Point Utility Systems	HDQTRS
MIL-HDBK-1028/8	Pest Control Facilities	HDQTRS

NOTE: Design manuals, when revised, will be converted to military handbooks.

This handbook is issued to provide immediate guidance to the user. However, it may or may not conform to format requirements of MIL-HDBK-1006/3 and will be corrected on the next update.

CONTENTS

AIRCRAFT FIXED POINT UTILITY SYSTEMS

Page

Page

APPENDIX

FIGURES

TABLES

Section 1: INTRODUCTION

1.1 Scope. This handbook contains design criteria for ground power utilities service to naval aircraft at shore activities. Utilities included are engine starting air, environmental control system compressed air, hangar preconditioned air, apron and maintenance hangar utility air, 400 Hz and 60 Hz electrical power. The installations include central facilities supply, distribution systems and aircraft fixed point (permanently located) services.

Section 2: FIXED POINT UTILITY SYSTEMS

2.1 General. Design of the Fixed Point Utility System (FPUS) requires determining the number and type of aircraft to be served, ground support requirements of the particular aircraft, expected diversity of the aircraft loads and site configuration. Resolving these variables provides the central facilities utility demands, equipment capacities, line size and routing of the distribution system and aircraft service point requirements.

2.1.1 Planning. The FPUS concept is based upon the economy of supply of aircraft utilities from a centralized plant of energy-efficient components. Include the following considerations in FPUS planning for a particular aircraft maintenance facility:

a) Orderly expansion of the system components to accommodate probable future hangar bays and/or parking apron service points.

b) Economic feasibility of supplying adjacent or nearby facilities (existing or future) from the centralized supply.

2.1.2 Aircraft Services. Fixed-point systems shall supply aircraft utilities at parking apron service points and maintenance hangar service points. The FPUS required are compressed air, preconditioned air for hangar aircraft, and electrical power. Two system design alternatives are feasible (Refer to Table 1 for a summary of aircraft utility demands.):

2.1.2.1 Alternate 1. The Air Start System provides compressed air at the parking apron service points. Aircraft cooling is provided by mobile ground carts. The selection of the air start system or ECS system is based upon system requirements and economic factors. Factors affecting the system selection include central plant and utility distribution construction costs, local environmental conditions, and local utility rate structures. Noneconomic factors which must be considered are operational convenience including manpower requirements, space limitations, and system dependability. The air start system will generally have the lowest initial cost and shortest pay-back period while using the least energy of any current design option.

2.1.2.2 Alternate 2. The Environmental Control System (ECS), provides compressed air for engine starting air and ECS compressed air at the parking apron service points from a central source. The ECS system will generally have the lowest operating and maintenance costs, resulting in the highest overall life-cycle cost savings. The ECS system also has inherent operational advantages by requiring fewer operating personnel and minimizing the need for ground support equipment. The ECS system requires no starting air recovery period. See Figure 8 in this Section, and Figure 11 in Section 7, for additional information. Dedicated and separate panels for the electrical and mechanical services shall be provided. For maintenance Hangar Service Points, provide electrical and mechanical services as shown in Figures 9, 10, 11, and 12 in the later sections of this handbook. Separate dedicated panels for mechanical and electrical services shall be provided.

2.1.3 Central Equipment Facilities. The central facilities area shall provide the equipment building and yard area for compressed air storage tanks and substation type transformers, and switchgear for main electrical service. The building shall accommodate the air compressors and auxiliary equipment, the 400 Hz generation switchgear, electrical service and distribution apparatus. The equipment for preconditioned air supply to hangar aircraft shall be located within a hangar equipment room, a penthouse of the shop area or a separate structure. Refer to NAVFAC DM-4.05, 400 Hz Generation and Distribution Systems for additional details.

2.1.4 Utilities Distribution. The underground mains and feeders shall provide for the utilities distribution to the maintenance hangar service points and parking apron service points. The compressed air lines and electrical conduits shall be routed in the same trench. The access manholes shall be provided outside the paved areas. For cable-pulling manholes, refer to MIL-HDBK-1004/2, Power Distribution Systems.

2.1.5 Site Configuration. The layout of FPUS shall be subject to the correlated siting of maintenance hangars, parking apron space and taxiways. For the relationship of hangars to aircraft parking areas and taxiways, refer to NAVFAC DM-21, Airfield Pavement Design Series. The parking apron layout is prescribed in NAVFAC P-80, Facility Planing for Navy and Marine Corps Shore Installations. For a typical FPUS layout to serve a predescribed hangar and parking apron complex see Figure 1. The following criteria apply:

a) The central equipment facility shall be located as near the hangar as practical at a location offering the most direct access to the parking apron. Minimize the length of the underground mains to the parking apron.

b) Locate the section of underground mains between the central facilities and the first transition point outside the apron and taxiway pavements.

c) The section of underground mains serving the parking apron shall include a compressed air loop to equalize distribution line pressure.

d) Feeder Distribution Center. A feeder distribution center shall be provided consisting of aboveground, pad-mounted equipment or underground vault-mounted switchgear located as close as practical to the service points to minimize aircraft service voltage drop. Refer to NAVFAC DM 4.05 for sample voltage drop calculations. Refer to Tables 6 and 7 of DM-4.05 for maximum system distances. See Figure 10 for additional details.

2.2 Utility System Load Determinations. The total number and type of aircraft plus the demands of other ground support activities to be supplied by the fixed-point facilities will determine load requirements for the utility system.

2.2.1 Aircraft Utility Demands. The utility demands required for the support of various aircraft are itemized in Table 1. The following aircraft unit demands shall be used as the minimum FPUS design criteria:

Table 1
Summary of Aircraft Utility Demands

	AIRCRAFT ENGINES		ELECTRICAL	AIR START SYSTEM STARTING AIR[5]		PRECONDITIONED COOLING AIR[7]		ECS COMPRESSED AIR	
AIRCRAFT SERIES	No.	TYPE	400 V kVA[1]	lb/min[3]	psig	lb/min[2]	psig	lb/min	psig
A-4E	1	J52	2.7	85.0	45	30.00	3	NA[9]	NA
A-6A	2	J52	12.2	85.0	45	50.00[4]	2	35.00	45
A-6G	2	J52	17.5[11]	85.0	45				
A-7E	1	TF41	4.48	85.0	45	32.00	3	60.00	45
F-4J	2	J79	23.5	180.0	75	30.00	3	50.00	45
F-14A	2	TF30	17.30(20)	85.0	45	48.92[4]	3	110.00	45
F-14D	2	F110-400	18.50	180.0[12]	75	40.92	3	110.00	75
F-18	2	F404	18.50[8]	132.0	45	50.00	3	110.00	45
S-3A	2	TF34	32.43	85.0	45	100.00	3	80.00	45
P-3C	4	T56	70.8	150.0	45	50.00	3	122.00	45
E-2C	2	T56	86.2	85.0	45	100.00	3	30.00	45
EGC-130	4	T56	42.3	*	*	*	*	*	*
EA-6B	2	J52	17.0	85.0	45	77.00	1.5	70.00	75
E6-A	4	CFM56	400.0	*	*	*	*	*	*
SH-60B	2	T700	15.5[8]	85.0[10]	45[10]	50.00[10]	3[10]	100.00[10]	45[10]
SH-60F	*	*	15.5	*	*	*	*	*	*
C/MH-53E	*	*	16	*	*	*	*	*	*

*Data to be provided by NAVAIR after testing is completed.

Table 1 (cont)
Summary of Aircraft Utility Demands

[1] Patuxent River Test (maximum measured load).
[2] Analysis of Fixed Point Utility System - Supplement "86" Report.
[3] NAEC-GSED-86 - Fixed Point Aircraft Utility Support System Report.
[4] Manufacturer's information.
[5] Requirements per engine.
[6] NAEC
[7] Nominal capacity at 45° F supply air (hangar locations only).
[8] NAEC - Report 92.528.
[9] ECS not available for A-4E Aircraft.
[10] Values are theoretical - not equipped for external air connections.
[11] NAVAIR Letter SER 4223B/3002 dated 9 January 1987.
[12] NAVAIR Specification Data, refer to MIL-STD-704A:

Normal Maintenance or Ground Operations
Air Vehicle Equipment
EPIA Receptacle (isolated source) - 80 kVA 400 Hz

Ground Tune Operations
One power amplifier and cathode emitter
EPIB Receptacle - 60 kVA 400 Hz

VLF Full Power
Ground Operations
EPIA Receptacle (isolated source) - 80 kVA 400 Hz
EPIB Receptacle - 75 kVA 400 Hz

E 16 Rack Power 3 power amplifiers
75 kVA 400 Hz

[13] E2-C - Provide 2-45 kVA transformers
[14] For specific information on aircraft not listed, contact NAVAIR 4221 on Autovon 222-0797.

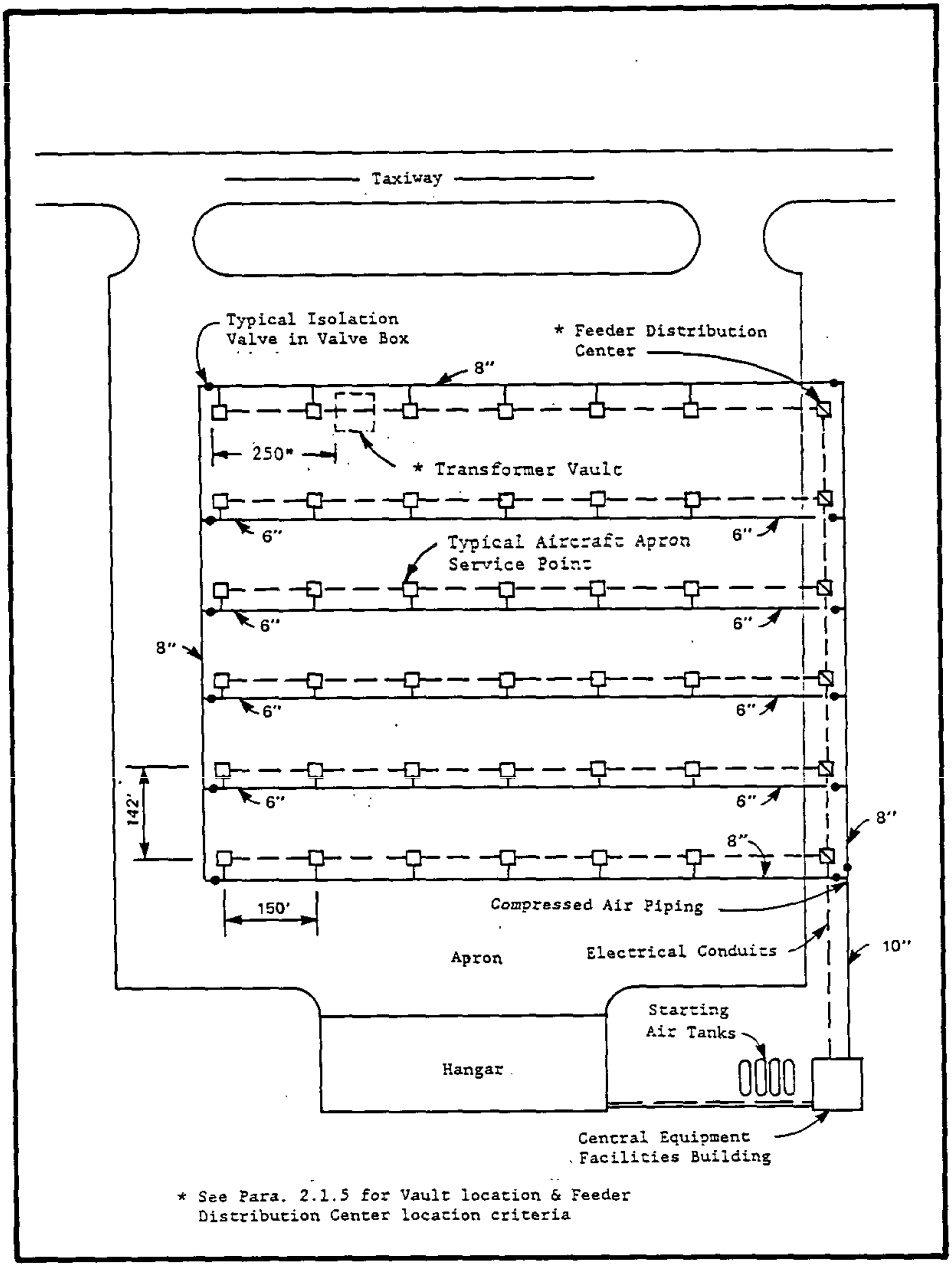


Figure 1
Typical FPUS Site Plan

PARKING APRON SERVICE POINTS

Provide mechanical and electrical services:

a) Mechanical:

Symbol	Utility Description
M-2	Aircraft Engine Starting Air: 85 pounds per minute (lb/min) 45 psig (310.23 kPa) Pressure dew point: 38° F (3.3° C) or for F-110 Engine Provide: 180 lb/min 75 psig (517.05 kPa) or ECS Compressed Air (option): 100 lb/min 45 psig (310.23 kPa) Pressure dew point 38° F or 110 lb/min 75 psig (517.05 kPa)
M-1	Utility Tool Air: 90 psig (620 kPa) 20 standard ft^3 per min (scfm) (0.57 m^3/min)

b) Electrical:

Symbol	Equipment
T-1	Transformer, 120 V, 1-phase, 3 kVA, lighting and convenience power
T-4	Transformer, 200 wye to 115 V, 3-phase, ac, 400 Hz aircraft electrical power
E-2	Receptacles, 480 V, 3-phase, 60 Hz, GSE power

AT HANGAR SERVICE POINTS

Provide mechanical and electrical services:

a) Mechanical:

Symbol	Utility Description
M-1	Preconditioned Air 50 lb/min 3 psig (20.68 kPa) 45° F (7.2° C)
M-1	Utility tool air: 90 psig (620.46 kPa) 20 scfm (0.57 m^3/min)

b) Electrical:

Symbol	Equipment
T-1	Transformer, 120-V, 1-phase, 3 kVA lighting and convenience power
T-4	Transformer, 200 wye to 115 V, 3-phase, ac, 400 Hz (Select transformer kVA to match aircraft and application. Refer to Table 1, MIL-HDBK-1028/1, Aircraft Maintenance Facilities, and NAVFAC DM-4.05.)
E-2	Receptacles, 480 V, 3-phase, 60 Hz, GSE power

2.2.2 System Load Diversity. The system load diversity shall be determined by obtaining the system load diversity factor from Figure 2. Divide the diversity factor into the total number of aircraft under consideration to determine the number of aircraft expected to exert a simultaneous demand.

2.2.3 System Load Demands. The system load demands shall be determined by multiplying the aircraft unit demand by the expected simultaneous demand for the portion of the system under consideration. Refer to para. 2.2.1 for aircraft minimum unit demand criteria.

2.3 Starting Air System. The starting air system shall provide only compressed air for aircraft engine starting and for pneumatic tool operation at parking apron service islands and maintenance hangar service points. The system design shall comply with standards specified in NAVFAC DM-3.5, Compressed Air and Vacuum Systems.

2.3.1 System Components. A schematic diagram of the starting air system is shown in Figure 3. The basic components of the system are:

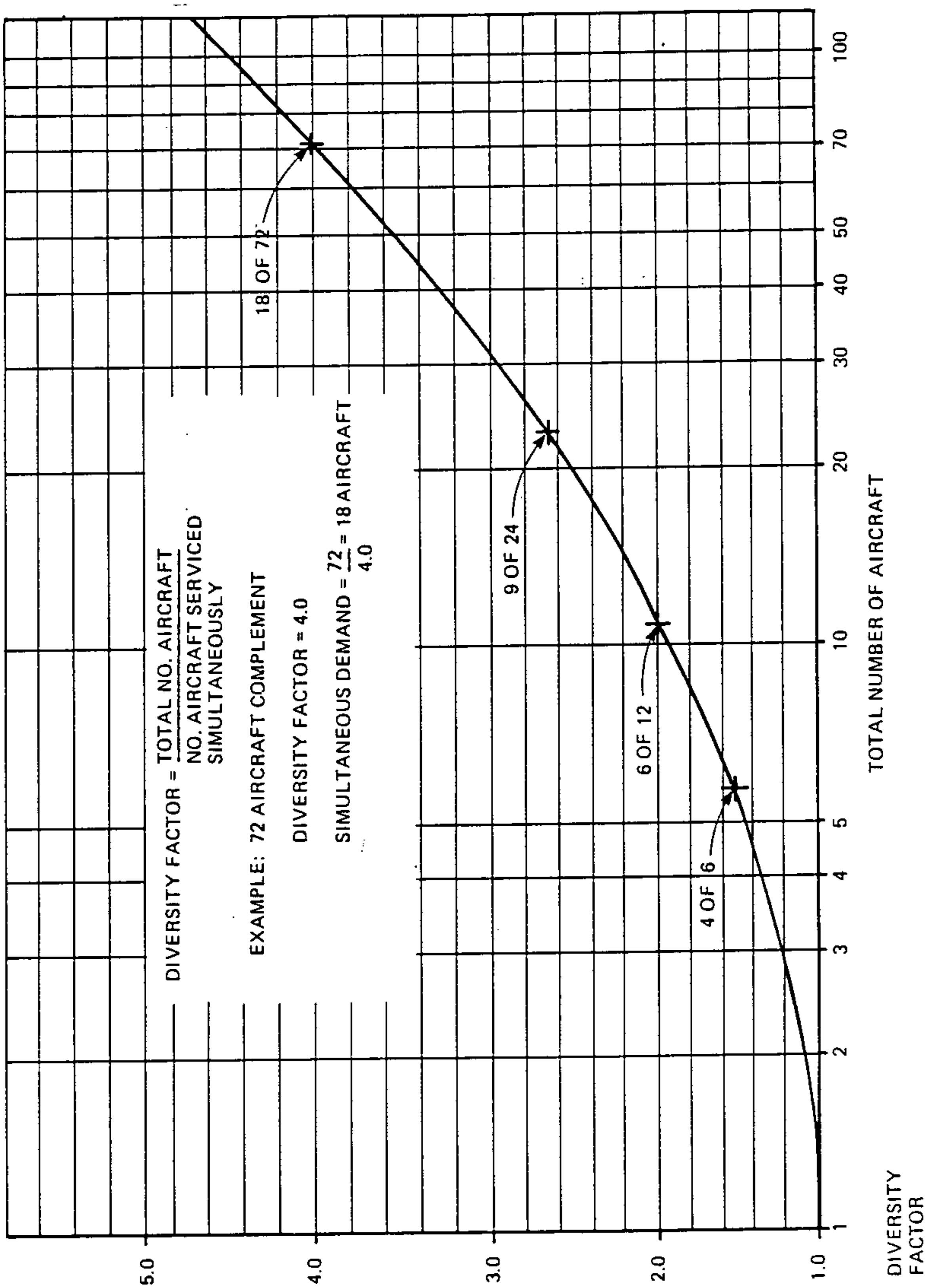


Figure 2
FPUS Diversity Curve

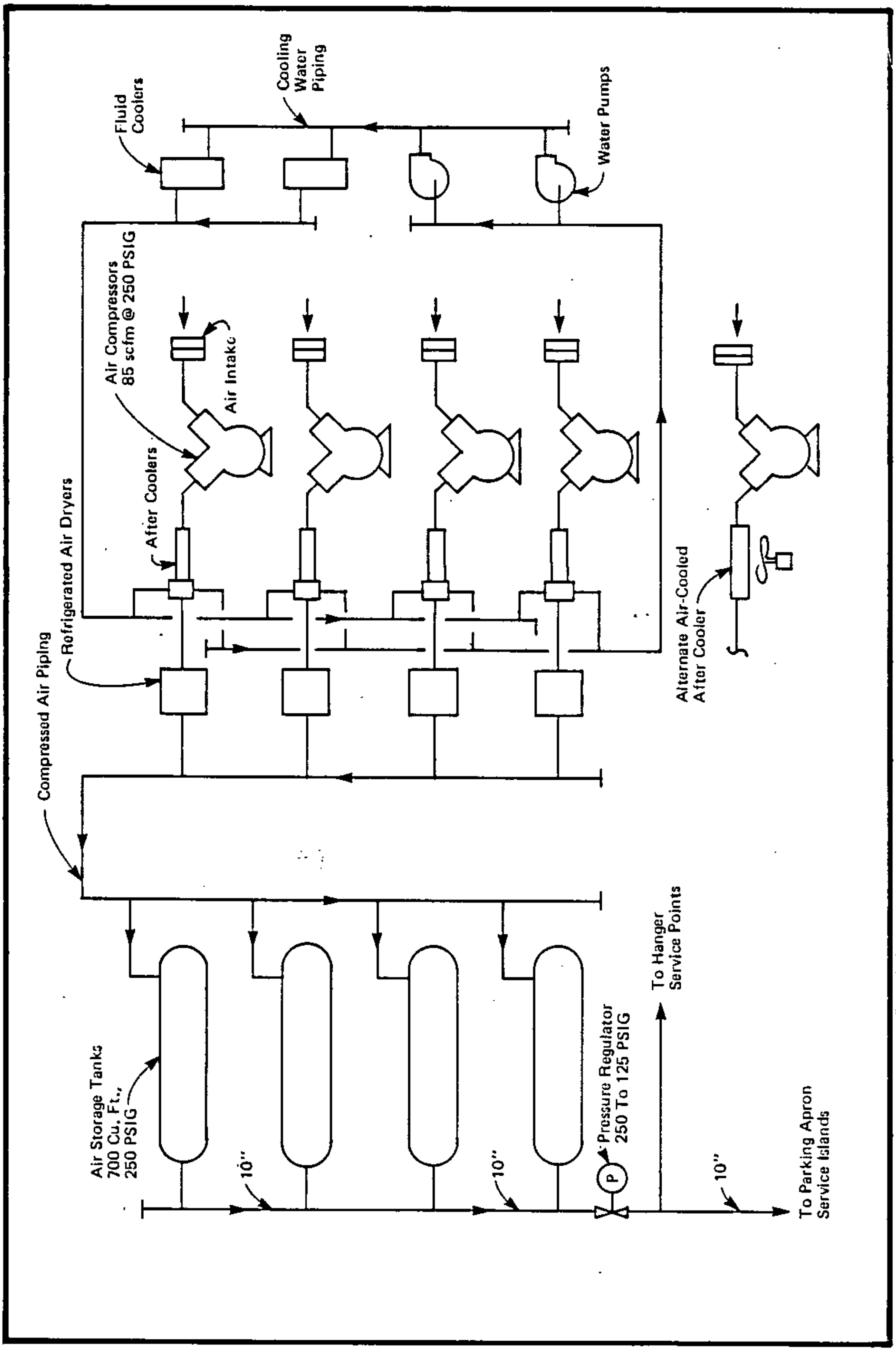


Figure 3
Starting Air System

a) electric motor-driven, reciprocating-type air compressors,

b) air dryers,

c) compressor cooling system,

d) compressor and compressed air system controls,

e) receiver storage tanks,

f) underground distribution system, and

g) aircraft hangar and parking apron service point facilities.

2.3.2 Design Requirements. A broad range of starting air requirements exists because of differences in aircraft types and functions of the squadron or group. The starting air system shall have a minimum compressor size and receiver tank storage capacity to supply air for the starting in 2 minutes of 18 of a full complement of 72 two-engine aircraft with a 2-hour recovery period. Section 3 relates this criteria requirement to designs for less than a full complement of aircraft.

2.3.3 Design Conditions. The equipment ratings shall be based on standard ambient conditions of 14.67 psia (101.13 kPa) atmospheric pressure and 70° F (21° C) dry bulb temperature. The system shall be designed to supply air at the parking apron service island in the quantity required measured at 45-psig (310.23 kPa), or 75-psig (517.05 kPa).

2.4 Environmental Control System. The function of the Environmental Control System (ECS) is to provide compressed air for aircraft engine starting, ECS compressed air, and pneumatic tool operation at parking apron service islands and maintenance hangar service points. The ECS uses compressed air to operate the aircraft air cycle refrigeration machine which provides cockpit/cabin pressurization comfort conditioning, avionics and radar cooling and other heating and cooling tasks. The system design shall comply with piping and installation standards specified in NAVFAC DM-3.03, Heating, Ventilating, and Air Conditioning, and Dehumidifying Systems, and DM-3.5.

2.4.1 System Components. A schematic diagram of the environmental controls compressed air system is shown in Figure 4. Basic components of the system are the:

a) electric motor-driven centrifugal or rotary-screw type compressors,

b) air dryers,

c) compressor cooling system,

d) compressor and compressed air system controls,

e) underground distribution system, and

f) aircraft hangar and parking apron service point facilities.

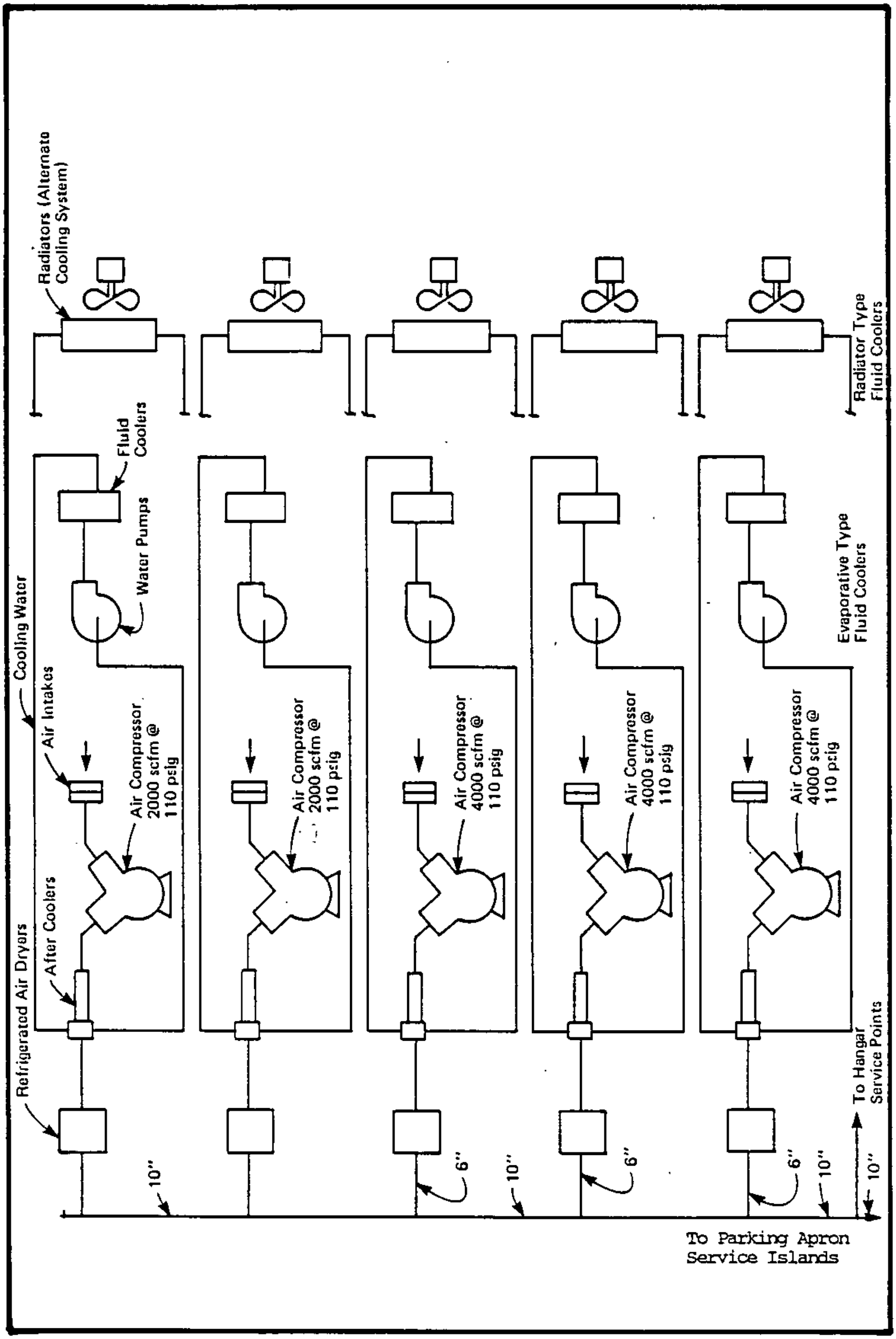


Figure 4
ECS Air System

2.4.2 Design Requirements. A broad range of starting and cooling air requirements exists because of differences in aircraft types and operational function of the squadron or group. The ECS shall have a minimum compressor size to supply air for the simultaneous starting of 18 of a typical full complement of 72 two-engine aircraft or the cooling of 12 of a full complement of 72 aircraft. Because the ECS compressed air flow requirement is larger and is of longer duration than the starting air requirement, the ECS compressed air requirement is used to determine compressor size. With this requirement, all 18 aircraft can be started in 3 minutes with no recovery time required.

2.4.3 Design Conditions. For design conditions refer to para. 2.3.3.

2.5 Preconditioned Cooling Air System. The function of the preconditioned cooling air system is to provide 3.0-psig (20.68 kPa) cooling air for hangar aircraft during electronics system maintenance at the hangar service points. Preconditioned air bypasses the air cycle machine and is injected directly into the aircraft duct system where it is used to perform the cooling functions outlined in para. 2.4. System piping and installation shall comply with design standards specified in NAVFAC DM-3.03 and DM-3.5.

2.5.1 System Components. A schematic diagram of the preconditioned cooling air system is shown in Figure 5. The basic components of the system are:

a) electric motor-driven high-pressure blower type supply fans,

b) package air-cooled water chillers and auxiliaries,

c) preconditioned air system controls,

d) air distribution system, and

e) hangar service point facilities.

2.5.2 Design Requirements. A broad range of preconditioned air requirements exists because of differences in aircraft types. Design criteria requires a minimum of 50 lb (344.74 kPa) for six of a full complement of 72 aircraft, based upon 12 hangar aircraft positions. Notice that the total aircraft provided with compressed air is 18, as determined by the FPUS diversity curve. The number served in the hangar by preconditioned air is subtracted from the total to determine the number to be served by ECS compressed air on the parking apron.

2.5.3 Design Conditions. Equipment ratings shall be based upon local ambient conditions. The system design shall utilize chilled water to cool 100 percent outside air to 45° F (7.2° C) saturation temperature. This air is then pressurized by the blower fan to 3.5-psig (24.13 kPa) where the heat of compression raises the air temperature to approximately 100° F (38° C). The pressurized air is distributed to secondary cooling coils at the hangar rear bulkhead where it is again cooled to 45° F and ducted to the aircraft at a connection point pressure of 3-psig (20.68 kPa). Secondary coil enclosure and discharge air duct must be insulated to minimize heat gain and condensation. In climates where coil freeze-up is possible, a face and bypass damper should be used to bypass outside air around the primary cooling coil when ambient is 35° F (2° C) and below.

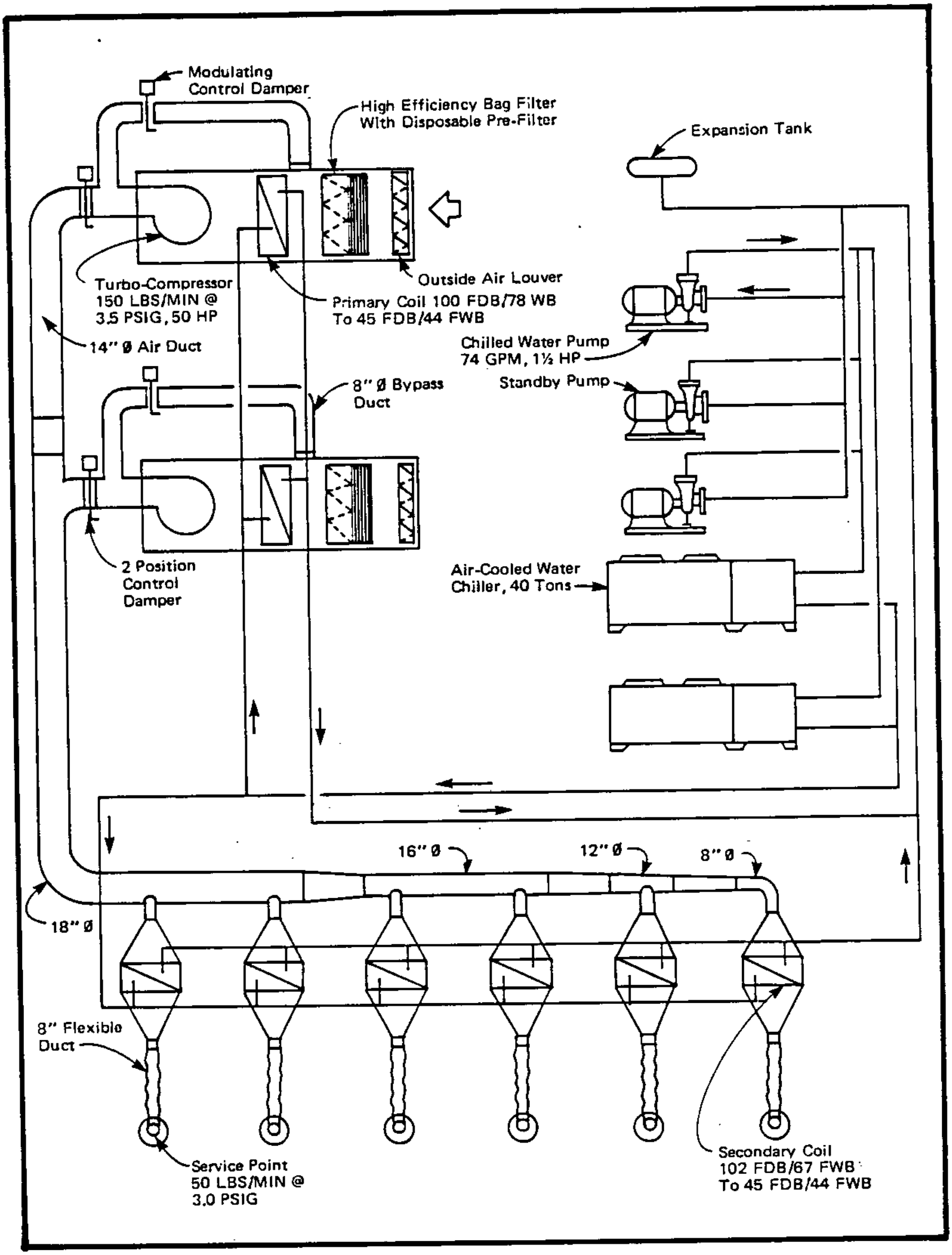


Figure 5
Preconditioned Cooling Air System

2.6 Electrical System. The electrical system provides the main power supply and distribution for FPUS central equipment operations and central facilities building services, and distributes 400 Hz and 60 Hz power to parking apron service points and hangar service points. Provide load-center type unit substation to supply FPUS facility power from the naval air station primary distribution system. System design shall comply with electrical installation standards specified in MIL-HDBK-1004/1, Electrical Engineering, Preliminary Design Considerations, through MIL-HDBK-1004/6, Lightning Protection, and National Fire Protection Association (NFPA) Publicaton No. 70-1984, National Electrical Code. Provide 25% spare electrical transformer capacity for future load growth. Use double-ended substations when two primary feeders are available.

2.6.1 System Components. Schematic diagrams of typical electrical systems for the ECS and air start system are shown in Figures 6, 7 and 8. The basic components of the system are:

a) low-voltage switchgear with main breaker and metering;

b) motor control center;

c) 400 Hz, motor-generator units with automatic paralleling (refer to NAVFAC DM-4.05);

d) 400 Hz, metal-enclosed, fused, load break type switchgear;

e) transformer and circuit breaker distribution panel for small power and control supply;

f) underground distribution system with manholes as required;

g) electrical Feeder Distribution center (see Figure 10) or vault-mounted equipment (refer to NAVFAC DM-4.05, Figure 7, for typical 400 Hz System Diagram);

h) thermostatically-controlled heaters for condensation control within electrical equipment in outdoor locations; and

i) aircraft hangar service point and parking apron service point facilities.

2.6.2 Design Requirements. A broad range of electrical requirements exists because of differences in aircraft types and operational function of squadron or group. Design the electrical system to provide a minimum of 18, maximum or 20 each 100 A receptacles for the 400 Hz system. The system shall be designed to serve 18 of a full complement of 72 aircraft. The criteria also require that 100 A of 60 Hz power be provided for ground support for 18 of 72 aircraft (see Figure 9). The resulting electrical demand is proportioned between parking apron service islands and hangar service points with a ratio of two-to-one (or 12 and 6) respectively. Section 3 relates this criteria requirement to designs for less than a full complement of aircraft.

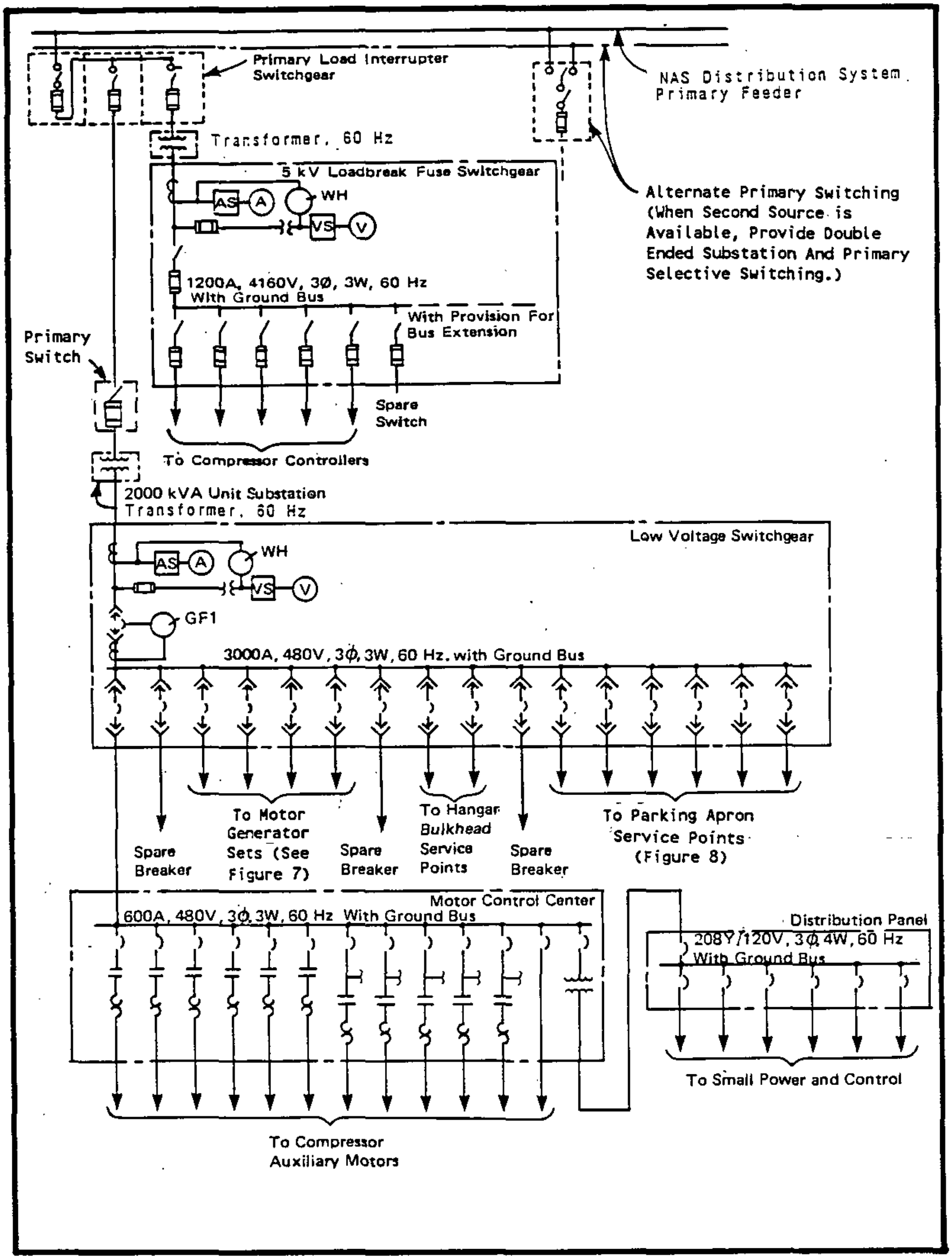


Figure 6
Typical One Line Diagram Central Facilities - ECS System

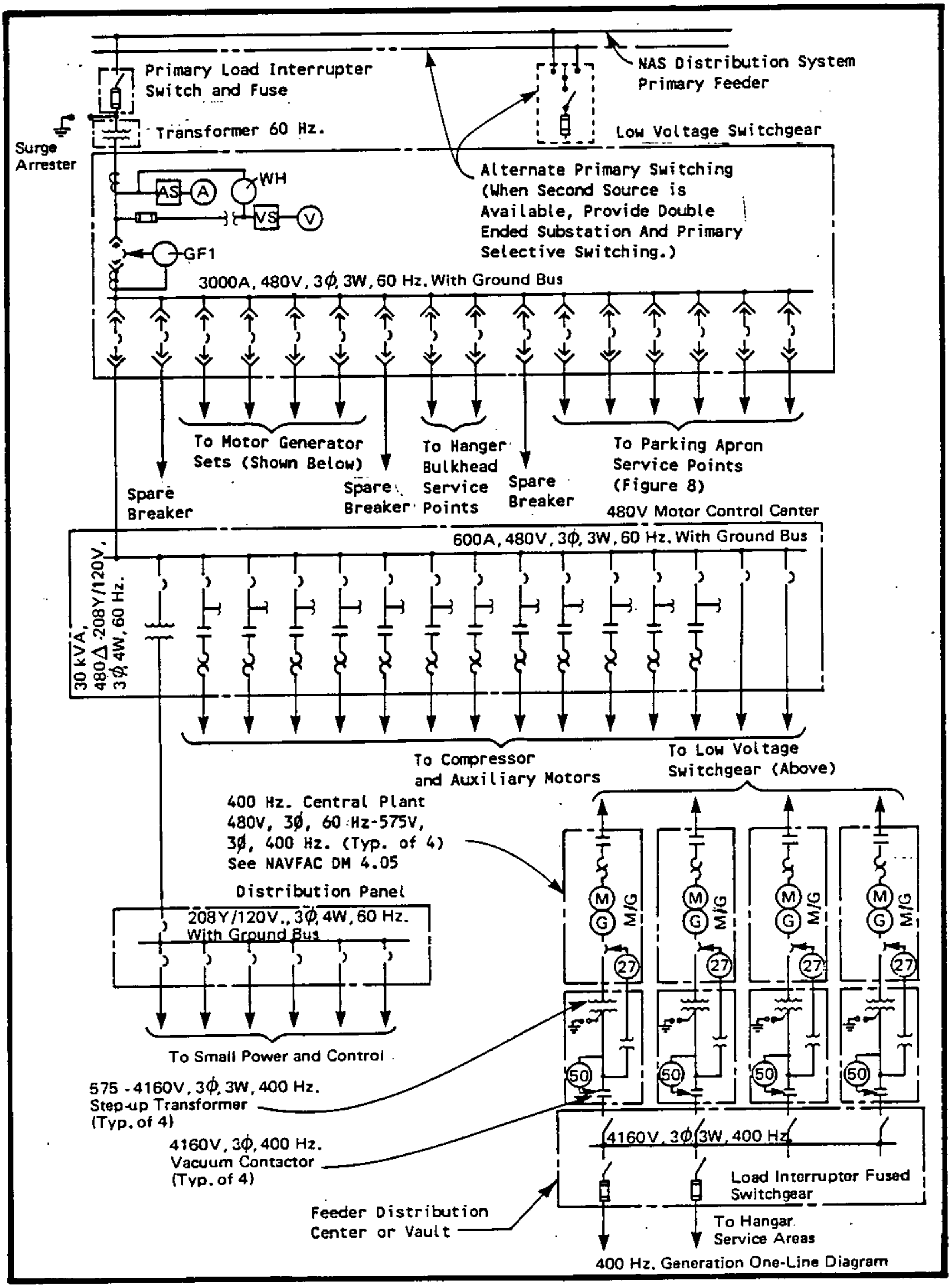
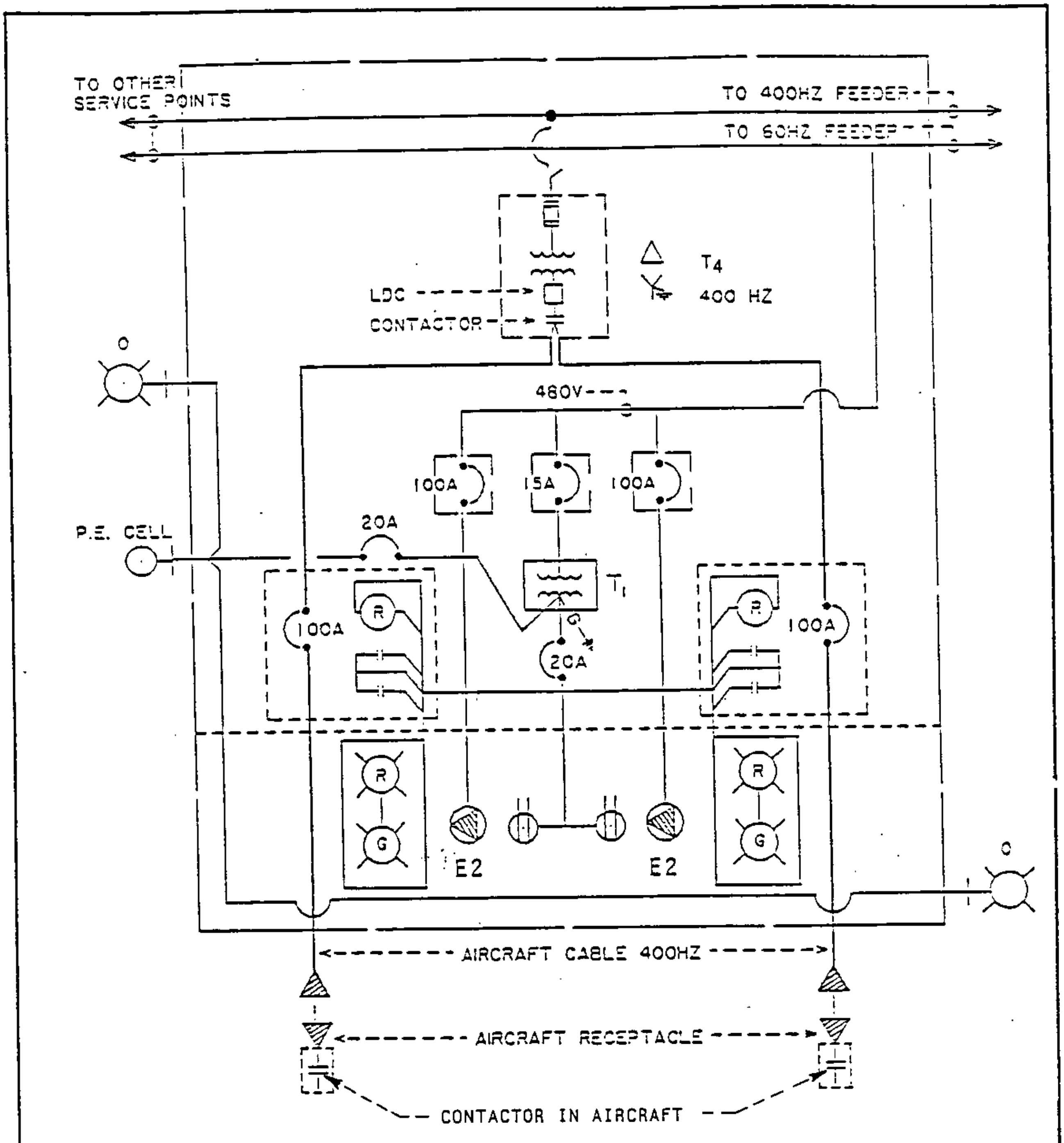


Figure 7
Typical One Line Diagram Central Facilities Air Start System

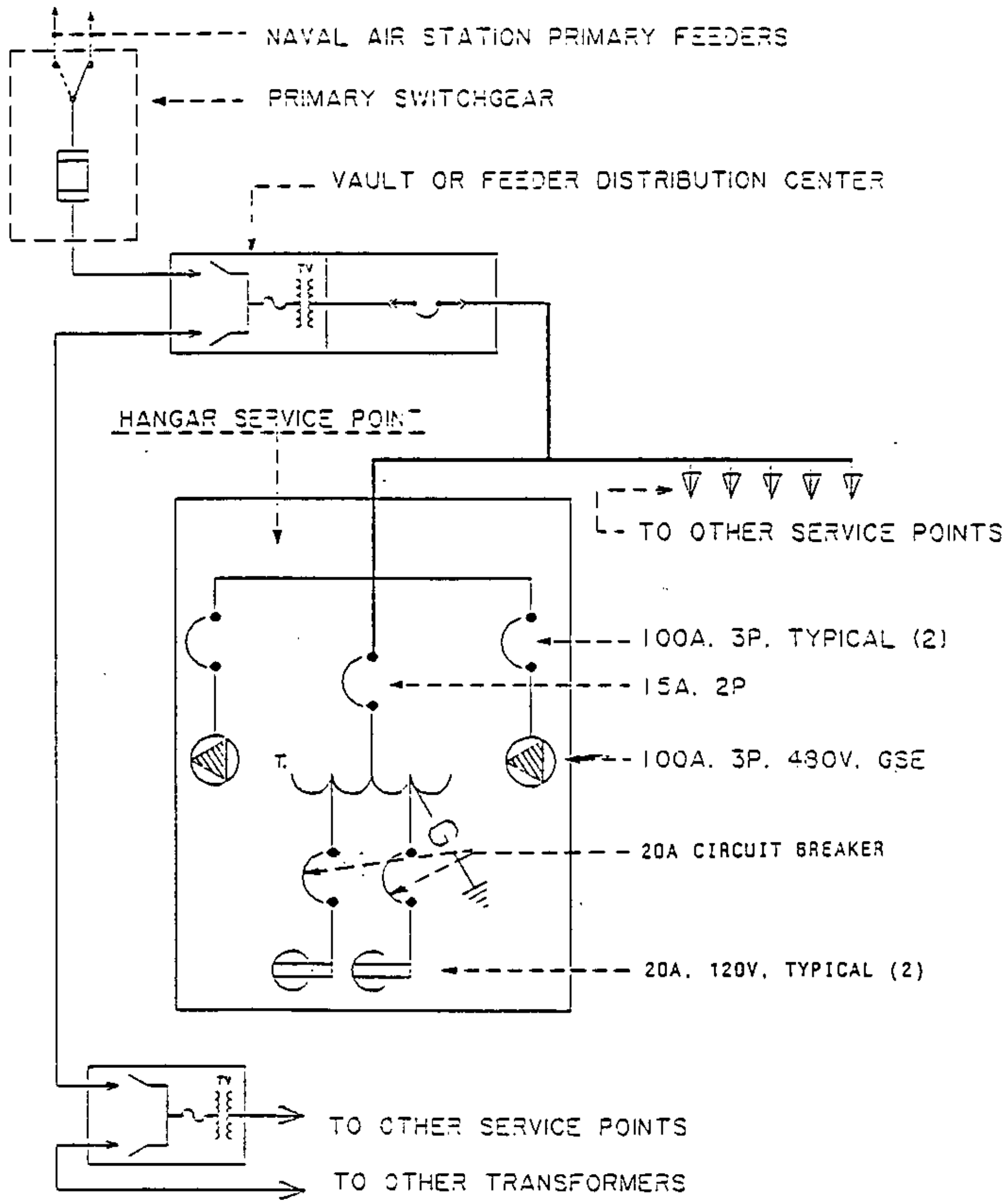


*SEE SECTION 8 FOR ELECTRICAL SYMBOLS & FIGURES 11 & 12 FOR DETAILS

	DATE	PLATE NO	SHEET NO
PARKING APRON SERVICE POINT	JAN 87	149-15	8

Figure 8
Typical One-Line Diagram Electrical Distribution And Aircraft Service Point

FIGURE NO. 9



	DATE	PLATE NO.	SHEET NO.
60 HZ POWER SYSTEM SINGLE LINE DIAGRAM HANGAR SERVICE POINT	DEC. 86	149-15	9

Figure 9
60 Hz Power System

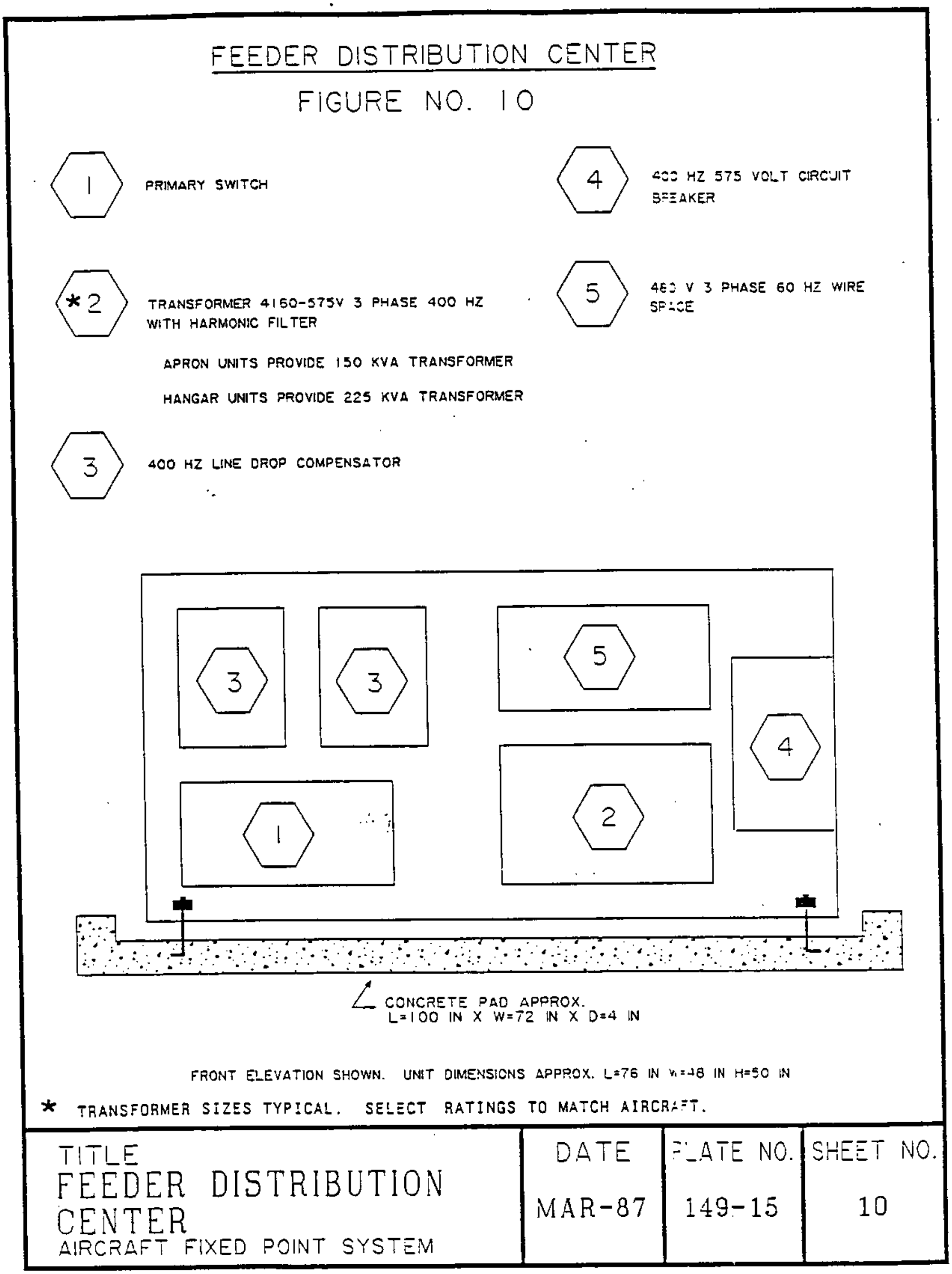


Figure 10
Feeder Distribution Center

Section 3: SYSTEM COMPONENT SELECTION

3.1 Standardization of Components. Standardization of FPUS components requires that central facilities equipment and main distribution components be selected for energy-efficient operation and according to the basic design methods defined in paras. 3.1.1 through 3.1.4.

3.1.1 Minimum Unit Demands. The minimum aircraft unit demands for aircraft ground support are as detailed in para. 2.2.1.

3.1.2 Maximum Unit Capacities. The maximum unit capacity of central facilities equipment shall be based upon the number of Ground Support Equipment (GSE) available to serve as standby. Generally, that availability will be approximately one-fourth of the central facilities total demand as determined in Section 2.

3.1.3 Design Method. The preceding requirements of aircraft unit demands, diversity of loads, minimum unit demand and maximum capacities of central facilities equipment, when properly coordinated, formulate the design method. The design method is formulated on the basis of the requirements of carrier-type aircraft. The number of general purpose or special mission aircraft assigned to a particular facility is unpredictable. For such applications, determine the total utility demand by dividing the product of the aircraft unit demand and the number of aircraft by the diversity factor.

3.1.4 Design Method Summaries. Tables 2 through 7 summarize the design method for the determination of the quantity and ratings of the central facilities equipment. Calculations are based on air at standard conditions of 14.7 psia (101.35 kPa), 68° F (20° C), 36 percent relative humidity.

3.1.4.1 Selecting Starting Air Equipment. Table 2 summarizes the method for selecting starting air equipment. Table 3 presents an example for a starting air system based upon the following conditions:

a) Compressor discharge pressure = 250 psig (1,723.5 kPa)

b) Pressure drop, compressor-to-receiver = 10 psig (68.94 kPa)

c) Pressure drop, PRV to service point = 20 psig (137.88 kPa)

d) Pipeline volume = 2,300 ft^3 (64.4 m^3) at an average pressure of 115 psig (792.81 kPa)

The above information is necessary to determine the allowable system pressure drops. The minimum pressure required in the receivers for this example is 65 psig (448.1 kPa) which equals 45 psig (310.23 kPa) service point pressure plus 20 psig pipeline pressure drop. The maximum receiver pressure is 240 psig (1,654.56 kPa) since 10 psig is lost in the piping system between the compressor discharge and the receiver inlet.

Table 2
Summary of Design Method for Quantities and Ratings, Central Facilities Equipment Selection, Starting Air System

BASIS OF DETERMINATION FOR RECOMMENDED UNIT CAPACITY AND NUMBER OF EQUIPMENT UNITS:

Step	Description
1.	Number and type of aircraft:
2.	Aircraft service requirements: Starting air = lb/min psig (per engine) Electrical = kVA, hertz
3.	Aircraft to be served simultaneously: $\frac{\text{Total number of aircraft}}{\text{Diversity factor}}$ = aircraft to be served
4.	Number and location of services to be provided: Starting air = number, flight line Electrical = number, hangar Electrical = number, flight line
5.	System capacity: Starting air storage capacity: Number aircraft x lb/min x min x no. engines = lb Storage volume, std. cubic feet (scf) = lb x specific volume Pipeline equiv. volume = $\frac{\text{pipe volume x allowable pressure drop}}{\text{atmospheric pressure}}$ Receiver capacity = $\frac{\text{(stor. vol.-pipe equiv.) x atmos. pressure}}{\text{allowable pressure drop}}$ Starting air compressor capacity: $\frac{\text{Storage, volume, scf}}{\text{Recovery time, minutes}}$ = scfm Electrical capacity: Number aircraft x kVA/aircraft = kVA
6.	Equipment unit size: $\frac{\text{Total system capacity (Item 5)}}{\text{*Number of units}}$ = unit capacity
7.	Select manufacturer's standard size that meets or exceeds unit capacity calculated

*Recommended number of units is 4 (selected for 25 percent of total system capacity).

Table 3
Summary of Design Method Starting Air System

RECOMMENDED UNIT CAPACITY:

Step Description

1. Number and type of aircraft: 72 F-14 aircraft

2. Aircraft requirements:
   Starting air = 85 lb/min 45 psig 2 engines
   *Electrical = 20.0 kVA, 400 hertz

3. Aircraft to be served simultaneously:
   $\frac{72 \text{ aircraft}}{4.0 \text{ diversity factor}}$ = 18 aircraft

4. Number and location of services to be provided:
   Starting air = 18 on flight line
   Electrical = 6 in hangar
   Electrical = 12 on flight line

5. System capacity:

   Starting air storage capacity:
   18 aircraft x 85 lb/min x 1 min x 2 engines = 3060 lb
   3060 lb x 13.33 scf/lb = 40,800 scf (total)
   2300 cf x $\frac{115\text{-}65 \text{ psig}}{14.7 \text{ psi}}$ = 7,823 scf (pipeline)
   $\frac{40{,}800\text{-}7823 \text{ scf}}{240\text{-}65 \text{ psig}}$ x 14.7 psi = 2770 scf (receiver)

   Starting air compressor capacity:
   $\frac{40{,}800 \text{ scf}}{120 \text{ min}}$ = 340 scfm

   Electrical:
   18 aircraft x 20 kVA/aircraft = 360 kVA

6. Equipment unit size:
   Starting air: (receiver capacity)
   $\frac{2770 \text{ scf}}{4}$ = 692 scf
   Starting air: (compressor capacity)
   $\frac{340 \text{ scfm}}{4}$ = 85 scfm

7. Select 4 compressors at 85 scfm 250 psig each and 4 nominal 700 scf storage tanks.

*Includes Spare Capacity - (see Table 1).

Table 4
Summary of Design Method for Quantities and Ratings, Central Facilities Equipment Selection, and Environmental Control Air System

BASIS OF DETERMINATION FOR RECOMMENDED UNIT CAPACITY AND NUMBER OF EQUIPMENT UNITS:

Step	Description
1.	Number and type of aircraft:
2.	Aircraft service requirements: ECS air = lb/min psig (per engine) Electrical = kVA, hertz
3.	Aircraft to be served simultaneously: $\frac{\text{Total number of aircraft}}{\text{Diversity factor}}$ = aircraft to be served
4.	Number and location of services to be provided: Preconditioned air = number, hangar ECS air = number, flight line (aircraft served less number, hangar) Electrical = number, hangar Electrical = number, flight line
5.	System capacity: ECS air compressor capacity: Number, flight line x lb/min x specific volume scf/min Electrical: Number aircraft x kVA/aircraft = kVA
6.	Equipment unit size: $\frac{\text{Total system capacity (Item 5)}}{\text{*Number of unit modules}}$ = unit capacity Select manufacturer's standard size that meets or exceeds unit capacity calculated.

*Recommended number of unit modules is four. (For large capacity systems, the preferred compressor selection is three units at 25 percent system total with the fourth module divided into two units at 12.5 percent each.)

Table 5
Summary of Design Method, Environmental Control Air System

RECOMMENDED UNIT CAPACITY

Step	Description
1.	Number and type of aircraft: 72 F-14 aircraft
2.	Aircraft service requirements: ECS air = 100 lb/min 45 psig Electrical = 20.0 kVA, 400 hertz
3.	Aircraft to be served simultaneously: $\frac{\text{72 aircraft}}{\text{4.0 diversity factor}}$ = 18 aircraft
4.	Number and location of services to be provided: Preconditioned air = six in hangar ECS air = 12 on flight line Electrical = 12 on flight line Electrical = six in hangar
5.	System capacity: ECS air compressor capacity: 12 aircraft x 100 lb/min x 13.33 scf/lb = 16,000 scfm Electrical: 18 aircraft x 20 kVA = 360 kVA total demand
6.	Equipment unit size: ECS air: (compressor capacity) $\frac{\text{16,000 scfm}}{4}$ = 4000 scfm
7.	Select three compressors at 4000 scfm and two at 2000 scfm, all at 110 psig discharge pressure.

Table 6
Summary of Design Method for Quantities and Ratings, Preconditioned Air Equipment Selection

BASIS OF DETERMINATION FOR RECOMMENDED UNIT CAPACITY AND NUMBER OF EQUIPMENT UNITS:

Step	Description
1.	Number of hangar service points and type of aircraft:
2.	Ambient air: °F dry bulb and moisture content, grains/lb
3.	Aircraft service requirements: Preconditioned air = lb/min or scfm psig °F (saturated)
4.	System capacity:
4a.	Preconditioned air capacity: Number service points x lb/min at psig = lb/min or scf/min (Add system pressure drop to determine fan discharge pressure)
4b.	Cooling load: (primary coil at air handler) Sensible = scf/min (Item 4a) x 1.08 x air temperature difference Latent = scf/min x .68 x air moisture difference, grains/lb
	Cooling load: (secondary coil at service point) Sensible = scf/min (Item 3) x 1.08 x air temperature difference Latent = scf/min x .68 x air moisture difference, grains/lb
5	Equipment unit size: (A minimum of two units is recommended.) $\frac{\text{Total System Capacity (Item 4)}}{2}$ = unit capacity
6.	Select manufacturer's standard size which meets or exceeds unit capacity calculated.

Table 7
Summary of Design Method, Preconditioned Air System

RECOMMENDED UNIT CAPACITY

Step	Description
1.	Number of hangar service points and type of aircraft: 6 F-14 aircraft
2.	Ambient air: 100°F db, 110 grains/lb
3.	Aircraft service requirements: 50 lb/min 3 psig 45°F
4.	System capacity:
4a.	Preconditioned air capacity: Six service points x 50 lb/min = 300 lb/min or 4000 scfm at 3.5 psi discharge pressure (0.5 psi system drop)
4b.	Cooling load: (primary coil) Sensible = 4000 scfm x 1.08 x (100-45)°F = 237,600 Btuh Latent = 4000 scfm x .68 x (110-44) grains/lb = 179,520 = 417,120 Btuh Fan heat = 124,500 Btuh (44 bhp) x 2 fans = 249,000 Btuh Fan temperature rise = 249,000 Btuh / (4000 x 1.08) = 57°F Fan discharge temperature = 45 + 57 = 102°F
4c.	Cooling load: (secondary coil) Assume 43°F saturated leaving temperature: 667 scfm x 1.08 x (102-43) = 42,500 667 scfm x .68 x (44-41) = 1,360 43,860 Btuh Six service points x 43,860 Btuh = 263,160 Btuh
5.	Equipment unit size: Air Handler: 4000 scfm / 2 = 2000 scfm Cooling Unit: (417,120 Btuh + 263,160 Btuh) / 2 = 340,140 Btuh or 28.3 tons
6.	Select two air handlers at 2000 scfm 3.5 psig and two air-cooled water chillers, nominal 40 tons each at 40°F water temperature and 105°F condenser air temperature (ambient design plus 5°F).

3.1.4.2 Selecting ECS Air Equipment. Table 4 is a summary of the method for selecting ECS air equipment. An example of an ECS air system is provided in Table 5, based upon the following conditions:

a) Compressor discharge pressure = 110 psig (758.34 kPa)

b) Pressure drop, compressor to service point = 10 psig (68.94 kPa) at minimum load and not exceeding 65 psig (448.11 kPa) at maximum load.

A summary of the method for selecting preconditioned air equipmentis provided in Table 6. An example for a preconditioned air system is provided in Table 7, based upon the following conditions:

a) Ambient air at 100° F (38° C) dB, 110 grains/lb moisture

b) System pressure drop = 0.5 psig (3.447 kPa)

c) Temperature gain, service point to aircraft = 2° F (16.6° C) dB

d) Supply fan of 44 brake horsepower, 90 percent efficient, 124,500 Btuh (36,478.5 W) heat gain each.

3.2 Starting Air System. The starting air systems shall comply with the requirements of NAVFAC DM-3.5 and NFGS-15487, Aircraft Fixed Point Utility Systems (Proposed). A compressor and auxiliary equipment shall be provided as a coordinated assembly by the air compressor manufacturer requiring a maximum of 30 BHP per 100 cfm (2.8 m^3/min) of intake air. Compressors shall operate satisfactorily, individually, or in parallel with any combination of other units. A compressor and compressed air system controls shall be provided to provide fully automatic operation.

3.2.1 Air Compressor and Auxiliaries. Air compressors and the auxiliary assembly shall be provided as defined in paras. 3.2.1.1. through 3.2.1.9.

3.2.1.1 Compressor. Two-stage, vertical or horizontal, cross-head type, single or double-acting, water-cooled, oil-free style shall be provided.

3.2.1.2 Intercooler. Air-cooled finned-tube coil or water-cooled type, directly or remotely attached to compressor.

3.2.1.3 Motor. V-belt drive, open-drip proof, squirrel-cage, electric motor rated 460 V, 3-phase, 60 Hz with 1.15 service factor.

3.2.1.4 Air Intake Filter Silencer. Dry-media type with disposable elements. Install filter silencer on compressor intake and design to attenuate intake noise to 84 dBA or less.

3.2.1.5 Aftercooler. (For warm climates above 85° F (29.4° C) design dry bulb.) Provide shell and tube water-cooled type mounted between compressor and air dryer. Furnish aftercooler with moisture separator, drain trap and sight flow indicator.

3.2.1.6 Aftercooler (Alternate). (For cool climates 85° F design dry bulb and below.) Provide horizontal or vertical draft finned tube heat exchanger with propeller type fan and electric motor all assembled on heavy-duty frame in a galvanized steel housing.

3.2.1.7 Oil Separator. Provide three-stage coalescing type with bolted and hinged access flange for removable filter media. The unit shall be installed between the system aftercooler and air dryer.

3.2.1.8 Refrigerated Air Dryer. Provide self-contained, commercial quality refrigeration system with moisture separator, condensate trap and all internal wiring and piping. Dryer shall be installed between oil separator and air receiver tank.

3.2.1.9 Cooling Water Assembly (For water-cooled aftercooler). Closed circuit type with continuous cooling water recirculation shall include evaporative cooling coil, centrifugal forced draft fan, recirculating spray pump, electric motor drives, mist eliminators, and interconnecting piping mounted on a common steel base.

3.2.1.10 Circulating Pumps. Circulating pumps shall be end-suction centrifugal type installed inside the central facilities building.

3.2.1.11 Controls. Compressors and compressed air system shall be furnished with completely factory-assembled control system. Control system shall provide automatic capacity control (load sequencing) and safety controls for warning and equipment protection. A freestanding cabinet type control panel shall be furnished and installed near the compressors.

3.2.2 Air Receiver Storage Tanks. Air receiver tanks shall be horizontal, cylindrical, welded steel tanks designed for 250 psig working pressure in accordance with Section VIII, Unfired Pressure Vessels, of the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code. Coat tank interiors with corrosion-resistant, chemically-inert material. Provide tanks with drain valve, automatic condensate trap, safety valve, air inlet and outlet connections, flanged manhole and support saddles. Tanks shall be installed adjacent to the central facilities building and provided with concrete pads and fabricated steel support saddles.

3.2.3 Miscellaneous Equipment and Piping. Miscellaneous equipment and piping shall be furnished, installed, tested and operated successfully. Piping systems and components shall conform to American National Standards Institute (ANSI) B31.1, Power Piping. All pipe, fittings, valves and accessories shall be of the proper type for pressure and temperature of each piping system. Joints for ferrous piping shall be flanged, screwed or welded. The piping system shall include the following:

3.2.3.1 Distribution System Pressure Control Valve. The pressure control valve shall reduce and maintain a constant system pressure of 125 psig (47.53 kPa).

3.2.3.2 Pressure Relief Valve. Pressure relief valve shall protect distribution system components from overpressure in excess of 140 psig (965.16 kPa).

3.2.3.3 Piping. Pipe shall be American Society for Testing and Materials (ASTM) A53, Grade B, carbon steel seamless Schedule 40 for sizes 2-1/2 in. (63.5 mm) and larger; Schedule 80 for sizes 2 in. (50.8 mm) and smaller. Refer to ASTM A53 Specifications for Pipe, Steel, Black and Hot Dipped, Zinc-Coated Welded, and Seamless.

3.2.3.4 Miscellaneous Equipment. Miscellaneous equipment at aircraft service points as itemized in Section 6.

3.2.4 Distribution System. Compressed air shall be distributed to hangar and parking apron in underground lines, with cathodic protection, in common trench with electrical duct bank. Compressed air distribution pressure shall be 125 psig (861.75 kPa) gauge at 60° F (15.5° C) . Pipe shall be of carbon steel welded construction with coal-tar or polyethylene coating, and shall be direct buried. Distribution header shall be run from central facilities to apron loop and connect isolated feeder lines to serve service islands.

3.3 Environmental Control Cooling Air System. The design of the environmental control cooling air system shall comply with the requirements of NAVFAC DM-3.03, DM-3.5 and NFGS-15487. Furnish compressor and auxiliary equipment as a coordinated assembly by the air compressor manufacturer requiring a maximum of 23 BHP for each 100 cfm (2.8 m^3/min) of intake air. Compressors shall operate satisfactorily, individually, or in parallel with any combination of other units. Furnish compressor and compressed air system controls to provide fully automatic operation.

3.3.1 Air Compressor and Auxiliaries. Compressors and the auxiliary assembly shall be provided as defined in paras. 3.3.1.1 through 3.3.1.10.

3.3.1.1 Compressor. Multiple-stage, water-cooled, oil-free style centrifugal or rotary screw type shall be provided.

3.3.1.2 Intercoolers and Aftercooler. Shell and tube water-cooled or air-cooled type with moisture separator and drain trap shall be provided.

3.3.1.3 Drive Motor. A 3,600 rpm, squirrel cage, induction motor for centrifugal compressor and 1,800 rpm, constant-speed, synchronous motor for rotary screw compressor shall be provided. A drip-proof electric motor rated 5,000 V, 3-phase, 60 Hz shall also be provided.

3.3.1.4 Air Intake Filter-Silencer. A two-stage, dry media type air intake filter silencer with disposable elements shall be provided. The filter shall be installed between outdoor weather-tight intake hood and compressor intake and shall be designed to attenuate noise.

3.3.1.5 Oil Separator. A three-stage coalescing type oil separator shall be provided with bolted and hinged access flange for removable filter media. The unit shall be installed between the compressor discharge and air dryer.

3.3.1.6 Refrigerated Air Dryer. A self-contained, commercial quality refrigeration system shall be provided with moisture separator, condensate trap and all internal wiring and piping. Install dryer between oil separator and main air line.

3.3.1.7 Cooling Water Assembly (Evaporative Type). A closed-circuit type with continuous cooling water recirculation and include evaporative cooling coil, centrifugal forced draft fan, recirculating spray pump, electric motor drives, mist eliminators, and interconnecting piping mounted on a common steel base.

3.3.1.8 Alternate Cooling Water Assembly. A radiator type cooling water assembly shall be used for climates of 80° F (27° C) and below. A closed-circuit type cooling water assembly shall be provided with continuous cooling water recirculation and horizontal air-cooled radiator type heat exchanger shall be provided. This assembly shall also provide propeller forced draft fans; a National Electrical Manufacturers Association (NEMA) Type 12 control cabinet housing all electrical controls; motor starters; transformers and relays; and interconnecting piping mounted on a common steel base. As an option, the cooling water assembly shall include a circulating pump completely piped and wired to an integral control cabinet.

3.3.1.9 Circulating Pumps. Circulating pumps of the end-suction centrifugal type shall be furnished and installed:

a) inside the central facilities building or

b) furnished as an integral component of the radiator type cooling water assembly.

3.3.1.10 Controls. Compressors and a compressed air system shall be provided with a completely factory-assembled control system. The control system shall provide automatic capacity control (load sequencing) and safety controls for warning and equipment protection. A freestanding cabinet type control panel shall also be provided and installed near the compressors.

3.3.2 Miscellaneous Equipment and Piping. Miscellaneous equipment and piping shall be furnished, installed, tested and successfully operated. Piping systems and components shall conform to ANSI B31.1. All pipe, fittings, valves and accessories shall be of the proper type for pressure and temperature of each piping system. Joints for ferrous piping shall be flanged, screwed or welded. Provide isolation valves and piping required to remove any major component for servicing during system operation. The piping system shall meet the following criteria:

a) Pipe shall conform to ASTM A53, Grade B, seamless carbon steel Schedule 40 for sizes 2-1/2 in. (63.5 mm) and larger, Schedule 80 for sizes 2 in. (51 mm) and smaller.

b) Miscellaneous equipment shall be provided at aircraft service points as itemized in Section 6.

3.3.3 Distribution System. Compressed air shall be distributed to hangar and parking apron in underground lines, with cathodic protection, in common trench with electrical duct bank. Compressed air distribution pressure shall be 100 psig (689.4 kPa) gauge at 60° F (16° C). Pipe shall be of carbon steel welded construction with coal-tar or polyethylene coating and shall be direct buried. Run distribution header from central facilities to apron loop and connect isolated feeder lines to serve service islands.

3.4 Preconditioned Cooling Air System. The preconditioned cooling air system shall comply with the requirements of NAVFAC DM-3.03, Heating, Ventilating, and Air Conditioning System, and NFGS-15487. The system shall provide fully automatic operation.

3.4.1 Air Handling Units. Air handling units shall be completely assembled products of a single manufacturer and shall be selected at the maximum efficiency range with components defined in paras. 3.4.1.1 through 3.4.1.2.

3.4.1.1 Supply Fan. A high-pressure blower, single-stage centrifugal type shall be provided.

3.4.1.2 Fan Motor. A 1,800-rpm, National Electrical Manufacturer's Association (NEMA) MG-1, Motors and Generators, dripproof, continuous-duty electric fan motor rated 460 V, 3-phase, 60 Hz shall be provided.

3.4.1.3 Cooling Coil. A fin-and-tube type for chilled water, conforming to Air-Conditioning and Refrigeration Institute (ARI) 410, Standard for Forced-Circulation Air-Cooling and Air-Heating Coils shall be provided

3.4.1.4 Filters. Extended-media (bag) type final filters shall be provided with replaceable (throw-away) prefilters, overall 85 percent efficiency, complete with pressure differential gauge to indicate dirty filters.

3.4.1.5 Casing. Minimum 12-gauge, galvanized steel, double wall casing with a minimum of 2-in. thick (51 mm) insulation between inner and outer panels.

3.4.2 Water Chillers and Auxiliaries. Water chillers and auxiliaries shall be provided as defined in paras. 3.4.2.1 through 3.4.2.5.

3.4.2.1 Water Chillers. Air-cooled, factory-assembled, one-piece, liquid chilling packages shall be provided in weathertight galvanized steel casings with reciprocating-type compressors, propeller condenser fans, and factory-wired capacity, safety and operating controls. The chiller shall have a minimum Energy-Efficiency Ratio (EER) of 7.5.

3.4.2.2 Circulating Pumps. Chilled water circulating pumps shall be end-suction centrifugal type installed inside the mechanical room.

3.4.2.3 Water Piping. Chilled water piping and fittings shall be:

ASTM A53, Grade B, Carbon Steel Schedule 40 with Flanged, Welded or Screwed Fittings. Steel piping is preferred but the following alternate materials are also acceptable:

ASTM B88, Type L, Hard Drawn Copper with Wrought Copper Fittings.

ASTM D1785 CPVC Pipe and Fittings.

3.4.2.4 Secondary Cooling Coils. Secondary cooling coils shall be fin-and-tube type for chilled water service contained in a high-pressure casing with drain pan.

3.4.2.5 Pipeline Accessories. Chilled water pipeline accessories shall include centrifugal air separator, expansion tank with air fitting, and chemical pot feeder. Insulate all chilled water piping with minimum 1-1/2 in. (38.1 mm) fiberglass or mineral wool with vapor barrier and aluminum jacket where installed outdoors. Provide isolation valves and piping required to remove any major component for servicing during system operation.

3.4.3 Air Distribution. Air Distribution shall be high-pressure round continuously welded spiral seam duct with flange joints suitable for operating pressure of system. Ductwork shall be insulated from secondary coil discharge to aircraft connection. The air distribution system shall include the following:

a) Supply air sound attenuator (duct silencer) capable of noise reduction of a minimum 20 dB at octave bands 4 and 5.

b) Butterfly type motorized control dampers with airtight seals.

c) Miscellaneous equipment at aircraft service points as itemized in Section 6.

3.4.4 Controls. A preconditioned air system shall be provided with completely automatic control system. Air handlers shall be energized by a system sequencing panel through service point control switches. Air volume capacity is controlled by modulating bypass dampers that maintain supply duct static pressure. The control system shall include a logic sequencing panel which determines the number of air handlers to run based upon the number of active service points. Controls shall lock out all other service points above the specified maximum to prevent system overload. Primary and secondary chilled water coils shall have two-position (ON-OFF) control valves energized by service point control switches and system sequencing panel to allow full circuit flow when cooling system is activated.

Variable water system pressure that occurs, depending upon the number of active secondary coils, is regulated by automatic flow control valves (pressure-compensating type) at each primary and secondary coil. Variable water system pressure is also regulated by a main header supply/return differential pressure-regulating valve that maintains constant system water flow through chillers and pumps by bypassing supply water to the return line when less than the maximum number of hangar service points are active.

3.5 60 Hz Electrical System. The electrical systems shall comply with the requirements of MIL-HDBK-1004/1, MIL-HDBK-1004/6, and the NAVFAC DM-4 Series. All system components shall be fully rated for the intended application.

3.5.1 Switchgear and Equipment. Switchgear and equipment power shall be obtained from the existing station distribution system, hangar, or adjacent buildings. The electrical service shall be designed for the total power required for building supports and the FPUS equipment. Provide primary, fused, switch protection; lightning protection; substation-type service transformer; underground service entrance; low-voltage switchgear; secondary metering; lighting and small power transformers and control panel.

Service supplied from the primary distribution system at the site shall provide a substation-type transformer (if required). Transformers shall have a delta-connected primary and grounded wye-connected secondary.

3.5.1.1 Switchgear Assembly. A 480 wye/277 V, 3-phase, 4-wire low-voltage switchgear assembly shall be provided for power distribution in the building. Supply motor control center, parking apron service islands, hangar service points from switchgear. A 25% spare capacity for future requirements shall also be provided.

A unitized 480 wye/277 V, 3-phase, 4-wire, 60 Hz motor control center shall be provided for compressors and auxiliaries, ventilating fans, unit heaters and 480-208 wye/120 V receptacle and small power transformer.

3.5.2 Distribution System. 60 Hz power shall be distributed to hangar and parking apron service points by underground main feeders supplied from the 480 V, 3-phase, low-voltage switchgear. Underground feeders shall be installed in concrete-encased, nonmetallic duct banks in accordance with NFGS-16301, Underground Electrical Work.

3.5.2.1 Main Feeders. Main feeders shall be 480 V, 3-phase, 3-wire with color-coded, insulated, grounding conductor. Conductors shall be sized according to criteria unit demand with diversity applied for the number of service points connected (see Figure 2). Main feeders shall supply subfeeder circuit breakers located in parking apron distribution boxes. Subfeeder circuit breakers shall be rated 600 V, 225 A, 3-pole.

3.5.3 Aircraft Grounding Point Requirements. Aircraft grounding points shall be provided as required by NAVAIR. Locations to be coordinated with NAVAIR requirements. Refer to CNATRA Instructions 11130.2C dated 19 August 1987.

3.6 400 Hz Electrical System. The 400 Hz electrical system shall supply aircraft electrical power requirements from motor-generator type frequency converters and utilization equipment as described in NAVFAC DM-4.05. The system design shall provide for no-load to full-load voltage variations which are within the requirements of MIL-STD-704, Aircraft Electric Power Characteristics.

3.6.1 Metal Enclosed Switchgear. Provide 5 kV metal-enclosed switchgear assembly for the distributon of the 4,160 V, 3-phase, 400 Hz power. The switchgear shall be a completely factory-wired assembly with incoming fused switches, and outgoing circuit breakers, instruments, and instrument transformers. The enclosure shall be freestanding, self-supporting units. The switches shall be 3-pole, group operated, interrupter switches. The assembly shall include common main bus and grounding bus and be fully rated for the intended service.

3.6.2 Utilization Transformers, Auxiliaries, and Protection Devices. Provide 200 wye to 115 V, 3-phase, 400 Hz stepdown transformers at each service apron and hangar (refer to NAVFAC DM-4.05, and Figure 8).

3.6.2.1 Transformers, General. Transformers and auxiliaries shall be in accordance with NAVFAC NFGS-16492, Motor Generator Sets, 400 Hz, January 1987, and shall be supplied with secondary, shunt-connected harmonic filters, line drop compensators and circuit protection. Primary protection shall be a fused air interruptor switch or a vacuum-type contactor. Transformers shall be sized to serve two aircraft positions with criteria demand and diversity applied.

3.6.2.2 Transformers for Parking Apron Service Point. Transformers for parking apron service point installation shall be waterproof, epoxy encapsulated, dry type transformers. Enclosure shall be of welded steel plate construction with gasket sealed, bolted cover.

3.6.2.3 Transformers for Installation in Hangars. Transformers for installation in hangars shall be dry-type or cast resin type units, installed as required by the 1987 National Electrical Code. The enclosure assemblies shall include secondary bus with contactors and overload protection for two 400 Hz, 200 wye/115 V aircraft services (see Figures 8 and 9).

3.6.3 Distribution System. 400 Hz power shall be distributed to hangar and parking apron service points by feeders supplied from the metal enclosed switchgear in accordance with NAVFAC DM-4.05. Conductors shall be sized according to criteria unit demands with diversity applied for the number of aircraft served (see Figure 2).

Section 4: CENTRAL FACILITIES BUILDING

4.1 General. The function of the FPUS central facilities is to provide a common source of supply for aircraft utilities and to provide protective shelter for the maintenance and repair of the central equipment. Emphasis shall be placed on siting to permit FPUS planning as described in para. 2.2.1. Refer to MIL-HDBK-1028/1, Aircraft Maintenance Facilities, for criteria and requirements.

4.2 Building. The building shall be a prefabricated metal building of modular design. For consideration of prefabricated structures, refer to NAVFAC DM-1 series. The materials selected shall conform to 25-year economic life considerations for an industrial type building. The design shall include requirements for fire protection. In specific site locations where seismic forces are encountered, selection of materials and designs shall be in accordance with NAVFAC P-355, Seismic Design for Buildings.

4.2.1 Restrictions on the Use of Aluminum. Aluminum roofing and/or siding shall not be specified for structures located on or near the sea coast where the monthly rainfall is inadequate to keep surfaces washed clean and free from salt deposits or incrustation due to onshore winds and salt-laden atmosphere. Consideration shall be given to corrosion of aluminum on interior building surfaces. Aluminum surfaces shall be isolated from incompatible metals or material preservatives and masonry or concrete surfaces by treating with a heavy coat of alkali-resistant paint or by other approved means.

4.2.2 Architectural Requirements. Space allocations shall provide for flexible and economical equipment additions and/or an orderly expansion of the building. Space configuration shall be as required for the proper maintenance of the equipment to be installed and shall allow the installation of a monorail and traveling hoist to be installed under the roof framing in the approximate center of the building. The building design shall provide toilet facilities and heating, ventilating and lighting equipment necessary for a proper working environment.

4.2.2.1 Walls. Sidewalls shall be of preformed, protected sheetmetal panels with blanket insulation with vapor barrier on interior side. Liner panels of preformed, protected sheet metal shall be furnished for all interior wall areas.

4.2.2.2 Roof. The roof shall be of preformed, protected sheetmetal panels with blanket insulation and vapor barrier on interior side (exposed ceiling).

4.2.2.3 Floors. Floors shall be concrete, finished using a wood float (making certain all laitance is removed), and then surface-treated with a liquid chemical curing-sealing compound.

4.2.2.4 Entrances. The building shall have an entrance at each end consisting of a pair of flush hollow metal doors. Entrances shall have a concrete apron raised slightly above the finished grade.

4.2.2.5 Rooms. Separate rooms shall be provided for the mechanical systems and electrical switchgear in conformance with National Fire Protection Association (NFPA) Electrical Code, NFPA 70.

4.2.2.6 Floor Trenches. Floor trenches with removable steel covers shall be provided for compressed air piping and electrical conduits. The floor trenches shall be arranged to accommodate the compressed air, and the 4,160-V switchgear connections and to provide underfloor egress for the FPUS underground mains. The trench floor shall be sloped to drains provided at each end.

4.2.3 Structural Requirements. Structural designs shall be based on local live-load conditions, wind loading and seismic conditions as governed by criteria for the specific site location. Local site frost lines and soil bearing capability shall be incorporated in the design. Refer to NAVFAC DM-2 series, Structural Engineering, for criteria and requirements.

4.2.3.1 Foundations. Generally, shallow spread footing foundations shall be used. The site soil conditions, however, could necessitate investigation of alternate type foundation systems. The exterior foundation system shall be a grade beam continuous over spread footings or pile caps, as required, at the building columns.

4.2.3.2 Building Frame. The building shall be of rigid frame, construction clear spanning the building width. The roof system shall have a slope of 2 in. (51 mm) vertical to 12 in. (305 mm) horizontal. Framing shall include roof purlins and wall girts. The structure shall support a monorail and traveling hoist with a 2,000 lb. (906 kg) capacity in the overhead space without interior columns.

4.2.3.3 Floor Structures. Floor shall be reinforced concrete slab-on-grade with a design to support the appropriate equipment and forklift wheel loads.

4.2.3.4 Equipment Pads. Equipment pads shall be of reinforced concrete and shall be a minimum of 6 in. (152 mm) thick and designed to accommodate the particular equipment base. Pads for air compressors shall be isolated from floor slabs.

4.2.4 Mechanical Requirements. The mechanical systems shall comply with the standards specified in NAVFAC DM-3 series, Mechanical Engineering, and as defined in paras. 4.2.4.1 through 4.2.4.3.

4.2.4.1 Plumbing System. The facilities design criteria shall be as required by NAVFAC DM-3.01 Plumbing Systems, and shall provide for standard plumbing for toilet, floor and floor trench drains. Drinking fountains shall be provided.

4.2.4.2 Heating System. Building heating shall be as prescribed by NAVFAC DM-3.03, Heating, Ventilating, Air Conditioning, and Dehumidifying Systems, provided by thermostatically controlled electrical, overhead, unit heaters. Capacity shall provide a minimum 65° F (18.3° C) space temperature. Equipment heat shall not be credited to heating load.

4.2.4.3 Ventilation System. Ventilation shall be provided with wall-mounted exhaust fans and opposite wall intake louvers. Ventilation shall be as required by NAVFAC DM-3.03 for both building and full equipment heat loads and sized to limit indoor/outdoor temperature differential to a maximum 10° F (-12° C) during summer season.

4.2.5 Electrical Requirements. The electrical systems shall comply with the standard requirements of NAVFAC DM-4 series on electrical engineering. All components shall be rated for system application. See Figures 8 and 9 for electrical equipment details.

Provide dry-type, 480-208 wye/120 V, 3-phase transformer with delta-connected primary and 3-phase, 4-wire distribution panel for convenience and small power supply.

Provide convenience outlets (grounding type duplex receptacles) every 30 ft (9 m) of wall space.

4.2.5.1 Lighting. A 208 wye/120 or 277 wye/480 V lighting system shall be provided meeting the following criteria:.

a) Lighting Fixtures - refer to NAVFAC NFGS-16530, Lighting, Exterior, for additional information.

b) Lighting Levels - provide a lighting level in accordance with MIL-HDBK-1004/4, Electrical Utilization Systems.

4.2.5.2 Communications. Telephone, service entrance telephone cabinet, conduit runs, and telephone closet.

Section 5: FEEDER DISTRIBUTION CENTTERS

5.1 Electrical Distribution. Provide pad-mounted enclosures for 60 Hz and 400 Hz equipment including transformers, switchgear, and associated devices (see Figure 10). Outdoor units shall be NEMA type IV for parking apron. Hangar units shall be NEMA Type I. Refer to Section 2, para. 2.1.5 of this handbook for physical location criteria (see Figure 7 for additional details).

Section 6: UNDERGROUND INSTALLATIONS

6.1 Mains and Feeders. Fixed point-utility services shall be distributed to the hangar and parking apron in underground mains. The mains shall be installed in the same trench with access at the transition gate boxes. The routing of mains between the central facilities and the gate boxes shall be outside the apron and taxiway concrete as much as possible. All underground installation, including distribution box designs, shall conform to the requirements of NAVFAC DM-2 series and NAVFAC DM-21.

6.1.1 Compressed Air Piping. Underground compressed air piping shall be carbon steel welded construction with a coal-tar or polyethylene coating. Pipe shall be laid on a 6 in. (152 mm) sand base with granular backfill. Horizontal and vertical alignment shall be maintained. Entrances to service islands shall be through sleeves with link seals. Underground piping shall have cathodic protection.

6.1.2 Electrical Duct Banks. Electrical conduit shall be nonmetallic installed in concrete encased duct banks in accordance with NAVFAC NFGS-16301.

6.2 Service Access Points. Access to compressed air line valving shall be provided through flush-mounted valve boxes, valving shall provide isolation for line segments as indicated in Figure 1. Electrical feeders shall be terminated in feeder distribution centers and service point enclosures.

6.2.1 Valve Boxes. Compressed air shutoff valves on underground main loop and branch piping shall be installed in valve boxes flush with grade, with flush-mounted removable cast-iron covers.

Section 7: AIRCRAFT SERVICE POINTS

7.1 Parking Apron Service Points. The function of the service point is to dispense compressed air and electrical services for aircraft ground support on the parking apron. Each island serves two aircraft. For details of construction and equipment installations see Figures 8, 9, 13, and 14.

7.1.1 Construction. Service points shall have low profile design structures fabricated of steel angle frame with sheet steel side panel enclosures. Top panels are of one-piece formed aluminum and bolted to the frame. The enclosure is vented at top and bottom. The assembly is mounted on a concrete base pad approximately 6 in. (152 mm) above the apron grade. Service point structures shall be protected from vehicular traffic with concrete-embedded steel posts.

7.1.2 Mechanical Equipment Components. Compressed air piping and appurtenances shall be contained in rear half of the superstructure. Each island is served by a 3 in. (76 mm) line from the underground main. A 3 in. main shutoff valve shall be provided with moisture blow-off valves before and after. A 3 in. main pressure-reducing valve provided 45 psig (310.26 kPa) (75-psig (517.11 kPa) for F-4J) supply to a 3 in. flexible hose connector mounted externally on the end of the enclosure. Flexible aircraft starting air hose (Government-furnished equipment) is attached to the swivel joint. A pressure switch is provided at the outlet of the pressure-reducing valve which activates a low pressure warning light mounted on the exterior of the enclosure. The pneumatic tool air is supplied by connection to the 3 in. service line before the main pressure reducing valve. The tool air piping shall contain the following:

a) Shutoff valve (V1),

b) Pneumatic tool filter (F2),

c) 90-psig (620.53 kPa) pneumatic tool-air and pressure regulator (V15),

d) Pneumatic tool lubricator (M3), and

e) Two pneumatic tool quick-connectors mounted externally on the end of the enclosure (M-1).

The following items shall be provided and mounted on exterior side of the enclosure (see Figures 14, 15, and 16 for mechanical system details):

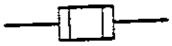
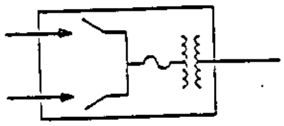
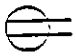
a) main shutoff valve operating handle (V1),

b) pressure gauge (supply air inlet to regulator),

c) pressure gauge (starting air connection),

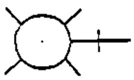
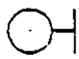
d) Main blow-off valve operator,

e) Strainer blow-off valve operator, and

SYMBOL	DEVICE
	FUSE
	SUBSTATION
	DRAWOUT CIRCUIT BREAKER
	CONTACTOR
LDC	LINE DROP COMPENSATOR
	AIR CIRCUIT BREAKER
	RECEPTACLE, CLASS L, 100A 3P, 480V
HFA	HARMONIC FILTER ASSEMBLY (HFA)
	RECEPTACLE, 120V, GFI WEATHERPROOF TYPE
TV	TRANSFORMER VAULT
T_1	TRANSFORMER 1 PHASE 120 V 60 HZ
T_4	TRANSFORMER 3 PHASE 400 HZ 200 - 115 V

TITLE	DATE	PLATE NO.	SHEET NO.
F.P.U.S. ELECTRICAL SYMBOLS	DEC. 86	149-15	11

Figure 11
FPUS Electrical Symbols

SYMBOL	DEVICE
O 	OBSTRUCTION LIGHT
P.E. CELL 	PHOTOCELL
	RED INDICATING LIGHT FOR ON POSITION
	CONTROL RELAY 120 VOLT AC
	GREEN INDICATING LIGHT FOR OFF POSITION
GSE	GROUND SUPPORT EQUIPMENT

TITLE	DATE	PLATE NO.	SHEET NO.
F.P.U.S. ELECTRICAL SYMBOLS	DEC. 86	149-15	12

Figure 12
FPUS Electrical Symbols

SYMBOL	COMPONENT DESCRIPTION
V1	MAIN SHUT-OFF VALVE. 3" BUTTERFLY VALVE. 200 PSI RATED, ALUMINUM-BRONZE DISC AND METAL-REINFORCED BUNA-N CARTRIDGE SEAT (FOR BUBBLE-TIGHT SEAL). ONE PIECE SHAFT. LUGGED BODY. WITH EXTENSION SHAFT AND MIN. 8-POSITION LOCKING LEVER OPERATOR. MIN. FLOW 2700 SCFM AT 90 PSIG, WITH 2 PSI PRESSURE DROP.
V2	MAIN CONTROL VALVE. 3" AXIAL FLOW VALVE WITH NITRILE RUBBER SEALING SLEEVE. CLASS 150 (MAX. PRESSURE 250 PSIG OR GREATER). MIN. FLOW 2700 SCFM AT 90 PSIG IN, 78 PSIG OUT. WITH BOLTING SET FOR MOUNTING BETWEEN FLANGES.
V3	OUTPUT PRESSURE SELECTOR VALVE. THREE-WAY BALL VALVE. 3/8" NPT PORTS, BRASS CONSTRUCTION, PANEL-MOUNTED WITH BLACK NYLON OR METAL LEVER HANDLE. MIN. C_v=2.0.
V4	OUTPUT BLOWDOWN VALVE. TWO-WAY, TWO PORT SPOOL VALVE. BRONZE. WITH AIR PILOT AND SPRING RETURN. 1-INCH NPT PORTS. C_v MIN.=8.0. WITH EXHAUST MUFFLER.
V5	START CONTROL VALVE. TWO-WAY, TWO PORT SPOOL VALVE. WITH PALM BUTTON OPERATOR AND SPRING RETURN. BRONZE. FOR PANEL MOUNTING. 1/4" NPT PORTS. C_v MIN.=1.2. NORMALLY CLOSED.
V6	STOP CONTROL VALVE. THREE-WAY TWO-OUTLET BRONZE SPOOL VALVE. WITH PALM BUTTON OPERATOR AND SPRING RETURN. FOR PANEL MOUNTING. 1/4" NPT PORTS. C_v MIN.=1.2.
V7	START CONROL LATCH VALVE. THREE-WAY, TWO-OUTLET BRONZE SPOOL VALVE. WITH AIR PILOT AND SPRING RETURN. 1/4" NPT PORTS. C_v MIN. =1.2.
V8	START LATCH SHUTTLE VALVE. TWO-INLET, ONE-OUTLET, BRASS OR SS SHUTTLE VALVE. 3/8" NPT PORTS. C_v MIN. =1.2.
V9	OPENING SPEED CONTROL VALVE. MICROMETER ADJUST NEEDLE VALVE. 1/4" NPT PORTS, BRASS W/SS TRIM, BUNA-N SEALS. WIDE OPEN C_v=0.60.
V10	CLOSING SPEED CONTROL VALVE. SIMILAR TO V9. 3/8" NPT PORTS. MIN. C_v=0.60.
V11	START-LOCKOUT PRESSURE ADJUSTMENT VALVE. SIMILAR TO V9, 1/4" NPT PORTS. MIN C_v=0.30.
V12	PRIMARY REGULATOR ISOLATION AND EXHAUST VALVE. THREE-WAY, TWO-OUTLET BRONZE SPOOL VALVE, WITH AIR PILOT AND SPRING RETURN. 1/4" NPT PORTS. C_v MIN.=1.2.
V13	BLOW-OFF VALVE
V14	UTILITY AIR SHUT-OFF VALVE. 1/2" NPT BRONZE BALL VALVE. WITH LEVER HANDLE. WIDE OPEN C_v=9.0.
V15	UTILITY AIR PRESSURE REGULATOR. 100 SCFM AT 130 PSIG INLET. 5PSI PRESSURE DROP. SPRING-LOADED DIAPHRAGM TYPE. ADJUSTABLE. NON-BLEED, RELIEVING.
V16	CONTROL TRAY SUPPLY AIR ISOLATION VALVE. SAME AS V14, ONLY 3/4".
V17	OUTPUT LINE SURGE RELIEF VALVE. SET 90 PSIG, DISCHARGE 1200 SCFM TO ATOMSPHERE AT 100 PSIG. 2" NPT.
V18	PRIMARY PRESSURE REGULATOR (FOR V2). AIR LOADED. 1" CAST IRON BODY, NEOPRENE DIAPHRAGM, BUNA-N VALVE DISC. HIGH PRESSURE VERSION, 1/4" ORIFICE.

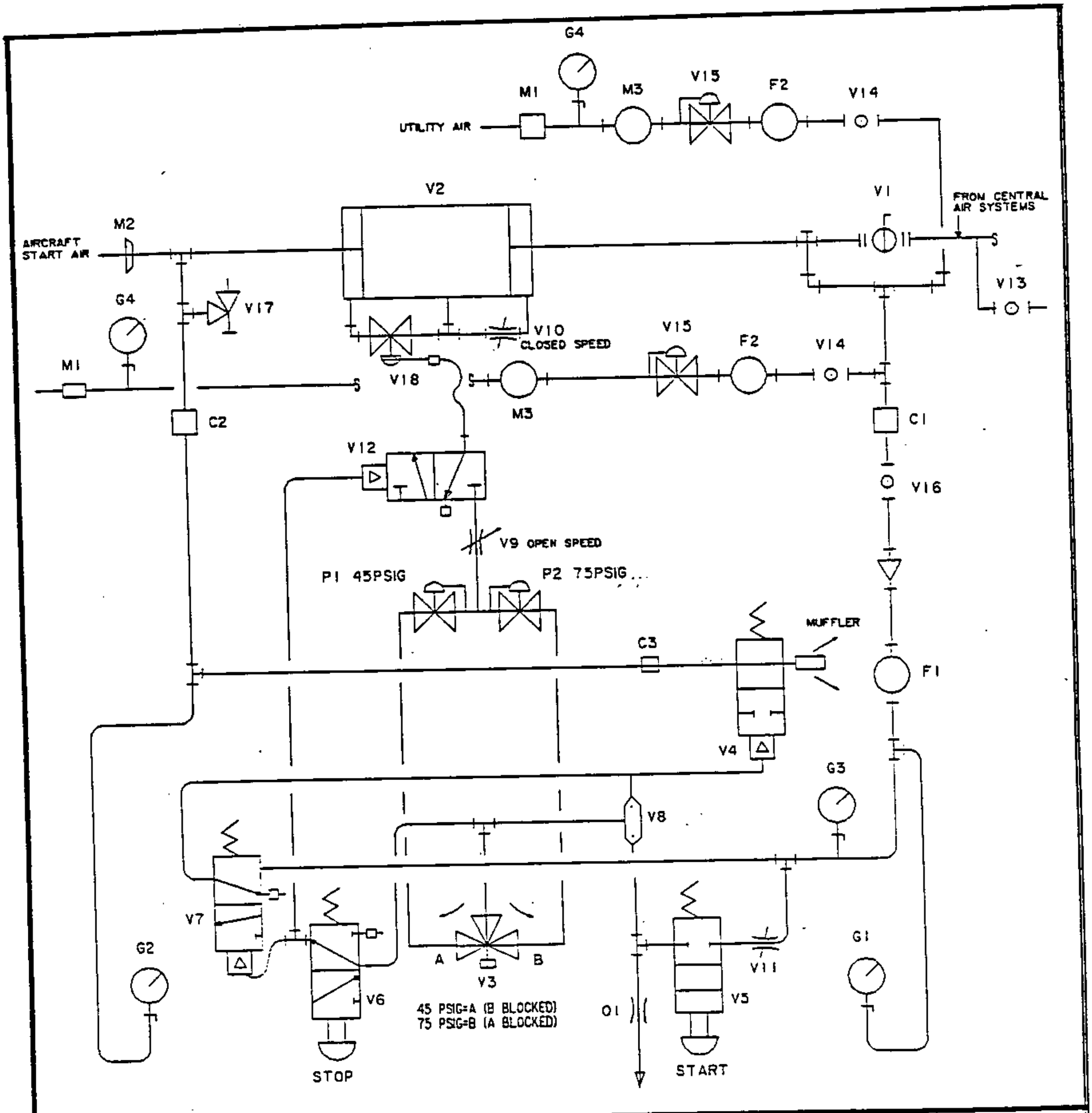
TITLE	DATE	PLATE NO.	SHEET NO.
AIRCRAFT SERVICE MECHANICAL SYMBOLS	MAR 87	149-15	13

Figure 13
Aircraft Service Mechanical Symbols

SYMBOL	COMPONENT DESCRIPTION
F1	UTILITY AIR FILTER. 100 SCFM AT 125 PSIG, WITH 5 PSI INITIAL PRESSURE DROP, METAL BOWL, AUTO DRAINER. 1/2" NPT PORTS. 5 MICRON ELEMENT.
F2	CONTROL AIR FILTER. 50 SCFM AT 100 PSIG WITH 5 PSI INITIAL PRESSURE DROP, METAL BOWL, AUTO DRAINER. 1/2" NPT PORTS. 5 MICRON ELEMENT.
C1	CONTROL TRAY SUPPLY AIR CONNECTOR. GALVANIZED MALLEABLE IRON PIPE UNION, 150 POUND, BRASS SEAT, NUT TYPE WITH BUNA-N O-RING. 3/4" NPT.
C2	CONTROL TRAY SENSING/BLOWDOWN CONNECTOR. 1" NPT.
C3	V4 CONNECTOR. 1" NPT.
M1	UTILITY AIR OUTPUT CONNECTOR. 100 SCFM AT 7 PSIG (MAX.) PRESSURE DROP. 120 PSIG. 1/2" MALE PT. BRASS AND SS CONSTRUCTION.
M2	CONSOLE OUTPUT AIR LINE CONNECTOR. 3" FLEXIBLE HOSE CONNECTION POINT.
M3	AIR LUBRICATOR. 90 SCFM AT 125 PSIG, 11 OZ. METAL BOWL, DIE CAST ZINC ALLOY BODY, FLEXIBLE PARTS ARE OF BUNA-N OR POLYURETHANE.
P1	45 PSIG OUTPUT PRESSURE PILOT (FOR V18). 1/4" NPT GENERAL PURPOSE AIR PRESSURE REGULATOR, RELIEVING TYPE, ADJUSTABLE SPRING LOADING, DIAPHRAGM TYPE, SAFE WORKING PRESSURE 200 PSIG OR HIGHER, CAST METAL BODY.
P2	75 PSIG OUTPUT PRESSURE PILOT (FOR V18). SAME AS P1
O1	START CONTROL BLEED ORIFICE. 1/4" NPT BRASS PIPE PLUG, DRILLED ON CENTERLINE 0.10".
G1	AIR MAIN PRESSURE GAUGE. 4" DIAL, 0-200 PSIG, PANEL MOUNTED, BACK CONNECTED, 1/4" NPT CONNECTION, POLYAMID OR SS CASE, SAFETY GLASS LENS, ADJUSTABLE POINTER, WATERTIGHT CASE.
G2	OUTPUT AIR PRESSURE GAUGE. SAME AS G-1 EXCEPT 0-100 PSIG.
G3	START LOCKOUT PRESSURE ADJUSTMENT GAUGE. 2-1/2" DIAL, 0-200 PSIG, 1/4" NPT BOTTOM CONNECTION, SS CASE, SAFETY GLASS LENS, WATER-TIGHT CASE.
G4	UTILITY AIR PRESSURE GAUGE. 2-1/2" DIAL, 0-200 PSIG, REAR FLANGE, 1/4" NPT BACK CONNECTION. SS CASE WITH SAFETY GLASS LENS.

TITLE	DATE	PLATE NO.	SHEET NO.
AIRCRAFT SERVICE MECHANICAL SYMBOLS	MAR 87	149-15	14

Figure 13 (Continued)
Aircraft Service Mechanical Symbols



TITLE	DATE	PLATE NO.	SHEET NO.
AIRCRAFT SERVICE CONSOLE SCHEMATIC	MAR-87	149-15	15

Figure 14
FPUS Mechanical Schematic

f) Tool-air shutoff valve operator.

7.1.3 Electrical Equipment Components. Electrical apparatus and service connection shall be contained in the forward half of the enclosure. Each point shall be served by a 3-phase, 3-wire, 400 Hz distribution feeder from a vault or a feeder distribution center. Provide a 200 wye/115 V, 3-phase, 4-wire transformer, and a 480 V, 3-phase, 3-wire, 60 Hz feeder.

7.1.3.1 400 Hz Components. The 400-Hz components shall be as follows:

a) Contactors shall have an aluminum enclosure and shall be mounted on the interior of the enclosure panel. Contactors shall be furnished with lugs for connection of the 4-wire, size 2 AWG conductor, flexible aircraft power cable that conforms to MIL-STD-90328, Cable Assembly External Electrical Power, Aircraft 115/200 V, 400 Hz (Government-furnished equipment). Cable grips and neoprene grommets for enclosure sidewall openings shall be provided for the direct (hard-wired) connection of the aircraft power cable to the contactor. Contactors shall have 120 V operating coil and control circuits. Contactors shall have one normally open and one normally closed auxiliary contact.

b) Two-position (on-off) weatherproof selector switches mounted on the exterior of the enclosure (on the side of the associated contactor) for control of 400 Hz.

c) Each contactor shall have two weatherproof pilot lights, one marked "Power On" with red lens and one "Power Off" with green lens mounted on exterior of the enclosure (on the side of the associated contactor).

7.1.3.2 60 Hz Components. The 60 Hz Components (see Figure 8) shall be as follows:

a) Two 100 A, 3-pole, 600 V, 60 Hz, molded case circuit breakers, one breaker shall be mounted on the interior of each side panel.

b) Two 100 A, 480 V, 3-phase, 4-wire, 60 Hz receptacles conforming to MIL-C-22992 (Class L) and MS90555-C-44-150S (Government-furnished equipment). This receptacle will match cable plugs MS90556C-44-151P, MS905556-C-44-152P or MS90556-C-44-156P provided with the ground support equipment. One receptacle shall be mounted on the exterior of each side panel.

c) One 1-phase, 3-kVA, 480-120 V, 60 Hz, dry-type transformer with 2-pole primary circuit breaker and a 1-pole, 20-A secondary breaker. The transformer shall provide power for control, 120 V receptacles and obstruction lights. The transformer and the protecting breakers shall be mounted on the interior sheet steel barrier between the mechanical and electrical sections.

d) Two 20 A, 125 V, 1-phase, 2-pole, 3-wire, 60 Hz, weatherproof receptacles with ground-fault interrupting. One recepetacle shall be mounted on each of the exterior side panels.

e) Two obstruction warning light fixtures shall be furnished for each service point enclosure. Fixtures shall consist of cast aluminum body for bracket mounting and with a red fresnel globe. Lamps shall be type

116A21/TS, 117 W, 120 V, 60 Hz. Fail-safe photoelectric control shall be provided for fixtures at each service island. Fixtures shall be mounted near opposite corners of the superstructure.

f) One low-air-pressure warning light shall be mounted on exterior panel adjacent to pressure gauge.

Section 8: HANGAR SERVICE POINTS

8.1 Hangar Service Points. The function of the service points is to dispense compressed air, preconditioned air, and electrical services for aircraft maintenance in the hangar space. Service points shall be located near the center of each two aircraft spaces and shall provide service for two aircraft. (Service points shall be installed on hangar fire wall at a minimum of 18 in. (457 mm) above hangar finished floor. Conduits entering this area from below are to have seal fittings.

If fire lanes are not provided along fire wall, markings shall be provided on the hangar floor to define a 5-ft (1.5 m) minimum radius about the service points. Aircraft extremities shall not extend into the marked zones. Signs warning of hazardous zones shall be furnished and installed above each service point. Signs shall read: "Warning - keep aircraft engine and fuel tank areas outside of marked zones." All installation in the high bay area shall be in accordance with the requirements of the National Electrical Code. For detail of enclosure and equipment installations see Figures 8 and 9.

8.1.1 Construction. Hangar service points shall have wall-mounted, formed-sheet aluminum enclosures for electrical equipment. The enclosure shall have hinged and gasketed access doors. Compressed-air apparatus shall be mounted on sheet steel structural support board attached to a steel channel wall bracket.

8.1.2 Compressed Air Equipment Components. Compressed-air piping and appurtenances shall be wall-mounted adjacent to the electrical apparatus at each service point. Each service point shall be provided with a 1-in. (25.4 mm) air supply line from the 2-in. (51 mm) hangar main. Each service point shall contain the following:

a) two 1/2-in. (38 mm) needle valve shutoffs,

b) two pneumatic tool filters,

c) two 90-psig (620.52 kPa) pressure regulators,

d) two pneumatic tool lubricators,

e) four pneumatic tool quick-connectors, and

f) two wall-mounted hose racks (tool air hoses are Government-furnished equipment).

8.1.3 Preconditioned Air Equipment Components. Preconditioned air service drop from secondary coils shall have 75-ft (22.86 m) length of 8-in. (203.2 mm) flexible duct looped over wall-mounted rack. Each service point shall have the following:

a) One 8-in. motorized shutoff valve,

b) One service selector switch in NEMA 1 enclosure,

c) One wall-mounted hose rack, and

d) One 75 ft (23 m) length of 8 in. insulated flexible duct (aircraft connections are Government-furnished equipment).

8.1.4 Preconditioned Air Equipment Components (Alternate). Preconditioned air service drop from secondary coils shall extend from secondary coils down fire wall near compressed air apparatus and under the deck in polyvinyl chloride (PVC) conduit to service pit mounted flush with deck (1-in. drainage runoff lip) near center of hangar or aircraft service point. Ductwork installed below deck shall be high-pressure preinsulated flexible duct. The end 10 ft (3.05 m) section shall be spring-loaded, self-storing type to assist replacement in pit after use. Each service point shall have the following:

a) one 8 in. motorized shutoff valve (at fire wall),

b) one service selector switch in NEMA 1 enclosure (at fire wall),

c) one length as required 8 in. high-pressure preinsulated flexible duct,

d) one 10 ft (3.05 m) length, 8 in. high-pressure preinsulated flexible duct-spring loaded type,

e) one length as required 10 in. (254 mm) PVC conduit with long radius sweep-type elbows and 2 in. drainage tap at low point,

f) one elastomeric boot seal to connect metal duct drop to flexible duct and conduit, and

g) one fiberglass service pit with cast aluminum removable pit cover and access door for preconditioned air duct (Aircraft coupler is Government-furnished equipment.).

The PVC conduit for the underground flexible duct shall have provision for drainage which shall be collected in common drain header and routed to plumbing sanitary or storm sewer as required by local code.

8.1.5 Electrical System Components. Service Points shall contain 60 Hz and 400 Hz componenets as follows:

8.1.5.1 400 Hz Components. The 400 Hz components shall consist of:

a) Transformer, 575-200 wye to 115 V, 400 Hz. Select transformer kVa to match aircraft (refer to Table 1).

b) two 100 A, 3-pole, 600 V, electrically operated contactors with 3-phase overload protection. Contactors shall be mounted in electrical equipment enclosure. Contactor shall be furnished with lugs for connections of 4-wire, size 2 AWG conductor flexible aircraft load cable (Government-furnished equipment). Cable grips and neoprene grommets for enclosure openings shall be provided for the direct (hard-wired) connection of the aircraft power cable to the contactor. Contactors shall have 120 V operating coil and control circuits. Contactor shall have one normally open and one normally closed auxiliary contact.

c) Two 2-position (on-off) weatherproof selector switches mounted on the exterior of the enclosure front hinged panel (on the side of the associated contactor) for 400 Hz control.

NOTE: Each contactor shall have two pilot lights, one marked "Power On" with red lens and one "Power Off" with green lens mounted on the exterior of the front hinged panel of the associated contactor.

8.1.5.2 60 Hz Components. The 60 Hz components shall consist of:

a) Two 100 A, 3-pole, 600 V, 60 Hz, molded case circuit breakers mounted on the interior of the enclosure.

b) Two 100 A, 480 V, 3-phase, 4-wire, 60 Hz receptacles conforming to MIL-C-22992 (Class L) and MS90555-C-44-150S (Government-furnished equipment). This receptacle will match cable plugs MS90556C-44-151P, MS90556-C-44-152P or MS90556-C-44-156P provided with the ground support equipment. Receptacles shall be mounted on the bottom exterior of the enclosure. Provide additional receptacles to match aircraft requirements.

c) One 1-phase, 3 kVA, 480-120 V, 60 Hz, dry type transformer with 2-pole primary circuit breaker and a 1-pole, 20 A secondary breaker. The transformer shall provide power for control and 120 V receptacles. The transformer and the protecting breakers shall be mounted on the interior of the electrical enclosure.

d) Two 20 A, 125 V, 1-phase, 2-pole, 3-wire, duplex receptacles with ground fault interrupting. One receptacle shall be mounted on each of the exterior center, hinged panels.

Section 9: ELECTRICAL SYMBOLS (FPUS)

Electrical equipment symbols for the Fixed Point Electrical Distribution system are shown on Figures 11 and 12. These symbols are filed in the NAVFAC GEMS system.

Section 10: FPUS MECHANICAL SYMBOLS

Mechanical equipment symbols for the Fixed Point system are shown on Figures 13 and 14.

APPENDIX A
METRIC EQUIVALENT CHART

The following metric equivalents are approximate and were developed in accordance with ASTM E380 and ASTM E621.

English (yd)		Metric (m)
7,000	6	401
1,700	1	554

English (ft)	Metric (m)
1,200	366
500	152
200	61
50	15

English (ft)		Metric (mm)
70		21 325
48	14	625
24	7	325
20	6	100
12	3	660
10	3	000
8	2	450
6	1	850
5	1	500
4	1	220
3		915
1		305

English (in.)	Metric (mm)	
2,000	50	800
	70	1,775
	36	1,000
	30	750
	26	660
	25	625
	20	500
	18	450
	12	300
	8	200
	6	150
	4	100
	2	50
	1	25
	3/4	20
	1/4	6
	1/16	2

APPENDIX A (Continued)

English (ft^2)	Metric (m^2)
450	1.8
150	3.95
1	0.093

English (fpm)	Metric (m/s)
75	.381
60	.305
50	.250

English (cfm)	Metric m^3/s)
150	.0708
50	.0236
40	.0189
7.5	.0035
1	.0005

English (lb)	Metric (kg)
18,000	8,165
2,000 (6 T)	5,443
10,000 (5 T)	4,536
6,000 (3 T)	2,725
4,000 (2 T)	1,814
3,000	1,361
2,000 (1 T)	907
500	230

English (lb/hr)	Metric (kg/s)
200	0.0252

English (psf)	Metric (Pa)
300	14,364
100	4,788

APPENDIX A (Continued)

English (psi)	Metric (Pa)
4,000	27,579,200
125	861,850
100	689,480
90	620,532
60	413,688
30	206,844

(Inch of Water at 39.2°F)

English	Metric (Pa)
0.10	24.91

English (° F)	Metric (° C)
85	29
75	24
65	18
25	– 4
	–10
	–23

English (Footcandles)	Metric (lux)
70	753.5
50	538.2
30	322.9
2	21.5

BIBLIOGRAPHY

Military Standard

MIL-STD-461A Electromagnetic Interference Characteristics, Requirements for Equipment

MIL-STD-25486 Connector Plug, Attachable External Electrical Power Aircraft, 115/200 V, 400-Hz

National Institute for Occupational Safety and Health Publication

Thomas L. Anania, Joseph A. Seta, Lead Exposure and Design Consideration for Indoor Firing Ranges

NIOSH publication is available from U.S. Department of Health and Human Services, 200 Independence Avenue, SW., Washington, DC 20201.

NAVFACENGCOM Design Manuals and P-Publications

Department of Defense activities may obtain copies of Design Manuals and P-Publications from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. Department of Defense activities must use the Military Standard Requisitioning and Issue Procedure (MILSTRIP), using the stock control number obtained from NAVSUP Publication 2002

Other Government Agencies and commercial organizations may procure Design and Manuals and P-Publications from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20420.

DM-7 Series on Soils and Foundations

MIL-HDBK-1008A Fire Protection for Facilities Engineering Design and Construction

P-272 (Pt I) Definitive Designs for Naval Shore Facilities

REFERENCES

ANSI/ASTM Standards may be obtained from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ANSI/ASTM Standards

A 53	Specifications for Pipe, Steel, Black and Hot Dipped Zinc Coated, Welded and Seamless
B31.1	Power Piping
B 88	Seamless Copper Water Tube
D 1785	Specificatons for PVC Pipe, Schedules 40, 80 and 120

ARI Standards are available from the Air-Conditioning and Refrigeration Institute, 1501 Wilson Boulevard, Suite 600, Arlington, VA 22209.

ARI 410	Standard for Forced-Circulation Air-Cooling and Air-Heating Coils

ASME Codes are published by The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME, Boiler and Pressure Vessel Code

Section VIII	Unfired Pressure Vessels

Military standards may be obtained from the U.S. Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. TWX: 710-670-1685, AUTOVON: 442-3321.

Military Standard

MIL-C-22992E	Connectors, Plugs and Receptacles, Electrical Waterproof, Quick-Disconnect, Heavy-Duty Type
MIL-STD-704	Aircraft Power Characteristics
MIL-STD-90328	Cable Assembly External Electric Power

National Electrical Manufacturers Association (NEMA) publications are available from their head office at 2101 L Street, NW., Washington, D.C. 20037.

NEMA MG-1	Motors and Generators

NFPA standards are available from the National Fire Protection Association, Boston, MA 02110.

NFPA-70-87	National Electric Code

NAVFACENGCOM Design Manuals and P-Publications

Department of Defense activities may obtain copies of Design Manuals and P-Publications from the Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. Department of Defense activities must use the Military Standard Requisitioning and Issue Procedure (MILSTRIP), using the stock control number obtained from NAVSUP Publication 2002.

Other Government Agencies and commercial organizations may procure Design Manuals and P-Publications from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20420.

DM-1 Series	Architecture
DM-2 Series	Structural Engineering
DM-3 Series	Mechanical Engineering
DM-3.01	Plumbing Systems
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MIL-HDBK-1004/5	400 Hz Generation and Distribution Systems
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DM-5 Series	Civil Engineering
DM-21 Series	Airfield Pavement Design
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NFGS-15487	Aircraft Fixed Point Utility Systems (Proposed)
NFGS-16301	Underground Electrical Work
NFGS-16475	400-Hertz Medium-Voltage Conversion/Distribution and Low-Voltage Systems
NFGS-16492	Motor-Generator Sets, 400 Hz
NFGS-16930	Lighting, Exterior

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MIL-HDBK-1028/6	AIRCRAFT FIXED POINT UTILITY SYSTEMS

3a. NAME OF SUBMITTING ORGANIZATION

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4. TYPE OF ORGANIZATION *(Mark one)*

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