UFC 3-555-01
01 March 2024

UNIFIED FACILITIES CRITERIA (UFC)

AIRCRAFT POINT-OF-USE POWER SYSTEMS

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AIRCRAFT POINT-OF-USE POWER SYSTEMS

Indicate the preparing activity beside the Service responsible for preparing the document.

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING SYSTEMS COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supersedes UFC 3-555-01N dated 16 January 2004, the electrical sections of UFC 4-121-10N, dated 16 January 2004, and the special power system requirements in UFC 4-211-01 dated 13 April 2017, Change 3 dated April 20 2021.

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FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD-3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States, its territories, and possessions is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA). Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Military Department's responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Systems Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Technical content of UFC is the responsibility of the cognizant DoD working group. Defense Agencies should contact the respective DoD Working Group for document interpretation and improvements. Recommended changes with supporting rationale may be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide website https://www.wbdg.org/ffc/dod.

Refer to UFC 1-200-01, *DoD Building Code*, for implementation of new issuances on projects.

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

The purpose of this UFC is to provide technical requirements for the electrical design of specialized Point-of-Use (POU) power distribution systems for aircraft, and electrical power systems associated with aircraft hangars and aviation support facilities. This includes 400 Hertz, 270 VDC, and 28 VDC systems. Apply the criteria provided in this UFC for the development of the plans, specifications, calculations, and Design/Build Request for Proposals (RFP). It serves as the minimum electrical design requirements for design-build and design-bid-build projects. Project conditions may dictate the need for a design that exceeds these minimum requirements.

The aircraft power feeder distribution systems for new designs are required to be low voltage (less than 600 VAC) POU utility systems. Each of the 400 Hz, 270 VDC, and 28 VDC converters are prohibited from serving more than one aircraft receptacle, unless specifically noted otherwise within this document.

1-1.1 Upgrades and Modifications to Existing Systems

Modernization of electrical systems within existing facilities solely for the purpose of meeting design criteria in this UFC is not required. Minor upgrades or modifications of existing facilities should consider the design criteria in this UFC, but it is not intended that an entire facility require modernization solely because of a minor modification to a part of the facility.

- Medium voltage 400 Hz distribution systems and low voltage (less than 600 volts) 400 Hz distributed systems are also not permitted for new designs. These systems require extensive specialized technical knowledge and experience to design and maintain, and should only be utilized on limited repair type projects for existing systems.

1-2 REISSUES AND CANCELS.

This UFC replaces and cancels UFC 3-555-01N dated 16 January 2004 and incorporates canceled electrical sections of UFC 4-121-10N dated 16 January 2004.

1-3 APPLICABILITY.

The information in this UFC applies to the design of all new construction projects, including additions, alterations, and renovation projects within the United States and outside of the United States and its territories and possessions.

Note: This UFC takes precedence over the aircraft hangar UFC 4-211-01 for the specialty electrical system power. The hangar UFC will be modified to reference this UFC during its next review cycle.

1-4 CONFLICTS.

If a conflict exists between this UFC and any other referenced code, standard, or publication, this UFC takes precedence. When there is a known deviation to a normally complied with standard (such as an "exception to" or "more stringent requirement" than one in MIL-STD-704), the specific deviation is identified in either the UFC or the associated UFGS.

1-5 REGULATORY AUTHORITIES.

The military authorities having jurisdiction for Specialty Power Systems are included below.

1-5.1 Navy and Marine Corps.

Due to the new, more stringent technical requirements in the UFGS, including the 400 Hz requirement to be fully rated in kW at unity power factor vs being rated in kVA, and the 270 VDC requirements that have been developed without referring to proprietary documents, all manufacturers will have to develop and prove their new designs. These designs, including the factory routine, factory special, and field test plans, reports and backup data, must be reviewed and approved by NAVAIR and NAVFAC LANT. This is an extensive process requiring specific technical expertise in working with and verifying compliance with MIL-STD-704, and witnessing the tests at the manufacturer's facilities.

NOTE: The manufacturer's previous versions of military converters, and their commercial equipment, will not comply with this new criteria.

Coordination is therefore mandatory during the DD Form 1391, concept development and the design-build request for proposal (RFP) or design phases with NAVAIR (Naval Air Systems Command) and NAVFAC to determine the extent of the equipment review and approval process that is to be implemented and to identify funding requirements. The UFGSs for the converter systems identify numerous optional requirements which must also be edited appropriately based on the command requirements. It is anticipated, that until multiple manufacturers have achieved "approved designs, test plans and reports" from NAVAIR, both NAVAIR and NAVFAC LANT will need to be in the shop drawing review and approval loop.

- Contact NAVAIR POC: Henry Dent at (240) 434-6861.
  Email: henry.c.dent.civ@us.navy.mil.
  Command: Naval Air Warfare Center Aircraft Division (NAWCAD Test Methods and Facilities AB44).
- Contact NAVFAC POC: Rob Boller at (757) 322-4327.
  Email: robert.r.boller.civ@us.navy.mil.
  Command: NAVFAC Atlantic (LANT), Code PDC 44, Electrical Criteria Manager.

1-5.2 NAVAIR and NAVSEA Additional POC Information.

This criteria is not to be used for procurement of power converters installed on board aircraft or ships without specific authorization from both the Naval Air Warfare Center Aircraft Division (NAWCAD Power and Energy Division (AB43) at (301) 342-4161), and from the Naval Sea Warfare Command (contact the Technical Warrant Officer for the appropriate ship classification).

1-6 GENERAL BUILDING REQUIREMENTS.

Comply with UFC 1-200-01, *DoD Building Code (General Building Requirements)*. UFC 1-200-01 provides applicability of model building codes and government unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

1-6.1 Facility Requirements Document (FRD).

The airframe manufacturer's FRD, or equivalent document, is an integral requirement of aircraft specialty power systems design that contains additional airframe specific facilities requirements. FRDs are typically authored by the airframe manufacturer, contain many specific details, and are voluminous. Coordinate with the project manager to obtain the pertinent sections of the FRDs that are applicable to the project.

This UFC is not a substitute for the FRD of the design airframe(s) associated with the project. However:

- The UFC and associated UFGSs may have additional technical requirements that override the FRD requirements. An example is the new requirement for 400 Hz converters to be sized in kW vs the industry standard of kVA. The Navy and Marine Corps, and the Army FRDs are being addressed to incorporate this NAVAIR and Army mandated change. See paragraph Aircraft 400 Hertz (Hz) Service for additional information.
- The FRD may have new airframes, or existing platforms may have new requirements that this UFC has not addressed. These additional technical facility requirements, data or other items may impact the aircraft power system design. When that occurs, the facility Basis of Design must identify the exceptions to criteria and how the requirement is being addressed and satisfied in addition to the requirements of this UFC.

1-7 SAFETY.

Comply with UFC 3-560-01*, Operation and Maintenance, Electrical Safety*, and NFPA 70E, *Standard for Electrical Safety in the Workplace*, for equipment-related electrical safety requirements.

Coordinate with requirements identified in paragraph Aircraft Interlock Circuit.

1-8 CYBERSECURITY.

All facility-related control systems (including systems separate from a utility monitoring and control system) must be planned, designed, acquired, executed, and maintained in accordance with UFC 4-010-06, *Cybersecurity of Facility Related Control Systems* and as required by individual Service Implementation Policy.

The Electrical Designer of record must determine if the equipment being provided will include a control system (i.e. remote access panels or any other form of remote controls). If it does, edit the UFGS 25 05 11, "*Cybersecurity for Facility-Related Control Systems*" in the project documents to identify the extent of cybersecurity required.

1-9 SUPPLEMENTAL TECHNICAL INFORMATION.

APPENDIX A contains additional technical information.

1-10 GLOSSARY.

APPENDIX B contains acronyms, abbreviations, and terms.

1-11 REFERENCES.

APPENDIX C contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

CHAPTER 2 EXTERIOR DISTRIBUTION REQUIREMENTS

2-1 POINT OF USE (POU) UTILITY SYSTEMS.

Provide a fixed Point of Use (POU) utility system based upon the number and type of aircraft to be served, ground support requirements of the particular aircraft, expected diversity and demand of the aircraft loads, and site configuration of facilities. This will include identifying 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 POU concept is based upon the economy of supply of aircraft utilities from a centralized plant / location using 60 Hertz (Hz) energy-efficient components. Include the following considerations in planning for each aircraft facility:

a. Orderly expansion of the system components to accommodate probable future hangar bays and parking apron service points.
b. Economic feasibility of supplying adjacent or nearby facilities (existing or future) from the centralized supply.
c. Relocatability of ground support equipment versus installed equipment.
d. Probability of function relocation or base closure.

2-1.2 Aircraft Services.

Provide electrical POU systems for ground-power operations using solid state conversion equipment to change 60-Hz input to 400-Hz, 270 VDC, and 28 VDC outputs as required for the applicable aircraft.

2-1.3 Central Equipment Facilities.

In multiple facility development, provide a central facilities area for the equipment building, and a yard area for pad mounted / substation type transformers and switchgear for the main electrical service. Include the electrical service and distribution apparatus in the building.

2-1.4 Utilities Distribution.

Provide an underground 60 Hz distribution system including equipment, manholes and ductbanks to the maintenance hangar service points and parking apron service points in accordance with UFC 3-550-01. Coordinate with the mechanical designer and the mechanical sections of UFC 4-211-01, *Aircraft Maintenance Hangars*, and route the mechanical systems (such as compressed air and pre-conditioned air) in the same trench with the electrical conduits. Locate the access manholes outside the paved areas.

2-1.5 Site Configuration.

Coordinate the layout of the POU systems with the siting of the maintenance hangars, parking apron space and taxiways in accordance with UFC 3-260-02, *Pavement Design for Airfields,* and the following requirements:

- Include load calculations and voltage drop calculations in the Basis of Design for all service and distribution feeders in accordance with UFC 3-501-01. See Table 2-1 Notes for additional discussion on the possible increased load on the input of the converter due to the full kW at Unity design requirement.
- Utilize 60 Hz service and distribution equipment rated for exterior use in accordance with NEMA 250, IEC 60529, and UFC 3-550-01. Utilize 400 Hz, 270 VDC, and 28 VDC equipment rated for exterior use in accordance with NEMA 250 and the options designated in the UFGSs.
  a. **For Navy and Marine Corps**: provide enclosures rated NEMA Type 3SX (or IEC IP55) or better, with corrosion resistant paint, provide sealed non-ventilated electronics enclosures, and conformal coating on electronic components such as PC boards.
  b. **For Army and Air Force**: provide enclosures rated NEMA Type 3S (or IEC IP55) or better. In corrosive locations, provide enclosures rated NEMA Type 3SX (or IEC IP55) or better, with corrosion resistant paint, and provide sealed non-ventilated electronics enclosures and conformal coating on electronic components such as PC boards.
- Consider the following for multiple facility and equipment location development:
  a. Locate the central equipment facility 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. Locate the feeder distribution center, consisting of pad-mounted equipment, off the apron as close as practical to the service points to minimize aircraft service voltage drop.
  d. When voltage drop calculations permit, the feeder distribution centers for apron service points may be located in the hangar or located outside nearer to the hangar. This may limit the amount of primary distribution that is required to be run throughout the site. It may also increase the number of distribution components that are located in dry environments instead of harsh environments which may be less expensive and require less maintenance.

e. When structures are installed on the apron for the aircraft parking spots, coordinate the location of the service points to be adjacent to, but not under the structures. Note – A new UFC is under development by the Airfield Criteria Team to clarify that these structures are designated to be “sun shades” and not “shelters”. That UFC will establish requirements, including that utilities are not permitted to be under “sun shades”.

f. See Figure 2-1 for one example of a typical POU system layout for serving a hangar and parking apron complex.

g. See Figure 2-2 and Figure 2-3 for examples of different layouts and types of structures installed at some bases.

For the Navy and Marine Corps, see UFC 2-000-05N; *Facility Panning for Navy/Marine Corps Shore Installations* for additional information on the parking apron layout for Navy and Marine Corps Shore Installations.

Figure 2-1 POU System “Aircraft Parking Apron” – Site Plan Layout Typical

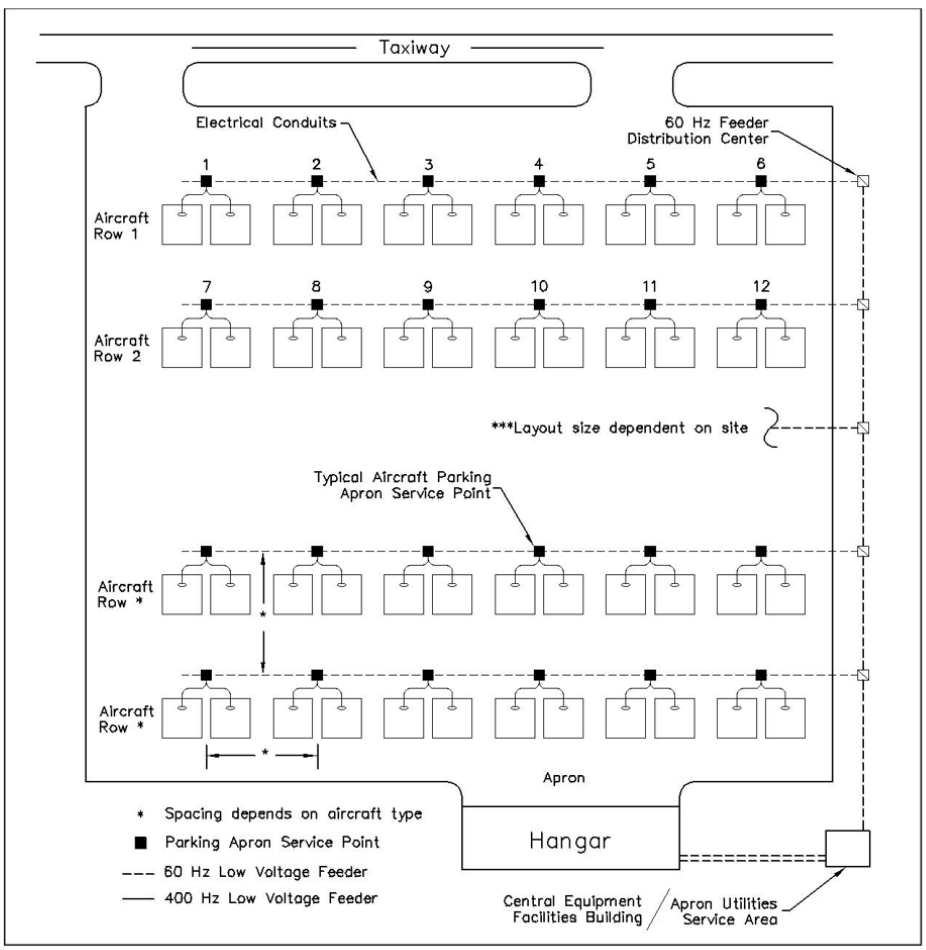

Figure 2-2 Example of Apron Layout with "Sun Shades"

Figure 2-3 Example of Apron Layout with POU Equipment

2-2 UTILITY SYSTEM LOAD DETERMINATIONS.

Use the total number and type of aircraft, plus the demands of other ground support activities to be supplied by the fixed point facilities, and determine load requirements for the utility system.

2-2.1 Aircraft Unit Demands.

For the Navy and Marine Corps: Utilize Table 2-1 Navy and Marine Corps Aircraft Electrical Requirements when completing load calculations.

Table 2-1 Navy and Marine Corps Aircraft Electrical Requirements

Aircraft Load Type	Aircraft Voltage: 400 Hz or 270 VDC	Designated Converter Size (See Notes 1 & 2)	Designated Cable Ampacity	Designated Cable Length
Fixed Wing	**400 Hz**	90 kW – see Note 3	260 Amp	105 ft (32 m)
Rotary Wing	**400 Hz**	45 kW - see Note 3	180 Amp	105 ft (32 m) (see Note 4)
Fixed Wing	**270 VDC**	72 kW - see Note 5	333 Amp	83 ft (25 m)
UAVs and limited other aircraft that are dedicated to 28 VDC	**28 VDC**	TBD – see Note 6		

Note 1: Provide designated Converter size unless there are specific project design requirements that have been approved by NAVFAC and NAVAIR. See paragraph *Regulatory Authorities* herein for POC information. Provide one cable per converter.

Note 2: Design to provide full capacity for each converter, measured at the aircraft end of the servicing cable, and utilize demand loading for utility distribution and transformer sizing. Coordinate with UFC 3-550-01 and UFC 3-501-01. Use Table 2-1, applicable to the number of aircraft being serviced in the facility under design, and apply the resulting number for the design demand factor for the Aircraft Load.

Note 3: The required load ranges for the 400 Hz converters are defined in the UFGS. The UFGS requires full load current (90 kW = 261 Amperes per phase and 45 kW = 130 Amperes per phase) compliance from the worst case lowest lagging power factor (currently 0.5 lagging), through full load at unity, up to the highest leading power factor (currently .7 leading).

a. These are very stringent requirements that are not met by a commercial off the shelf unit, or by previous converter designs. The two sizes, 90 kW and 45 kW have been standardized on, in order to facilitate approval of the equipment.

b. Because of the new requirements for the load range, converter input load will increase, possibly causing an increase in the feeder breaker conduit and wire sizes serving each unit. For new projects, and for apron unit replacement and building renovation projects where existing kVA sized units are being replaced by kW sized units, the Designer of Record (DOR) must obtain nameplate data from at least two manufacturers and document this information in their Basis of Design calculations.

c. Based on recent experiences with two manufacturers, it is imperative that NAVAIR and NAVFAC LANT POCs be involved on all projects in order to establish a database of manufacturers who have developed new designs.

d. As identified in the UFGS, these designs must be proven by the manufacturers by also developing Special and Routine Test Plans and Reports that are geared specifically to all the new requirements in the UFGS.

e. After NAVAIR approval of these test plans and the report format, the government intent is to witness the actual tests being performed at the factory.

f. Those documented reports from the witness testing would then be submitted in for NAVAIR and NAVFAC LANT final approval.

Note 4: Provide the designated Cable Length unless the project design requirements that have been approved by NAVFAC and NAVAIR identify a 90 ft (27 m) length as being required.

Note 5: The 270 VDC converters are used to supply 270 VDC (267 Amps) and limited amounts of 28 VDC electrical Interlock voltage (15 Amps), measured at the aircraft end of the servicing cable. See UFGS 26 35 44 for details.

a. The new UFGS requirements will require an identical approval process by NAVAIR and NAVFAC LANT POCs as described for the 400 Hz converters in Note 3 above.

b. For 270 VDC output systems, there is no difference in KW and KVA ratings. A 72 kW / 72 kVA DC converter must deliver 267 Amps under specified conditions.

Note 6: Per NAVAIR, when there is a requirement for a 28 VDC platform, request the specific FRD for the UAV or other limited aircraft, and coordinate with the NAVAIR POC designated in this UFC for any known special requirements that should be incorporated into the design and into a project specification. The NAVFAC LANT and NAVAIR POCs may have some sample specification paragraphs or testing requirements that could be used with a draft project specification, until an official UFGS has been developed.

2-2.2 System Load Demand.

In addition to establishing the system demand for individual apron and hangar loads, apply a system demand factor to the overall base system.

- Use Table 2-2 to establish the number of aircraft expected to exert a simultaneous demand for the portion of the system under consideration. The demand factors apply to aircraft using 270 VDC or 400 Hz.
- Base the electrical demand for the 60 Hz, 400 Hz, and 270 VDC systems, per the table; i.e. in a 36 aircraft squadron, the power demand should account for powering 12 aircraft (31 percent x 36 aircraft = 11.7, rounded up to 12). Proportion the resulting demand between parking apron service points and hangar service points with a ratio of 2 to 1 respectively.

Implement these results when establishing the service transformer and distribution equipment requirements in accordance with UFC 3-550-01 and basis of design calculations in accordance with UFC 3-501-01.

Table 2-2 System Demand Factors

Number of Aircraft	Demand Factor Percent
1	100
2	90
3	83
4	77
5	71
6	66
7 to 9	61
10 to 12	50
13 to 15	45
16 to 21	40
22 to 40	31
41 to 60	28
Over 60	25

2-2.3 Additional Load Considerations.

In addition to aircraft, there are other loads that may require 400 Hz, 270 VDC and 28 VDC power. Prior to supplying these facilities, verify that equipment installed will not be damaged by the hangar POU power tolerances. Separate local converters should normally be used for these systems. These loads include the following:

- Avionics. Repair shops for electronic equipment require specialty power for maintenance and testing. Coordinate with the using agency to obtain the actual load requirements in such cases.
- Other Facilities. Research, development, training, and other types of facilities may require 400-Hz, 270 VDC, and 28 VDC distribution systems. If the using agency cannot provide the actual load requirements, compute such loads on a watts per square foot (square meter) basis when firm loads are not available in accordance with UFC 3-501-01.

2-3 ELECTRICAL REQUIREMENTS ON APRONS.

Provide electrical service on aircraft parking aprons to accommodate the aircraft types and operational function of the squadron or group. The electrical distribution system may consist of pad mounted switches, transformers, switchboards, panelboards, service point equipment enclosures, and underground distribution feeders located near each row of planned aircraft parking. Provide a one line diagram, with legend and details clearly indicating the planned arrangement. Provide this equipment in accordance with UFC 3-550-01. An example of a one line for a typical system is shown in Figure 2-4.

2-3.1 Parking Apron Service Points.

Provide service from the Switchboards to each service point.

a. In the example distribution system indicated in Figure 2-1, each service point would serve two converters and each of these converters would serve an aircraft.

b. On some sites, a dedicated service point may be used for each aircraft parking spot if it is validated with the Activity. However, this may add more enclosures and equipment on the airfield.

c. The electrical requirements at each location, (often called an island) normally include 60 Hz receptacles and miscellaneous loads in addition to whichever special power system converters (400 Hz, 270 VDC or 28 VDC) are required. An example one line for a typical 400 Hz system is shown in Figure 2-5, and the associated legend is in Figure 2-6.

d. The UFGS now requires “individual converters”; i.e. one converter serving each parking spot. However, if space is a consideration on the apron, a single, low-profile, factory built and tested, dual converter unit is permitted. It must consist of two, independent, fully rated, simultaneous converters in a single enclosure, housing all the necessary components. The unit’s construction part of the UFGS may have to be modified to explain this exception. Coordinate with the Activity to verify that having a dual unit is acceptable, since it may entail outages for two aircraft instead of one during maintenance issue.

e. Coordinate the island locations and layout with the mechanical utilities designer to determine if a compressed air dispensing system needs to be incorporated into the main service point enclosure. If it does, incorporate the mechanical components in the rear half of the enclosure and the electrical components in the front half of the enclosure. (See UFC 4-211-01 for the mechanical requirements).

Figure 2-4 POU Aircraft Parking Apron – One Line Diagram

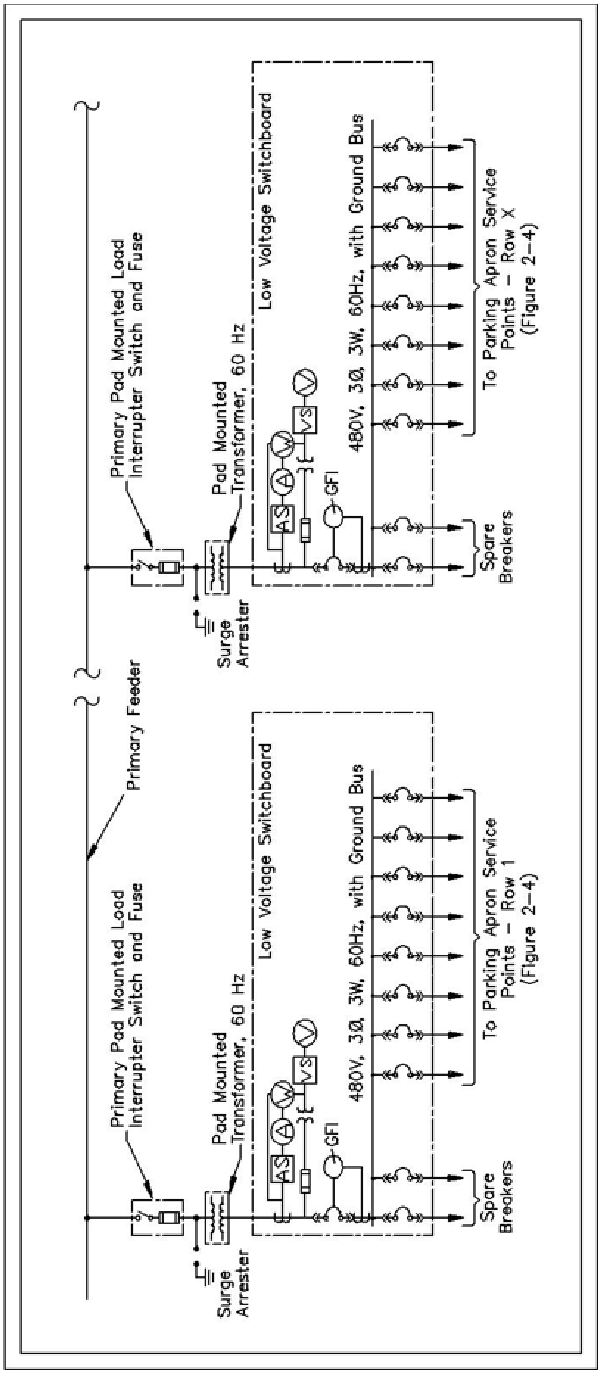

Figure 2-5 Parking Apron Service Point Arrangement / One Line

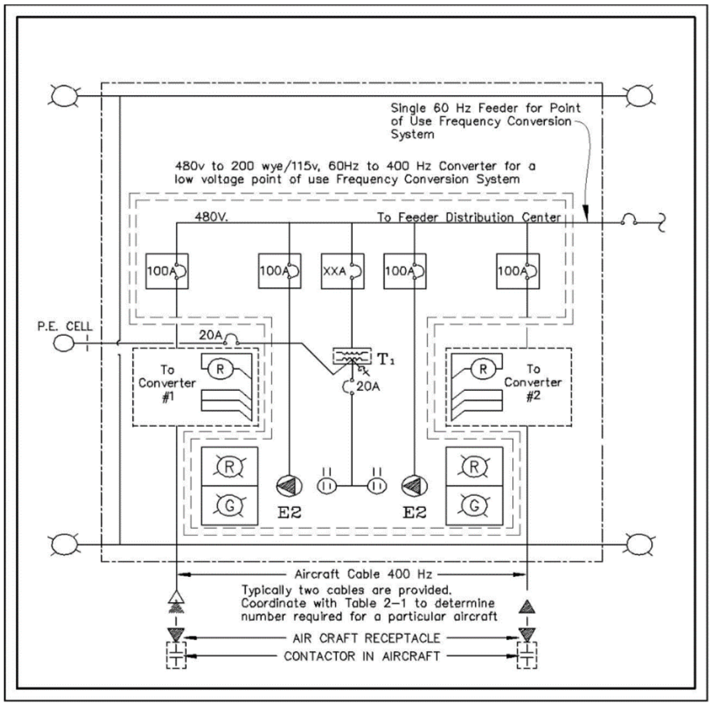

Figure 2-6 Legend

SYMBOL	DEVICE
	CONTACTOR
	Air or Molded Case Circuit Breaker (depends on use)
E2	RECEPTACLE, CLASS L, 100A, 3P, 480V
	RECEPTACLE, 120V GFI WEATHERPROOF TYPE
FC_1	Frequency Converter 480v to 200 wye/115v, 60 Hz to 400 Hz with Harmonic Filtering
T_1	TRANSFORMER 1 PHASE 120V, 60 Hz
	OBSTRUCTION LIGHT
P.E. CELL	PHOTOCELL
R	CONTACTOR/CIRCUIT BREAKER POSITION INDICATOR LIGHT CONTROL RELAY 120v AC
R	RED INDICATING LIGHT
G	GREEN INDICATING LIGHT FOR OFF POSITION

2-3.1.2 Construction.

The service point enclosures must be manufactured enclosures based on the location, and in accordance with paragraph Site Configuration. Field fabricated enclosures are not permitted. Mount the main service point enclosure assembly, and the associated converters, on a concrete base pad approximately 6 in. (152 mm) above the apron grade. Protect this entire assembly from vehicular traffic with concrete-embedded steel posts.

2-3.1.3 Electrical Equipment Components.

Provide each main service point with 60 Hz components (and the 60 Hz circuit breakers for the specialty 400 Hz or 270 VDC systems converters) as follows:

a. 60 Hz input circuit breaker(s) three-pole, 600 V. Size the input circuit breaker to include the specialty system converter loads. Operate the circuit breaker from the front of the service point enclosure. Note: all the 60 Hz breakers may be included in a panelboard / switchboard arrangement within the service point assembly.

b. Two 100 ampere and two additional, three-pole, 600 V, 60 Hz, molded case circuit breakers. Mount two breakers on the interior of each side panel. (One on each side will be used for Item c, and the second on each side will be used for the converter. Based on the new requirement for kW ratings, coordinate required ampacity of the converter breakers with at least two manufacturers.)

c. Two 100 ampere, 480 V, three-phase, four-wire, 60 Hz receptacles for Government furnished Ground Support Equipment (GSE). These receptacles are built by very few manufacturers and are identified by part numbers. Coordinate required outlet amperage (if other than 100 A) and type requirements with the users. Mount one receptacle on the exterior of each side panel.

d. One 3 kVA, one-phase, 480-120 V, 60 Hz, dry-type transformer with two-pole primary circuit breaker and a one-pole, 20-ampere secondary breaker. The transformer provides power for control, 120 V receptacles, and obstruction lights. When the mechanical system is included in the assembly, mount the transformer and the protecting breakers on the interior sheet steel barrier between the mechanical and electrical sections.

e. Two 20 ampere, 125 V, one-phase, two-pole, three-wire, 60 Hz, weatherproof receptacles with ground-fault interrupting. Mount one receptacle on each of the exterior side panels.

f. Provide obstruction warning light fixtures for each service point enclosure. Fixtures must be steady-burning red obstruction lights, FAA Type L-810. Provide in accordance with UFC 3-535-01, *Visual Air Navigation Facilities*, and FAA AC 70/7460-1. Provide fail-safe photoelectric control for the fixtures at each service island. Coordinate with the Activity to verify number required at each location. Typically, four fixtures are used, mounted near corners of the enclosure. If Activity concurs with limiting the number to two fixtures, install at opposite corners. If only one fixture is required by Activity, it must be a dual L-810 fixture.

g. Verify with Activity and Airfield Manager to determine whether or not LED fixtures are permitted.

h. Provide apron site lighting around the main service points in accordance with UFC 3-530-01, *Interior and Exterior Lighting Systems.*

i. When mechanical systems are included in the enclosure, mount one low-air-pressure warning light on the exterior panel adjacent to the mechanical system pressure gauge.

2-3.2 Converter and Cable Requirements.

Provide the converters in enclosures suitable for the exterior location of the project and in accordance with the requirements in Chapter 3.

Provide the cables in non-metallic ductbanks when underground, for the specialty systems as needed, and in accordance with the requirements in Chapter 3

CHAPTER 3 ELECTRICAL REQUIREMENTS IN HANGARS

3-1 NORMAL POWER DISTRIBUTION.

Provide normal power within Aircraft Hangars in accordance with the facility UFC 4-211-01. It is usually a 3-phase wye-connected, underground secondary service rated at 480 Volts Alternating Current (VAC). For projects outside of the United States and its territories and possessions, electric power is in accordance with UFC 3-510-01, *Foreign Voltages and Frequencies Guide.*

3-1.1 Hazardous (Classified) Locations.

Design hazardous (classified) locations including the hangar bay and adjacent spaces in accordance with NFPA 70, *National Electrical Code* requirements for hazardous locations. At a minimum, classify adjacent spaces that are not suitably cutoff as Class I Division 2 up to 18 inches (460 mm) above the floor of the hangar bay adjacent to the space.

Note: The area within 5 feet of any aircraft fuel vents and any fuel containing portion of the aircraft is Class I Division 2. For practical use and mission-flexibility, this is generally simplified to within 5 feet (1.5 m) horizontally of any aircraft surface and vertically from 5 feet (1.5 m) above the surface down to the floor.

- If a space is adjacent and communicates with a hazardous location, comply with the requirements and figures in UFC 4- 211-01.

For Navy and Marine Corps: Design all hangar bays electrically as hazardous areas for maintaining fueled aircraft regardless if the aircraft contain fuel or not. Assume all aircraft in hangar bay will enter fueled.

3-1.2 Electrical Equipment.

Comply with the facility UFC 4-211-01 for the minimum requirements for the electrical equipment enclosures in the hangars. Comply with the technical notes in the UFGSs for the equipment enclosures for converters located in the hangars.

For Army: All electrical equipment in the hangar bay is required to be in a NEMA 250 Type 3R or weather proof enclosure.

3-2 AIRCRAFT POWER DISTRIBUTION.

Aircraft have specific power requirements, including unique voltages, frequencies, and capacities. Review the aircraft requirements of the aircraft being maintained in the hangar bay to determine the appropriate services. Provide appropriate services in voltage, frequency, and capacity to service the aircraft.

Coordinate with the latest requirements in UFGS 26 35 43*, 400 Hertz (Hz) Solid State Frequency Converter* and UFGS 26 35 44*, 270 VDC Solid State Converter.* Provide permanently-mounted equipment located within the hangar bay or an adjacent space as follows:

- Permanently-mounted equipment may be installed within the hangar bay or within an adjacent space to the hangar bay. If equipment is installed in the hangar bay it may be either floor-mounted or mounted on the wall at a higher elevation. If the equipment is mounted at a higher elevation, coordinate the support of the equipment with the structural engineer. If the equipment is mounted on the floor, provide a stand for the equipment to elevate the equipment a minimum of 18 inches (0.46 m) AFF to avoid having the equipment in the Class I Division 2 hazardous space. Coordinate location of equipment to maintain the clear zone. Refer to UFC 4-211-01, paragraph 2-3: Minimum Aircraft Maintenance Bay Clearances for clear zone requirements.
- Provide a detail on the drawings that identifies the location, mounting and permitted maintenance access areas (the maintenance envelope) for each converter.
- Provide solid-state equipment for special power units.
- Permanently-mounted equipment typically has controls mounted on the face of the equipment. If the equipment is mounted at a higher elevation, or in an adjacent space, provide remote control and displays at an elevation within the hangar bay that is accessible by the user.

For Air Force:

a. Aircraft power distribution equipment is government furnished. Power distribution equipment may be provided as Service Equipment (SE) carts or permanently mounted equipment.

b. Government-furnished SE carts may be diesel powered or electrically powered. If an SE cart is diesel powered, park the SE equipment outside of the hangar bay and extend cables to the aircraft from the SE equipment. If an SE cart is electrically powered, provide a 480V, 3-phase receptacle on the wall or pedestal and extend the power from the connection to the equipment. SE carts are government furnished equipment. Coordinate the sizes and type of connection with the users and equipment available at the installation.

For Army, Navy and Marine Corps: All Converters are now required to be individual output, Point of Use (POU) converters, with each converter serving only one receptacle on an aircraft.

For Army: A combination converter (having both 400 Hz and 28 VDC outputs) is only permitted when it is specifically identified as being required on a particular project.

For Navy and Marine Corps:

a. Combination Converters, (having both 400 Hz and 270 VDC outputs, or having both 400 Hz and 28 VDC outputs) are not allowed**.**

b. Converters in hangars must be flush mounted against the wall, must not require back access for maintenance, and must comply with the "Maintenance Envelopes" identified on the project drawings.

c. Coordinate with the Navy Functional Data Sheets (FDS) and Space Types information in UFC 4-211-01 for additional information on Specialty Power Systems requirements, such as locations (like Avionics shops) where additional 400 Hz, 28 VDC, or 270 VDC services are needed.

3-2.1 Power Distribution Service Points.

Distribute aircraft power from permanently-mounted equipment located on the wall.

3-2.1.1 Wall-mounted connection points.

Different aircraft have different power requirements and connections. Match receptacle and cable type to aircraft being maintained. Provide wall-mounted connection points close to the distribution equipment. Coordinate the location of the connection points with the location of the aircraft connection point to minimize the length of the cable from the wall to the aircraft. Provide one of the following connections:

- Provide wall-mounted cable storage racks for storage of the cable. When receptacles are installed, mount receptacles above electrical hazardous location. Provide floor-mounted cable protectors from the wall across the service lane to the aircraft side of the service lane. Lay cables in the cable protector to protect cable from cross traffic while the cables are extended and in use.
- When approved by the Activity and Facilities Manager, provide wall-mounted electrically or air driven reels. Approval authority must agree to the potential additional maintenance and power quality issues related to how the power is transferred from the converter to the reel and to the cable on the reel. These additional connections and contact surfaces must be maintained. Install electric motors above the electrical hazardous location. Provide reel controls as part of the cable assembly. Coordinate motor size and type with length and weight of cable provided. If used, DOR must include reliability information from multiple manufacturers in the Basis of Design and add appropriate information to the specifications.

For Army: Cables connecting to the service point may or may not be provided as part of the service.

For Air Force:

a. Distribute aircraft power from government furnished SE carts. Government-furnished SE equipment is mobile and provides a flexible solution. The aircraft cables are typically connected to the SE cart. The equipment is owned and maintained by the maintenance mission and typically the equipment will be shared for hangar and on-ramp maintenance. A storage area may also be required for the equipment.

b. The cables connecting to the aircraft power distribution service point may or may not be provided as part of the service. Coordinate the provision of the cables with the mission owner.

For Navy and Marine Corps: Provide cables connecting to the service point as part of the service.

3-2.1.2 Permanently-Mounted Pedestal.

For Air Force, Navy and Marine Corps: Permanently-mounted pedestals are not permitted.

For Army: Provide permanently-mounted pedestals. Coordinate the connection point in the hangar floor space with the location of the aircraft. Permanently mount the pedestal to the hangar floor. Locate pedestals to avoid aircraft movements. Coordinate the location of pedestals with the clearance requirements listed in UFC 4-211-01, paragraph 2-3: Minimum Aircraft Maintenance Bay Clearances. Pedestal may have multiple mechanical, electrical, and communication services including power, compressed air, network connections, and water. Coordinate types of all service utilities to be provided on pedestal with activity. Route utility connections under the hangar floor from the wall to the pedestal. Mount all electrical utilities a minimum of 18 inches (0.46 m) AFF. Seal all electrical penetrations from the floor, per NFPA 70.

3-2.1.3 Retractable (Pop-up) Pedestal.

Retractable (Pop-up) pedestals are not permitted.

3-2.1.4 Aircraft Power Distribution Point Utility Coordination.

Other services including compressed gasses, water, and preconditioned air are required to maintain aircraft. Coordinate the location of electrical services with all other utilities.

3-3 AIRCRAFT POWER SYSTEMS.

Provide the appropriate aircraft power systems in voltage, frequency, and capacity to service the aircraft being maintained.

For Army: Special Power.

a. Use Table 3-1: Army Aviation Platform Ground Service Baseline Requirements for Service Baseline Requirements.

b. Integrate the system with the building power system and provide a complete system with all cables and connectors required to interface with the aircraft. No ground power units (carts) are allowed. Design system to provide access to each aircraft parking space without any cables or equipment passing thru the five foot clear zone around the hangar bay floor.

For Navy and Marine Corps: Refer to Table 2-1 for additional information.

Table 3-1 Aviation Platform Ground Service Baseline Requirements

GROUND SERVICE	AVIATION PLATFORM GROUND SERVICE BASELINE REQUIREMENTS							
	AHH-64A	AH-64D	UH-60A/L	UH/MH-60M, X	CH-47D	DH/MH-47E, F, G	OH-58D	ARH-70A
400 Hz 200/115 V	35 kW	35 kW	45 KW	45 kW	20 kW	40 kW	10 kW	N / A
28 VDC START	NONE	NONE	NONE	NONE	NONE	NONE	500-750A START	500-800A START
28 VDC SERVICING	NONE	NONE	NONE	NONE	300A SERVICING	300A SERVICING	200A SERVICING	200A SERVICING

3-3.1 Aircraft 400 Hertz (Hz) Service.

Design a complete, functioning 200Y/115VAC, three phase, 400 Hz power system, including converter, cables, and connectors, to support the aircraft maintenance activities. Provide Point of Use (POU) 400 Hz service in the hangar bays and in shops where 400 Hz is required by the users.

- Combination converters (having multiple 400 Hz outputs, having both “400 Hz and 28 VDC” power outputs, or having 400 Hz and 270 VDC outputs) are not permitted on Navy and Marine Corps projects. A combination converter (having both 400 Hz and 28 VDC outputs) is permitted on an Army project when it is specifically identified as being required.

- Previous versions of criteria referred to 400 Hz equipment sized only in kVA at 0.8 lagging power factor. This has changed, and designs are now required to use kW instead of kVA as the unit of power measurement for converters here and on the project drawings. This significant change in equipment designation, has been made to:
  a. Ensure that our equipment meets the full required load range, including full power at unity power factor.
  b. Eliminate the problems that have been occurring with existing equipment in the field.
  c. And to accommodate the increasing nonlinear load characteristics of Military equipment.
     - For Navy and Marine Corps documents, including their Facilities Requirements Documents (FRD)s, are being revised to coordinate with this change to kW. Army documents are in the review process. UFGS 26 35 43, *400 Hz Solid State Frequency Converter* has been rewritten to incorporate this requirement.

3-3.1.1 400 Hz Converter Sizes.

Coordinate the exact number and sizes of converters with the users supported.

For Army: Converters are sized per Table 3-1.

For Navy and Marine Corps: Provide 90 kW converters for all fixed wing aircraft and provide 45 kW converters for all rotary wing aircraft unless there are specific project design requirements approved by NAVFAC and NAVAIR. See Table 2-1. (One example, may be the direct replacement of an existing, larger kW converter),

Design the system to provide power to each aircraft parking spot. Design system to compensate for voltage drop and provide sufficient voltage at the point of service. Provide voltage drop calculations, in accordance with requirements in UFC 3-501-01, to meet the voltage requirement at the aircraft point-of-service, and to meet the requirements of the aircraft power monitor. See Appendix A for sample equations.

For Air Force: Aircraft 400 Hz systems are provided using government-furnished SE or government-furnished fixed equipment. A fixed 400 Hz system may be provided for a building, if approved by Civil Engineering (CE).

For Army, Navy and Marine Corps: 400 Hz converters, cables, and connectors are Real Property Installed Equipment (RPIE) equipment.

3-3.1.2 Aircraft 400 Hertz (Hz) Special Power Distribution Cables.

Provide 400 Hz cable in accordance with SAE AS7974 and SAE AS5756/6, consisting of six power conductors, two per phase, helically laid around one central neutral conductor and six control conductors, minimum of #18 American Wire Gage (AWG), specifically designed for 400 Hz applications.

For Army:

a. Coordinate the cable amperage and cable length between 30 and 100 ft. (9.1 to 30.5 m) with the aircraft on the project.

b. Base the size of the power conductors on the kilowatt (kW) rating of the aircraft.

c. Base the length of the cable on the distance from the distribution equipment to the aircraft location.

For Navy and Marine Corps:

a. Use the 260 Amp and 105 feet (32 meters) length options in the specification for all cable assemblies with the 90 kW converters.

b. Use the 180 Amp and 105 feet (32 meters) length for all 45 kW converters, unless the project requirements given to the designer of record specifically identify that the 90 feet (27 meters) length is sufficient.

3-3.1.3 Aircraft Cable Provision.

Coordinate how the cables are being provided for the project with the users. The cables may be part of the Military Construction (MILCON) or the cables may be equipment provided by the user. If the cables are permanently affixed to the facility distribution system, the cable is considered to be part of the MILCON. If the cables can be disconnected from the facility distribution system, the cable is provided by the user.

3-3.1.4 Aircraft Cable Interlock Circuits.

Incorporate safety requirements into the converter / cable interlock circuits. Comply with NFPA 70 E and UFC 3-560-01, which mandates the use of Standard Operating Procedures (SOPs) for electrical equipment. Confirm that any exemptions or exceptions to the safety criteria has been identified within these SOPs.

For Army, Navy and Marine Corps:

a. Provide the “split F interlock” for all new installations. This interlock is built into the cable end to ensure that the cable is not energized until it is connected to the aircraft, and that it is automatically deenergized as soon as disconnecting from the aircraft has begun. See MIL-DTL-32180 for technical information, and typical details and schematics on the operation of the interlock.

b. When the aircraft cable specification is used for existing converters, coordinate with the Activity to ensure they understand the new safety requirements being built into the new “split F interlock” cable ends, and that the Activity has the appropriate Standard Operating Procedures (SOPs) in place, per UFC 3-560-01, for the remainder of their existing equipment.

For Air Force: When involved with certain “Legacy” Air Force Aircraft, the 28 VDC may need to be changed to utilize one of the 115 V, 400 Hz phases instead. Coordinate with Activity to confirm requirements.

3-3.2 Aircraft 28 Volts Direct Current (VDC) Service.

Design a complete and functioning 28 VDC power system, including converter, cables, and connectors, to support the aircraft maintenance activities. Provide Point of Use (POU) 28 VDC service in the hangar bays and in shops where 28 VDC is required by the users.

For Army: A combination converter (having both 400 Hz and 28 VDC outputs) is permitted on an Army project when it is specifically identified as being required. This information has been incorporated as options in the UFGS 26 35 43, *400 Hertz (Hz) Solid State Frequency Converter*.

For Navy and Marine Corps: Combination converters (having multiple 28 VDC outputs, or having both “400 Hz and 28 VDC” power outputs) are no longer permitted on Navy and Marine Corps projects. Individual 28 VDC Converters are required. Contact NAVFAC Atlantic, Code DC 44 – Criteria Manager at (757) 322-4327, for a draft 28 VDC specification that can be modified for the specific project.

Coordinate the exact number and sizes of converters with the users supported. Design the system to provide power to each aircraft parking spot, when required.

For Airforce: Aircraft 28 VDC Service Distribution systems are provided using government-furnished SE cart or government furnished fixed equipment. A fixed 28 VDC system may be provided for a building, if approved by CE.

For Army, Navy and Marine Corps: 28 VDC converters, cables and connector are RPIE equipment. The use of centralized systems serving multiple aircraft are prohibited.

3-3.2.1 Aircraft 28 VDC Distribution Cables.

Provide 30 to 100 ft. (9.1 to 30.5 m) 28 VDC cable assembly, consisting of two individual power conductors banded together with non-metallic bands in accordance with SAE AS5756. Provide strain relief, and appropriate integrally molded connector in accordance with SAE AS7974. Base the size of the conductor on the kW rating of the aircraft. Base the length of the cable on the distance from the distribution equipment to the aircraft location.

Coordinate how the cables are being provided for the project with the users. The cables may be part of the Military Construction (MILCON) or the cables may be equipment provided by the user. If the cables are permanently affixed to the equipment, the cable is considered to be part of the MILCON. If the cables can be disconnected from the facility distribution system, the cable is provided by the user.

3-3.3 Aircraft 270 VDC Service.

For Air Force, Navy and Marine Corps: Design a complete and functioning 270 VDC power system, including converter, cables, and connectors, to support the aircraft maintenance activities. Provide Point of Use (POU) 270 VDC service in the hangar bays and in shops where 270 VDC is required by the users. Combination converters (having “multiple 270 VDC outputs”, or having both “400 Hz and 270 VDC” power outputs) are no longer permitted.

For Air Force:

a. Coordinate the exact number and sizes of ground power units with the users supported. Design the system to provide power to each aircraft parking spot.

b. Aircraft 270 VDC systems are provided using government-furnished SE carts or government-furnished fixed equipment. A fixed 270 VDC system may be provided for a building, if approved by Civil Engineering (CE).

For Navy and Marine Corps:

a. Coordinate the exact number of ground power units with the users supported. Design the system to provide power to each aircraft parking spot.

b. The Navy and Marine Corps have standardized on one size, 72 kW for all 270 VDC converters. Coordinate with the requirements in UFGS 26 35 44, *270 VDC Solid State Converter*.

c. Aircraft 270 VDC converters, cables, and connectors are RPIE equipment.

3-3.3.1 Aircraft 270 VDC Distribution Cables.

Provide 30 to 100 ft. (9.1 to 30.5 m) 270VDC cable consisting of a single jacketed multi-conductor cable with power and controls incorporated into the cable with the appropriate connector. Base the size of the conductor on the kW rating of the aircraft. Base the length of the cable on the distance from the distribution equipment to the aircraft location.

Coordinate how the cables are being provided for the project with the users. The cables may be part of the Military Construction (MILCON) or the cables may be equipment provided by the user. If the cables are permanently affixed to the equipment, the cable is considered to be part of the MILCON. If the cables can be disconnected from the facility distribution system, the cable is provided by the user.

For Navy and Marine Corps: Refer to Table 2-1 for additional information.

3-3.4 Special Additional 60 Hz Power Service Points.

For Navy and Marine Corps: Provide special additional 60 Hz power service points in hangars as identified in the Navy Functional Data Sheets. Coordinate all requirements with users and aircraft manufacturer and dedicate adequate wall space for all equipment. The power service points may include:

a. Three-phase, 480V, 4-wire, 60 Hz, receptacles for government furnished support equipment (SE). These receptacles are built by very few manufacturers and are identified by part number. Coordinate required outlet amperage and type requirements with the users.

b. Single-phase, 120V, 60 Hz, ground fault interrupt duplex utility outlets.

c. For Triton Type IV hangars: As a minimum, provide one special receptacle for Ground Support Equipment (GSE) at each aircraft parking space (minimum four per hangar bay). The receptacle required is a 480 VAC, 100 ampere, three-phase, four-wire, 60 Hz, MIL-C-22992, Class L, Connector Size 44, with an Insert Arrangement per MS14055 Figure 5.

3-4 GROUNDING AND BONDING.

Provide grounding and bonding in accordance with UFC 3-575-01, *Lightning and Static Electricity Protection Systems*.

3-5 PHOTOGRAPHS.

Figure 3-1 Recent Converter Installations - Example 1

Figure 3-2 Recent Converter Installations (400Hz & 28 VDC) - Example 2

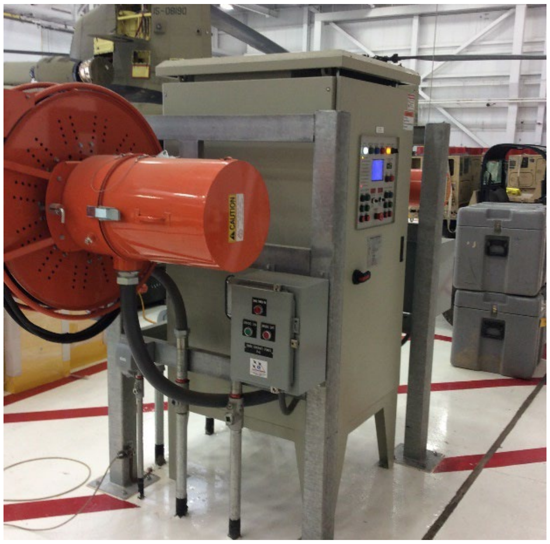

Figure 3-3 - Recent Converter Installations (270 VDC & 400 Hz) – Example 3

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APPENDIX A SUPPLEMENTAL TECHNICAL INFORMATION

A-1 CALCULATIONS.

Design analysis and documentation, including electrical calculations for Specialty Electrical Systems, are required in accordance with UFC 3-501-01 utilizing power modelling software. The standard 60 Hz calculations, complete to the incoming side of the converter, should all be covered in the Basis of Design requirements for other electrical UFCs. With Point of Use systems being required for all new designs, 400 Hz, 270 VDC and 28 VDC specialty system calculations should be limited to:

a. Converter connecter via specified cables direct to aircraft connector.

b. Converter to a cable reel, then to the aircraft.

c. Feeding from a platform mounted converter, down to the wall mounted connection points, then to the aircraft.

d. Feeding from the wall mounted converter (for Army) under the clear zone (walkway), to the pedestal mounted connection points, then to the aircraft.

Note: Future updates to this UFC will look at incorporating sample calculations with power modeling software printouts.

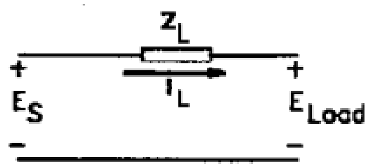
A-2 400 HZ CALCULATIONS.

The inductive contribution to the reactance voltage drop of 400-Hz systems is roughly seven times greater than that of 60-Hz systems, which necessitates certain modifications to conventional distribution and utilization system design to compensate for the increased voltage drop. The circuit diagram and formulas presented in Figure A-1 have been reproduced from the archived UFC 3-555-01N, and can be used with Table A-1 for determining 400 Hz system voltage drops.

- The minimum voltage required at the aircraft is 113 Volts.
- Therefore, maximum voltage drop allowed = 120 - 113 = 7 volts.

Table A-1 is a limited part of Table B-3 in archived UFC 3-555-01N, which was reprinted from “Actual Specifying Engineer,” February 1972. This table gives the effective A.C. resistance and inductance values for copper conductors for THHN/THWN insulations and in air, non-metallic conduits, and rigid aluminum conduits.

Figure A-1 **Simplified 400 Hz Circuit Diagram and Formulas**



E_S – Source Voltage=208Y/120

E_{Load} – Load Voltage

I_L – Line Current

Z_L – Line Impedence=$R_{ac}+jwL$

R_{ac} – Alternating Current Resistance

L – Inductance

w – Angular Frequency=2 x 3.14 x frequency

SIMPLIFIED CIRCUIT DIAGRAM

FORMULAS

$$E_S = I_L Z_L + E_{Load}$$

$$E_{Load} = E_S - I_L Z_L$$

Line–to–Neutral Voltage Drop= $|E_S| - |E_{Load}| = I_L\,|Z_L|$

Line–to–Line Voltage Drop= $\sqrt{3}\,(|E_S| - |E_{Load}|) = \sqrt{3}\,I_L\,|Z_L|$

NOTE: FORMULAS USING PER UNIT QUANTITIES ARE ALSO ACCEPTABLE PROVIDED ALL INFORMATION IS INCLUDED IN THE CALCULATIONS.

A-3 OTHER SYSTEM CALCULATIONS

Since FLEDS (400 Hz low voltage Flight Line Electrical Distribution Systems) and Medium Voltage 400 Hertz distribution systems are not permitted for new designs, see UFC 3-555-01N and UFC 4-211-01 for calculations that may have been used on existing systems.

Those archived UFCs also contain old sample methods for establishing a multi-facility utility demand calculation using aircraft demand loading, and for establishing a facility (Hangar) load calculation and facility transformer / service equipment sizes using converter kw loads and aircraft demand loading. However, they should be considered for informational purposes only, since they also intermix medium voltage 400 Hz and the low voltage distributed 400 Hz systems for converters that are larger than our current POU converters.

A-4 400 HZ NON-LINEAR LOAD BANK INFORMATION

In order to comply with the stringent 400 Hz non-linear load range requirements in UFGS 26 35 43, manufacturers will have to develop a means to test their converters. They must prove that they continue to meet the performance requirements when operating into a non-linear load with not less than 15 percent current Total Harmonic Distortion (THD), composed of not less than 6 percent of the third harmonic and not less than 7 percent of the 5th harmonic.

Per NAVAIR, the intent of the load description with the 15 percent current THD is to portray a 50 percent linear and 50 percent non-linear load, with a nonlinear load designed to emulate a six pulse rectifier supplying a resistive load. Figure A-2 is a sample schematic diagram that is referred to in the technical notes in UFGS 26 35 43 and has been provided by NAVAIR for manufacturer's information. If the manufacturers would like to discuss this diagram, please contact the NAVAIR POC designated in paragraph titled Regulatory Authorities in this UFC.

Figure A-2 **Example of Non-Linear Load Bank Schematic**

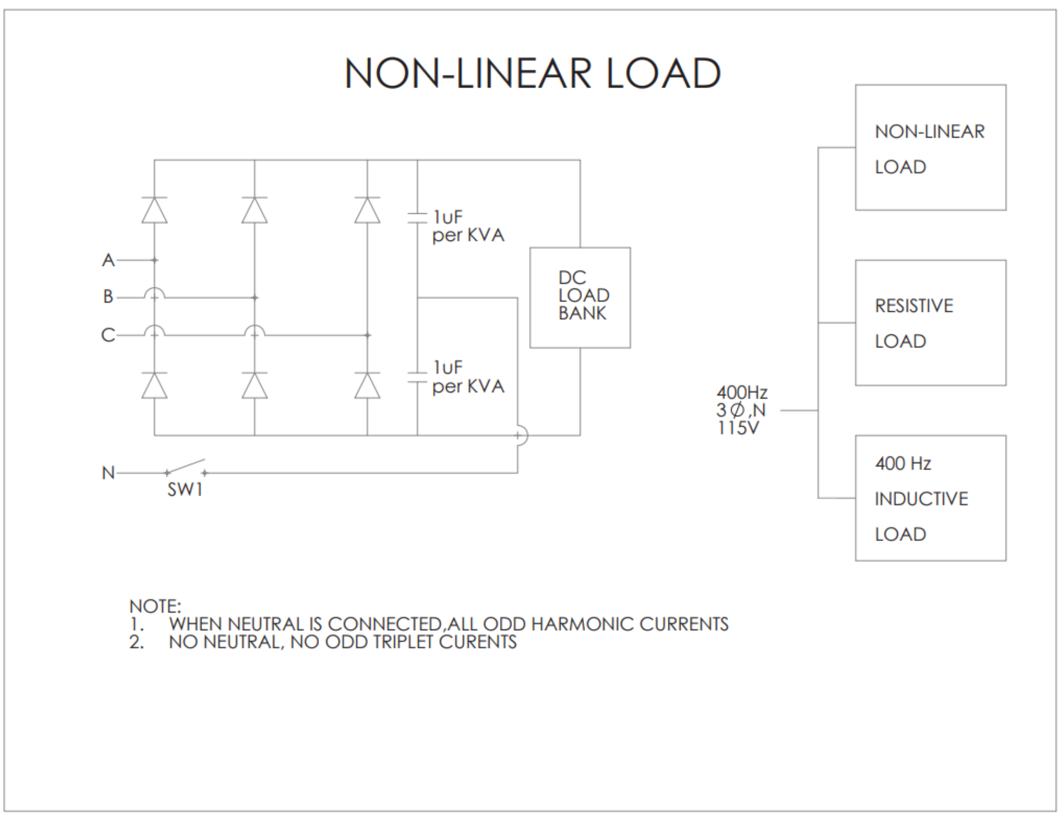


Table A-1 Effective AC Resistance and Inductance Values for THHN Copper Single Conductors at 400 Hz (Rac = microohms per ft, L = microhenries per ft)

Wire Size	In Air		Non-metallic Conduit		Rigid Alum. Conduit	
	Rac	L	Rac	L	Rac	L
#12	1970.67	0.08946	1970.67	0.10735	1970.67	0.10736
#10	1241.24	0.09131	1241.24	0.10957	1241.24	0.10957
#8	781.92	0.09403	781.92	0.11284	781.93	0.11284
#6	493.49	0.09223	493.49	0.11067	493.50	0.11067
#4	315.37	0.09317	315.37	0.11181	315.38	0.11181
#2	198.15	0.08921	198.15	0.10705	198.15	0.10705
#1	164.66	0.08788	164.66	0.10546	164.66	0.10546
#1/0	135.68	0.08675	135.68	0.10410	135.70	0.10410
#2/0	115.56	0.08506	115.56	0.10208	115.57	0.10208
#3/0	97.38	0.08346	97.38	0.10015	97.38	0.10015
#4/0	84.83	0.08263	84.83	0.09916	84.85	0.09916
250 MCM	76.68	0.08226	76.68	0.09872	76.68	0.09872
300 MCM	70.57	0.08090	70.57	0.09708	70.57	0.09708
350 MCM	64.35	0.08099	64.35	0.09719	64.36	0.09719
400 MCM	61.60	0.08015	61.60	0.09618	61.61	0.09618
500 MCM	54.79	0.07863	54.79	0.09436	54.79	0.09436
750 MCM	43.98	0.07779	43.98	0.09335	43.98	0.09335
1000 MCM	37.62	0.07684	37.62	0.09221	37.62	0.09221

Note 1: Table is a partial reprint from the 1972 February “Actual Specifying Engineer”.

Note 2: MCM is now more commonly referred to as kcmil, or thousands of circular mils.

APPENDIX B GLOSSARY

B-1 ACRONYMS

AC	Alternating Current
AFCEC	Air Force Civil Engineer Center
AWG	American Wire Gage
BIA	Bilateral Infrastructure Agreement
BOD	Basis of Design
CCR	Criteria Change Request
CE	Civil Engineering
DC	Direct Current
DoD	Department of Defense
DOR	Designer of Record
FDS	Functional Data Sheets
FLEDS	Flight Line Exterior power Distribution Systems
FPUS	Fixed Point Utility Systems
FRD	Facility Requirements Document
ft	Feet (or Foot)
GPU	Ground Power Unit
GSE	Ground Support Equipment
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HNFA	Host Nation Funded Construction Agreements
Hz	Hertz
kVA	Kilo-Volt-Ampere
LANT	NAVFAC Atlantic
lb	Pound

m	Meter
mm	Millimeter
MCM	kcmil, or thousands of circular mils
MILCON	Military Construction
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Systems Command
NAWCAD	Naval Air Warfare Center Aircraft Division
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
O&M	Operation and Maintenance
POU	Point-of-Use
RFP	Request for Proposals
RPIE	Real Property Installed Equipment
SE	Service Equipment
SOFA	Status of Forces Agreements
SOPs	Standard Operating Procedures
UFC	Unified Facilities Criteria
UFGS	United Facilities Guide Specifications
U.S.	United States
V	Volt
VAC	Volts Alternating Current
VDC	Volts Direct Current

APPENDIX C REFERENCES

C-1 GOVERNMENT

DEPARTMENT OF DEFENSE

MIL-STD-704, *Aircraft Electric Power Characteristics.*

MIL-STD-3007, *Standard Practice for Unified Facilities Criteria, Facilities Criteria, and Unified Facilities Guide Specifications*.

MIL-DTL-32180, *Cable Assembly, Electrical Aircraft.*

U.S. FEDERAL AVIATION ADMINISTRATION

www.faa.gov/

FAA AC 70/7460-1, *Obstruction Marking and Lighting*

UNIFIED FACILITIES CRITERIA

www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc

UFC 1-200-01, *DoD Building Code*

UFC 2-000-05N, *Facility Planning Criteria for Navy and Marine Corps Shore Installations*

UFC 3-260-02, *Pavement Design for Airfields*

UFC 3-501-01, *Electrical Engineering*

UFC 3-510-01, *Foreign Voltages and Frequencies Guide*

UFC 3-520-01, *Interior Electrical Systems*

UFC 3-530-01, *Interior and Exterior Lighting Systems*

UFC 3-535-01, *Visual Air Navigation Facilities*

UFC 3-550-01, *Exterior Electrical Power Distribution*

UFC 3-555-01N, *400 Hertz Medium Voltage Conversion/Distribution and Low Voltage Utilization Systems*

UFC 3-560-01, *Operation and Maintenance, Electrical Safety*

UFC 3-575-01, *Lightning and Static Electricity Protection Systems*

UFC 4-010-06, *Cybersecurity of Facility-Related Control Systems*

UFC 4-211-01, *Aircraft Maintenance Hangars.*

UNIFIED FACILITIES GUIDE SPECIFICATIONS

www.wbdg.org/ffc/dod/unified-facilities-guide-specifications-ufgs

UFGS 25 05 11, *Cybersecurity for Facility-Related Control Systems*

UFGS 26 35 43, *400 Hz Solid State Frequency Converter*

UFGS 26 35 44, *270 VDC Solid State Converter*

C-2 NON-GOVERNMENT

INTERNATIONAL ELECTROTECHNICAL COMMISSION

www.iec.ch

IEC 60529, *Degrees of Protection Provided by Enclosures*

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION

www.nema.org

NEMA 250, *Enclosures for Electrical Equipment (100 Volts Maximum)*

NATIONAL FIRE PROTECTION ASSOCIATION

www.nfpa.org

NFPA 70, *National Electrical Code*

NFPA 70E, *Standard for Electrical Safety in the Workplace*

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL

www.sae.org

SAE AS7974, *Cable Assemblies and Attachable Plugs, External Electrical Power, Aircraft*

SAE AS5756, *Cable, Power, Electrical, Portable*

SAE AS5756/6, *Cable, 3-Phase Power, Electric Portable, Multiconductor, 90 Degrees C, 600V, Ozone Resistant, Split phase*