

DDS 314-4
1 July 1980

Supersedes DDS 314-4, dated 1 October 1972

400-HERTZ POWER SYSTEM TEST PROCEDURE

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TABLES:

Table I: Instrument types and accuracies

List of Report Forms:

<u>Report Forms:</u>	<u>Title</u>
1	Instrument Data
2	Power Conversion Equipment--No Load Test
3	Power Conversion Equipment--Steady State Test
4	Power Conversion Equipment--Transient Test Load Removal
5	Power Conversion Equipment--Transient Test Load Applied
6	Power Conversion Equipment--Harmonic Voltage Analysis Test
7	Power Conversion Equipment--Harmonic Voltage Test--3 Phase
8	Power Conversion Equipment--Line Voltage Regulator No Load Stability Test
9	Line Voltage Regulator Steady State Test
10	Line Voltage Regulator Transient Test
11	Line Voltage Regulator Harmonic Test

314-4-a. References

- (a) DOD-STD-1399, Section 300
Interface Standard for Shipboard Systems,
Electric Power, Alternating Current
- (b) Design Data Sheet DDS 310-1. Design Details
of Generating Plants

314-4-b. Scope

This Design Data Sheet provides a guide for conducting 400-Hz power system tests to determine that the 400-Hz power system is compatible with the equipment served and that the system characteristics are within the limits specified in reference (a). For definitions, refer to reference (a). For definitions of ship operating conditions, see reference (b).

314-4-c. Test Instruments

Instruments required for these tests shall have accuracies in accordance with Table I. All instruments used for test measurements shall be calibrated. Instrument data and calibration dates shall be recorded on Report Form 1 as specified herein.

314-4-d. General description of tests

With normal (battle or functional) loads on the equipment providing power to the 400-Hz Power Conversion Equipment (PCE) primary power sources (normally the 60-Hz ship service distribution system), tests on the 400-Hz system shall be conducted at no load, normal battle or functional load, and alternate load, or a combination of normal plus alternate loads, as applicable. During tests under the various loaded conditions, all available equipment shall be in operation at the same time to insure compatibility of equipments. Only tests required for completion of Report Form 2 and 3, as specified herein, need be conducted when the PCE is dedicated to a single load.

The tests shall determine:

- Steady state voltage
- Steady state frequency
- Steady state line current
- Steady state voltage amplitude modulation
- Steady state voltage unbalance
- Average phase voltage for 3 phases
- Transient voltage, current, and frequency
- Voltage and frequency recovery time
- Maximum single harmonic
- Total harmonic distortion

During tests, the 400-Hz utilization equipment shall be observed and any malfunction in operation shall be noted. If there is no malfunction, this fact shall be recorded on the data sheet. If characteristics, such as voltage unbalance, amplitude modulation, or harmonics, exceed the limits specified in reference (a), individual loads shall be disconnected and measurements repeated for the particular characteristic to determine if the load causing the departure from the specified limit can be isolated. Loads causing characteristic limits to be exceeded shall be identified on the appropriate Report Form.

314-4-e. Meter checks

Frequency meter checks.- Prior to start of tests, it shall be ascertained that the 60-Hz power source is operating at nominal 60-Hz setting. The 3-phase voltages and frequency of the input power to the power conversion equipment (motor-generator sets, inverters, and converters) at the nearest switchboard load center or panel (distribution point) supplying the equipment shall be observed and recorded. With the 400-Hz PCE operating at no load and after the equipment has reached normal operating temperature, the frequency of the PCE shall be set at 400-Hz using a frequency standard. A check shall be made for error between the switchboard-mounted meter and the frequency standard. If the error is outside of the calibration limits of the switchboard-mounted meter, the meter shall be recalibrated in order to bring it within the calibration limits. If the error in calibration of the switchboard-mounted frequency meter cannot be corrected, the error shall be noted on Report Form 2 as specified herein.

Voltmeter checks.- Prior to start of tests, it shall be ascertained that the 60-Hz power source is operating at nominal 450 volts. With each 400-Hz PCE operating at no load, the output voltage of the equipment shall be set at 450 volts using a true rms voltage standard. If error is outside of the calibration limits of the switchboard-mounted meter, the meter shall be recalibrated in order to bring it within the calibration limits. If calibration of switchboard-mounted voltmeter cannot be obtained, the error shall be noted on Report Form 2 as specified herein.

314-4-f. Power conversion equipment test

No load or minimal load test.- Prior to starting, record the 3-phase voltages and the frequency of the input power to the PCE at the distribution point that normally feeds the equipment. Record the switchboard load center or panel number. With no load on the equipment, (or minimal load on equipment provided with no load disconnect) start the unit. After the equipment has reached normal operating temperature, record the phase voltages and frequency of the PCE output. These readings shall be taken at the nearest distribution equipment fed by the equipment. For power conversion equipment provided with output voltage compensation, the readings shall be taken at the distribution equipment or bus where the line voltage has been compensated. Record the distribution equipment number. Record the readings of 400-Hz switchboard-mounted voltage and frequency meters. Indicate any error. Record information on Report Form 2 as specified herein.

Steady-state tests.- With the PCE supplying its normal load, record the 3-input phase voltages, and the input frequency record and the number

of the switchboard where the readings were taken. Record the PCE output frequency and phase voltages, and the number of the switchboard where the readings were taken. For the output of the PCE, record the average line-to-line 3-phase voltage, the maximum voltage unbalance between phases, the percent voltage unbalance, and percent amplitude modulation of each phase voltage. Record the output line current in one phase, and the total kW rating of the load. Record the information on Report Form 3 as specified herein. If voltage unbalance limits are exceeded, record all output line currents.

Transient tests.- With the PCE supplying its normal load, suddenly remove the largest single load which can be deenergized and rapidly reenergized without damage. Allow the equipment to stabilize, then reapply the load in one step. Record the information required on Report Forms 4 and 5 as specified herein.

Repeat tests.- Repeat the steady-state test and the transient test with the PCE fed from the same 60-Hz source, but supplying alternate loads or a combination of normal and alternate loads, as applicable. Record the information on Report Forms 3, 4, and 5 as specified herein.

Harmonic analysis.- Measure the harmonic voltage measurements from the 1st through the 50th harmonic on one output phase of PCE at no load, normal load, and alternate load, or a combination of normal and alternate loads, as applicable. Record the information on Report Form 6 as specified herein.

Measure the harmonic voltages from the 1st through the 13th on all 3 output phases of PCE with the equipment feeding no load, normal load, and alternate load, or a combination of normal and alternate loads as applicable. Record the information on Report Form 7 as specified herein.

314-4-g. Line voltage regulator tests

Power conversion equipment - Line Voltage Regulator (LVR) no load stability test.- For each PCE that feeds line voltage regulators (LVR), perform the following tests: with no load on the PCE other than the unloaded LVR the PCE supplies, vary the PCE voltage slowly over its maximum adjustment range while monitoring the PCE output voltage modulation. Record the maximum value of the modulation and the voltage at the time of the maximum modulation. Note: Insure that all LVR's supplied by the PCE are energized during the test. In the case of LVR's installed on aircraft servicing systems having available load monitors, it will be necessary to place a nominal load of 1 to 2 amperes on the regulators to close the input power switch to the regulator. Record the information required by this test on Report Form 8 as specified herein.

Steady state tests.- With the LVR operating at normal load, adjust the regulator for proper output voltage in accordance with the LVR technical manual. Record the input power source, the input voltage, frequency, and line current. Record the regulator output voltage, frequency, line current, and percent voltage modulation. Repeat the procedure, except with the regulator supplied from its alternate source. Record the information on Report Form 9 as specified herein. Under remarks, indicate if the line voltage regulators are connected in 3-phase, and if connected wye or delta.

Transient test.- With the regulator supplying its normal load, suddenly remove the largest single load which can be deenergized and rapidly reenergized without damage. Record the voltage transient and recovery time and the frequency transient and recovery time. Identify the load removed and record the full load line current of the load. After allowing the regulator to stabilize, reapply the load and record the voltage and frequency transient and recovery time. Record the information on Report Form 10 as specified herein.

Line voltage regulator harmonic analysis test.- Make harmonic measurements on the output of 400-Hz voltage regulators. Record harmonic voltages 1st through 13th. Measurements shall be made at no load, and at normal load. Record the information on Report Form 11 as specified herein.

NOTE: Table I and Forms 1 through 11 follow.

TABLE I. INSTRUMENT TYPES AND ACCURACIES

TYPE MEASUREMENT	TYPE MEASURING INSTRUMENT	SPEED AND/OR ACCURACY	PARAMETER(S) MEASURED	REMARKS
Short-time transient	Fast storage scope or transient peak recorder	0.5 micro seconds to 800 micro seconds ± 5 percent reading ± 1 percent full scale	Peak voltage	Continuous during tests
Long-time transient (load switching)	Scope and camera plus transducer, V converter or Oscilloscope or Oscillograph	V=± 5 percent of transient I=± 5 percent F=± 1 percent nominal	Transients: Volts(V) Current(I) Frequency (F) V & F recovery time	Taken at time load is turned on and load is turned off
Steady-state	True rms digital voltmeter(V) 3-ph wattmeter(W)* Spectrum analyzer(H) Current transducer(I) Digital frequency meter(f) Single trace or dual trace storage oscilloscope with camera (A) * May use meter on switchboard if available	V=± 0.2 percent W=± 5 percent H=± 10 percent I=± 5 percent f=± 0.1 percent A=± 0.2 percent	3-ph average volts (V) 3-ph watts(W) Frequency(F) Current(I) Voltage unbalance (V) Harmonic distortion(H) Amplitude modulation(A)	Strip type on sample printer type instruments may be used for these readings as applicable.

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POWER CONVERSION EQUIPMENT -- NO LOAD TEST

SHIP NAME AND NO. _____

PCE No.									
kW Rating									
Type Power (Output)									
60 Hz	60-Hz. Swbd. No. (normal input)								
	Input voltage prior to start	AB							
		BC							
		CA							
Input frequency									
400 Hz Measurements	400-Hz Swbd No.		Normal	Alternate	Normal	Alternate	Normal	Alternate	
	Output Voltage after start	AB							
		BC							
		CD							
	Output frequency								
	Installed meters			Volts	Percent error	Volts	Percent error	Volts	Percent error
	Voltage meter	AB							
BC									
Frequency meter			Hz		Hz		Hz		

Remarks:

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POWER CONVERSION EQUIPMENT -- STEADY-STATE TEST

SHIP NAME AND NO. _____

		PCE No.		PCE No.		PCE No.	
		Normal	Alternate	Normal	Alternate	Normal	Alternate
60 Hz	Swbd. or Panel No.		XXXXXXXXXX		XXXXXXXXXX		XXXXXXXXXX
	Frequency	Hertz					
	Input Volts	Phase AB Phase BC Phase CA					
100 Hz Measurements	Swbd. or Panel No.						
	Frequency	Hertz					
	Output Volts	Phase AB Phase BC Phase CA					
	Average Line to Line 3-ph Volts						
	Maximum Voltage Unbalance	Between phases percent Unbalance					
	Percent Amplitude Modulation	Phase AB Phase BC Phase CA					
	Current	Phase measured Amperes					
kW of load							

Remarks:

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POWER CONVERSION EQUIPMENT -- TRANSIENT TEST -- LOAD REMOVAL

SHIP NAME AND NO. _____

PCE No. _____

	Normal	Alternate	Normal	Alternate	Normal	Alternate
400-Hz Voltage prior to removal of load						
Max. 400-Hz Voltage during transient						
0 Hz Voltage after transient						
Max. percent volt. rise						
Volt. recovery time						
Frequency prior to removal of load						
Max. transient freq.						
Freq. recovery time						
400-Hz Current prior to transient						
Phase Meas. Amps.						
Magnitude of current during maximum transient						
Current after transient						
Max. percent 60-Hz volt. rise						
60-Hz volt recovery time						
Load removed (name)						

Remarks:

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POWER CONVERSION EQUIPMENT -- TRANSIENT TEST -- LOAD APPLIED

SHIP NAME AND NO. _____

PCE No. _____

	Normal	Alternate	Normal	Alternate	Normal	Alternate
400-Hz Voltage prior to application of load						
Min. 400-Hz Voltage during transient						
400-Hz Voltage after transient						
Max. percent voltage dip						
Voltage recovery time						
Frequency prior to adding load						
Max. transient freq.						
Freq. recovery time						
400-Hz Current prior to transient						
Magnitude of current during maximum transient						
Current after transient						
Max. percent 60-Hz volt drop						
60-Hz volt recovery time						
Load added (name)						

Phase Meas.
Amps.

Remarks:

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POWER CONVERSION EQUIPMENT -- HARMONIC VOLTAGE ANALYSIS TEST

SHIP NAME AND NO. _____

Harm. No.	Freq. (Hz)	PCE No.			PCE No.			PCE No.		
		No Load	Nor. Load	Alt. Load	No Load	Nor. Load	Alt. Load	No Load	Nor. Load	Alt. Load
1	400									
2	800									
3	1200									
4	1600									
5	2000									
6	2400									
7	2800									
8	3200									
9	3600									
10	4000									
11	4400									
12	4800									
13	5200									
14	5600									
15	6000									
16	6400									
17	6800									
18	7200									
19	7600									
20	8000									
21	8400									
22	8800									
23	9200									
24	9600									
25	10000									
26	10400									
27	10800									
28	11200									
29	11600									
30	12000									
31	12400									
32	12800									

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POWER CONVERSION EQUIPMENT -- HARMONIC VOLTAGE ANALYSIS TEST

SHIP NAME AND NO.

Harm. No.	Freq. (Hz)	PCE No.			PCE No.			PCE No.		
		No Load	Nor. Load	Att. Load	No Load	Nor. Load	Att. Load	No Load	Nor. Load	Att. Load
33	13200									
34	13600									
35	14000									
36	14400									
37	14800									
38	15200									
39	15600									
40	16000									
41	16400									
42	16800									
43	17200									
44	17600									
45	18000									
46	18400									
47	18800									
48	19200									
49	19600									
50	20000									
Phased Meas.										
Total Percent Harm.										

Remarks:

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POWER CONVERSION EQUIPMENT -- HARMONIC VOLTAGE TEST -- THREE PHASE

SHIP NAME AND NO. _____

PCE No. _____

Phase	Harm. No.	Freq. Hz.	No Load			Normal Load			Att. Load		
			AB	BC	CA	AB	BC	CA	AB	BC	CA
	1	400									
	2	800									
	3	1200									
	4	1600									
	5	2000									
	6	2400									
	7	2800									
	8	3200									
	9	3600									
	10	4000									
	11	4400									
	12	4800									
	13	5200									
Total Percent Harmonic											

Remarks:

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POWER CONVERSION EQUIPMENT -- LINE VOLTAGE REGULATOR NO LOAD STABILITY TEST

SHIP NAME AND NO.

PCF No.

PCF Subid No.

Percent Voltage
Modulation
Voltage at time of
maximum modulation

Remarks:

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LTWE VOLTAGE REGULATOR STEADY STATE TEST

SHIP NAME AND NO. _____

Regulator No.						
KVA Rating						
Voltage						
Phase						
	Normal	Alternate	Normal	Alternate	Normal	Alternate
Input power source						
Input voltage						
Input frequency						
Input current						
Output Voltage						
Phase						
Output Frequency						
Output Current						
Output Percent Voltage Modulation						

Remarks:

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LINE VOLTAGE REGULATOR TRANSIENT TESTS

SHIP NAME AND NO.

Regulator No.

Max. Voltage transient percent

Voltage recovery time

Max. Freq. transient percent

Load removed and reapplied (name)

Line current to the load

RISE

DIP

RISE

DIP

RISE

DIP

Remarks:

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LINE VOLTAGE REGULATOR HARMONIC TEST

SHIP NAME AND NO. _____

Regulator No.		No Load		Mor. Load		No Load		Mor. Load		No Load		Mor. Load	
Harm. No.	Freq. Hz.												
1	400												
2	800												
3	1200												
4	1600												
5	2000												
6	2400												
7	2800												
8	3200												
9	3600												
10	4000												
11	4400												
12	4800												
13	5200												
Total percent harmonic Phase Meas.													

Remarks:

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