SEMI F47 Compliance Certificate
KEPCO High-Power Power Supplies
EPRI PEAC Corporation PQ Star℠ Test Program

Certification Date: July 23, 2003

PQ Star℠ Reference Number
SEMIF47.059

Manufacturer: *Kepco*

Product: *High Power RKW Series Power Supplies*

Model Number: *RKW 24-14K, RKW 28-23K, RKW 48-32K*

Serial Number (Unit Tested): *36400762, 32400593, and 29400545*

See Attachment C for SEMI F47 Description and Detailed Test Results.

Test Configuration: The *Power Supplies* were tested using SEMI F42 compliant voltage sag generator equipment.

Test Date(s):
July 17,18, 2003

Test Location:
EPRI PEAC Corporation
942 Corridor Park Blvd
Knoxville, TN 37932

Electrical Environment:
208Vac Single Phase, 50/60 Hz
(See Attachment A for details.)

This letter and subsequent documentation certifies that the KEPCO power Supplies mentioned above and in this document, in their original configuration has been voltage sag tested per **SEMI F42** test protocol and was found to comply with the **SEMI F47** voltage sag immunity standard at 50Hz and 60Hz. Based on these test results, it is expected that the entire RKW high power unit line is SEMI F47 compliant. This certification remains valid to the models tested only and as long as no component substitutions are made.

Certified by,

Eric L. Hubbard

Eric L. Hubbard
PQ Star Certification Test Technician

High-Power RKW Series Power Supplies

Attachment A – SEMI F47 Test Results

Testing was performed EPRI PEAC's Power Quality Laboratory in Knoxville, TN. The test protocol followed was SEMI F42 Test Method for Semiconductor Processing Equipment Voltage Sag Immunity. During the voltage sag test; the Power supplies were connected to a load bank and loaded to 100% of their load. Table A-1 shows the nominal power supplies model number, their power ratings, and the load conditions they were tested at.

Table A-2 through Table A-4 lists all points tested per SEMI F42 test method, per individual power supply. Figures A-1 through Figure A-3 show the power supply specific SEMI F47 ride-through curve. The SEMI specific points are highlighted for both 50 and 60 Hz. The power supplies were tested at points below the curve to fully characterize the components. During the testing of SEMI F47 test points (1s at 80%, 0.5s at 70%, 0.2s at 50%, and 0.05s at 50%) the output voltage of the power supply did not deviate. Deviation is noted in the test tables and at what points the output voltage deviated. It's important to note that all of the power supplies passed at 50 and 60 Hz, according to the SEMI F47 standard.

Table A-1 Power Supplies and Loads

Kepco Power Supplies Testing							
	Rated Load				Tested Load		
Model #	Power (W)	Vdc (V)	Idc (a)	R (ohms)	Power (W)	Vdc (V)	Idc (a)
RKW 24-14K	300	24	12.5	1.9	297.5	23.99	12.4
RKW 28-23K	600	28	21.4	1.3	593.8	28.01	21.2
RKW 48-32K	1500	48	31.3	1.5	1529.4	48.4	31.6

Table A-2 RKW 24-14K Test Results

Duration		Duration		Percent of Nominal			
Seconds	Cycles	Seconds	Cycles	DUT 60Hz	DUT 50Hz	SEMI F47	Results
1	60	1	50	35%	30%	80%	Passed
0.50	30	0.50	25	35%	30%	80%	Passed
0.50	30	0.50	25	30%	30%	70%	Passed
0.25	15	0.25	12.5	30%	30%	70%	Passed
0.20	12	0.20	10	30%	30%	70%	Passed
0.20	12	0.20	10	30%	30%	50%	Passed
0.17	10	0.17	8.5	30%	30%	50%	Passed
0.08	5	0.08	4	25%	25%	50%	Passed
0.07	4	0.07	3.5	20%	25%	50%	Passed
0.05	3	0.05	2.5	15%	15%	50%	Passed
0.03	2	0.03	1.5	0%	0%	50%	Passed
0.02	1	0.02	1	0%	0%	50%	Passed

Table A-3 RKW 28-23K Test Results

Duration		Duration		Percent of Nominal			
Seconds	Cycles	Seconds	Cycles	DUT 60Hz	DUT 50Hz	SEMI F47	Results
1	60	1	50	35%	35%	80%	Passed
0.50	30	0.50	25	35%	35%	80%	Passed
0.50	30	0.50	25	30%	30%	70%	Passed
0.25	15	0.25	12.5	30%	30%	70%	Passed
0.20	12	0.20	10	30%	30%	70%	Passed
0.20	12	0.20	10	30%	30%	50%	Passed
0.17	10	0.17	8.5	30%	30%	50%	Passed
0.08	5	0.08	4	25%	25%	50%	Passed
0.07	4	0.07	3.5	25%	25%	50%	Passed
0.05	3	0.05	2.5	20%	20%	50%	Passed
0.03	2	0.03	1.5	0%	0%	50%	Passed
0.02	1	0.02	1	0%	0%	50%	Passed

Table A-4 RKW 48-32K Test Results

Duration		Duration		Percent of Nominal			
Seconds	Cycles	Seconds	Cycles	DUT 60Hz	DUT 50Hz	SEMI F47	Results
1	60	1	50	40%	40%	80%	Passed
0.50	30	0.50	25	40%	40%	80%	Passed
0.50	30	0.50	25	35%	40%	70%	Passed
0.25	15	0.25	12.5	35%	35%	70%	Passed
0.20	12	0.20	10	35%	35%	70%	Passed
0.20	12	0.20	10	35%	35%	50%	Passed
0.17	10	0.17	8.5	35%	35%	50%	Passed
0.08	5	0.08	4	25%	25%	50%	Passed
0.07	4	0.07	3.5	25%	25%	50%	Passed
0.05	3	0.05	2.5	20%	15%	50%	Passed
0.03	2	0.03	1.5	0%	0%	50%	Passed
0.02	1	0.02	1	0%	0%	50%	Passed

Figure A-1 RKW 24-14K SEMI F47 Ride-Through Curve

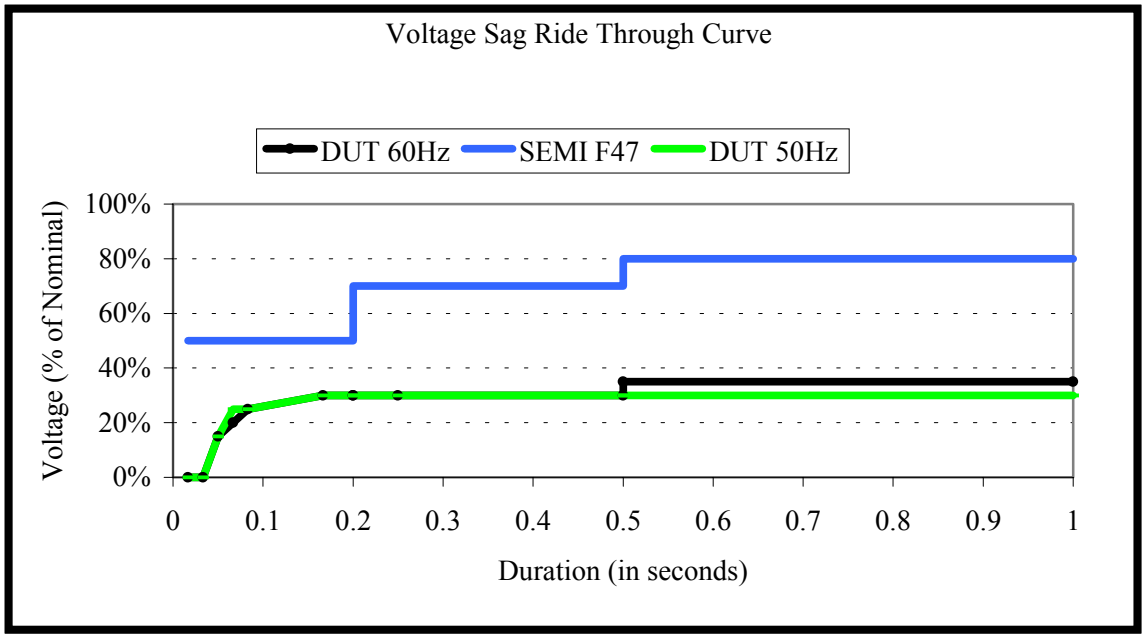


Figure A-2 RKW 28-23K SEMI F47 Ride-Through Curve

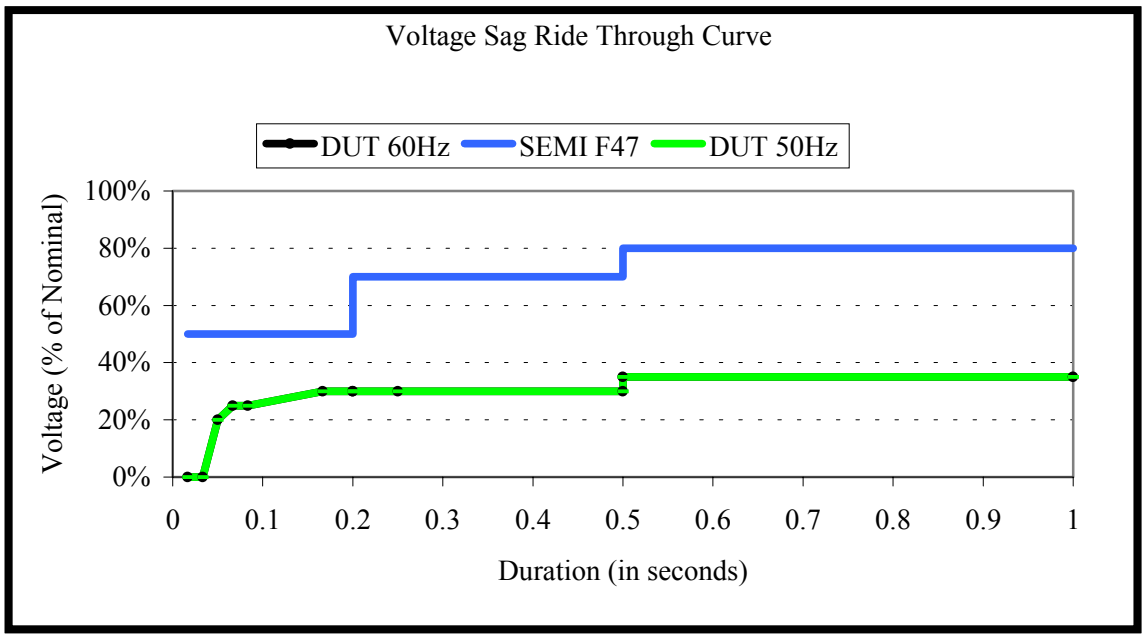
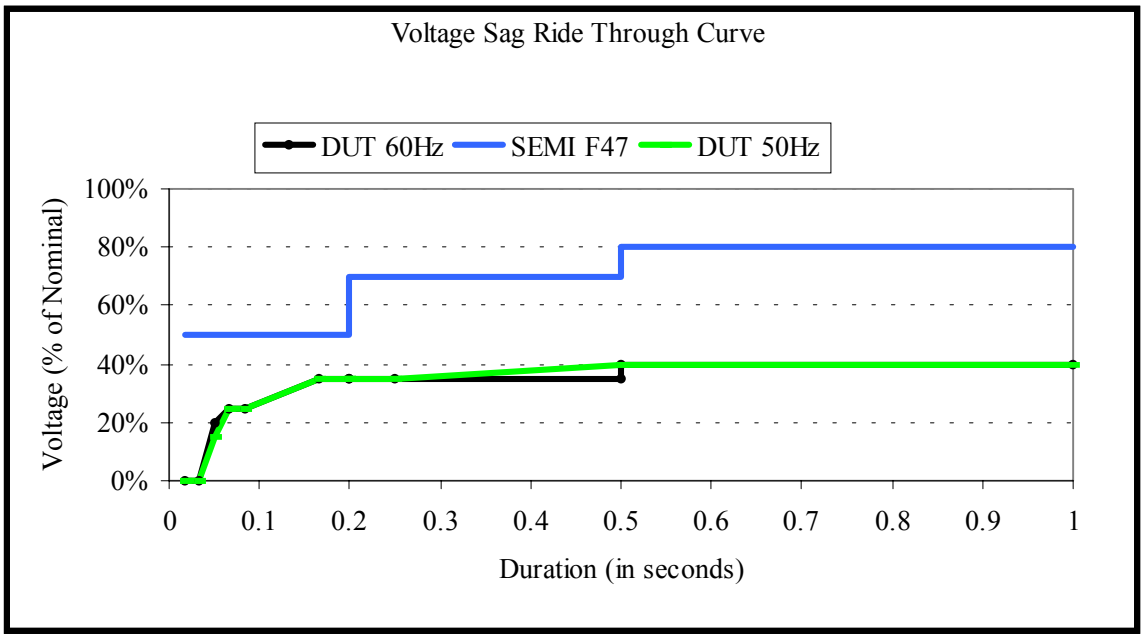


Figure A-3 RKW 48-32K SEMI F47 Ride-Through Curve



The power supplies showed themselves to be robust and resistant to sags, allowing 1s 40% sags in some instances, before the output of the power supplies would collapse. To illustrate the magnitude of the sags, figures below contain waveforms of the actual sags induced into the power supplies.

Figure B-1 Phases A-B, 50%, 12 Cycle Voltage Sag, 60 Hz

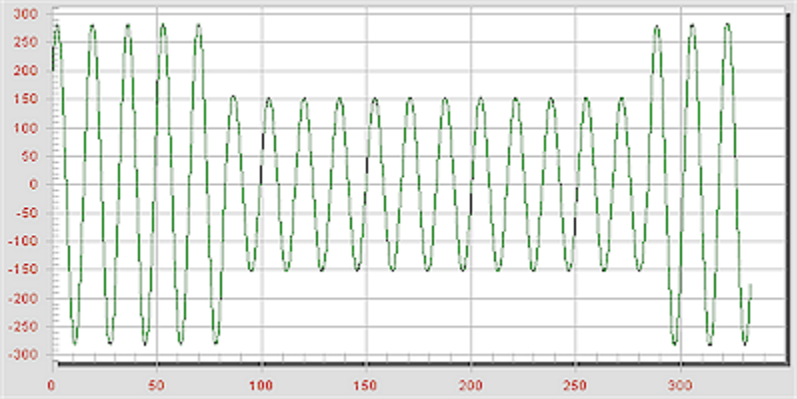


Figure B-2 Phases A-B, 70%, 30 Cycle Voltage Sag, 60 Hz

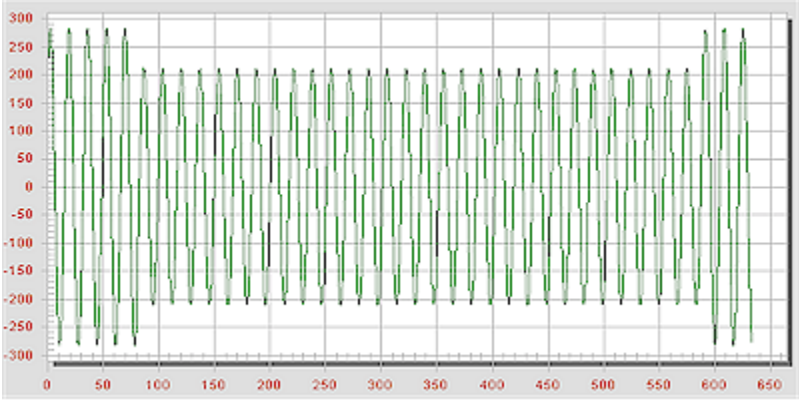


Figure B-3 Phases A-B, 50%, 10 Cycle Voltage Sag, 50 Hz

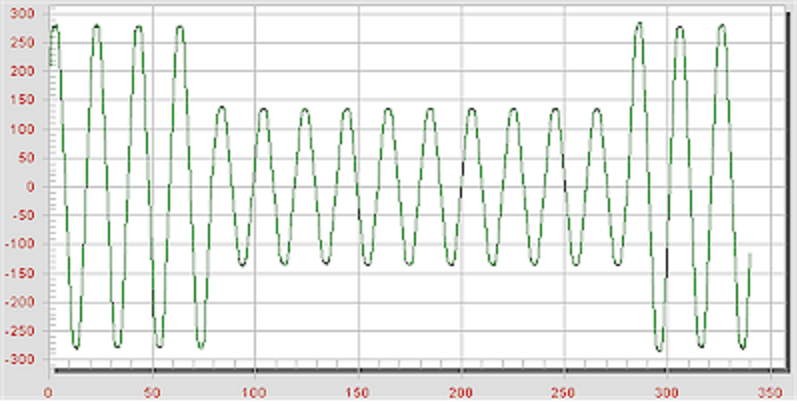
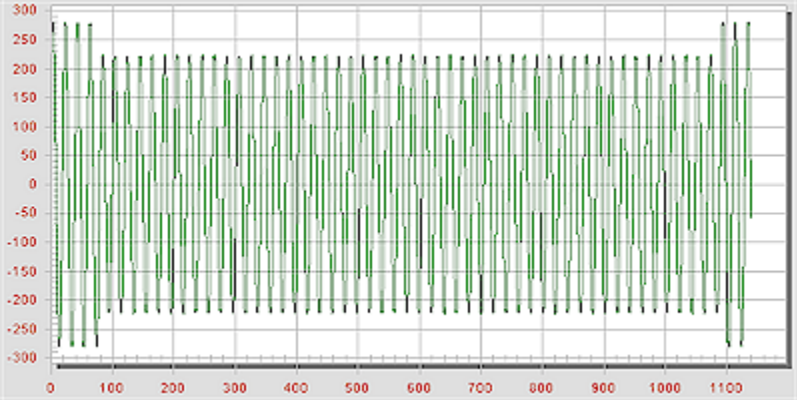


Figure B-4 Phases A-B, 80%, 50 Cycle Voltage Sag, 50 Hz



Electrical Environment

Steady state measurements were taken prior to testing. Table C-1 through Table C-3 lists measurements taken to characterize the electrical environment of the individual power supplies during SEMI F47 compliance testing, at 50/60 Hz.

Table C-1 Steady State Measurements RKW 24-14K

RKW 24-14K		
Measurement Parameters	**Test Process State 60 Hz**	**Test Process State 50 Hz**
Rated Voltage P-N	**208**	**208**
Voltage (Va-n)	**206**	**206**
Current (Ia)	**1.61**	**1.68**
Power (KWa-n)	**0.32**	**0.33**
Volt Amps (KVA)	**0.33**	**0.34**
Vthd (Phase A) %	**2.7%**	**2.8%**
Ithd (Phase A) %	**12%**	**15%**
I1	**1.6**	**1.65**
I3	**0.14**	**0.16**
I5	**0.11**	**0.2**
Power Factor	**0.98**	**0.98**
Crest Factors	**1.48**	**1.5**
Hertz	**60**	**50**

Table C-2 Steady State Measurements RKW 28-23K

RKW 28-23K		
Measurement Parameters	**Test Process State 60 Hz**	**Test Process State 50 Hz**
Rated Voltage P-N	208	208
Voltage (Va-n)	205	206
Current (Ia)	3.18	3.87
Power (KWa-n)	0.64	0.64
Volt Amps (KVA)	0.65	0.66
Vthd (Phase A) %	2.7%	2.75%
Ithd (Phase A) %	9%	9.20%
I1	3.16	3.81
I3	0.2	0.21
I5	0.17	0.16
Power Factor	0.99	0.99
Crest Factors	1.47	1.52
Hertz	60	50

Table C-3 Steady State Measurements RKW 48-32K

RKW 48-32K		
Measurement Parameters	**Test Process State 60 Hz**	**Test Process State 50 Hz**
Rated Voltage P-N	208	208
Voltage (Va-n)	205	203
Current (Ia)	7.88	7.96
Power (KWa-n)	1.6	1.6
Volt Amps (KVA)	1.61	1.62
Vthd (Phase A) %	280.0%	2.9%
Ithd (Phase A) %	390%	4%
I1	7.87	7.96
I3	0.16	0.22
I5	0.18	0.17
Power Factor	1	0.99
Crest Factors	1.38	1.41
Hertz	60	50

Attachment B - Test Configuration

Test Configuration
The SEMI F42 compliant voltage sag generator was placed in series with the main power feed, in according with SEMI F42 and shown in Figure B-1. The Main power feed for this test was an amplifier that was adjustable for voltage and frequency. This allowed a precise setting of 208 Vac and 50 or 60 Hz.
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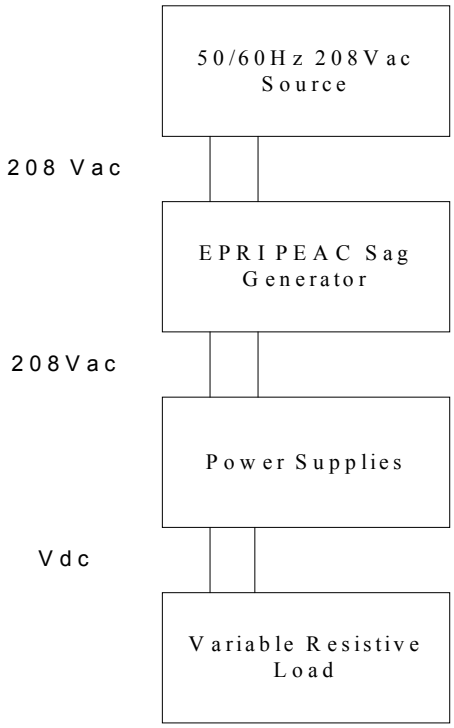
Figure B-1 – Test Configuration



Attachment C - SEMI F47 Abstract

The SEMI F47 "Specification for Semiconductor Processing Equipment Voltage Sag Immunity" document defines the threshold that a semiconductor tool must operate without interruption (per SEMI F42) and it also provides a target for the facility and utility systems. The Recognizing semiconductor factories require high levels of power quality due to the sensitivity of equipment and process controls and that Semiconductor processing equipment is especially vulnerable to voltage sags, this document defines the voltage sag ride-through capability required for semiconductor processing, metrology, and automated test equipment.

The requirements in this international standard were developed to satisfy semiconductor industry needs. While more stringent than existing generic standards, this industry-specific specification is not in conflict with known generic equipment regulations from other regions or generic equipment standards from other organizations. It is the intent of this standard to provide specifications for semiconductor processing equipment that will lead to improved selection criteria for sub-components and improvements in equipment systems design. While it is recognized that in certain extreme cases or for specific functions battery storage devices may be appropriate, it is not the intent of this standard to increase the size or use of battery storage devices provided with equipment. Focus on improvements in equipment component and system design should lead to a reduction or elimination in the use of battery storage devices to achieve equipment reliability during voltage sag events.

The SEMI F47 document specifies the minimum voltage sag ride-through capability design requirements for equipment used in the semiconductor industry. The expected equipment performance capability is shown graphically on a chart representing voltage sag duration and percent deviation of equipment nominal voltage. The primary focus for this specification is semiconductor processing equipment including but not limited to the following tool types:

- Etch equipment (Dry & Wet)
- Film deposition equipment (CVD & PVD)
- Thermal equipment
- Surface prep and clean
- Photolithography equipment (Stepper & Tracks)
- Chemical Mechanical Polishing equipment
- Ion Implant equipment
- Metrology equipment
- Automated test equipment

The actual SEMI F47 ride-through curve is shown below.

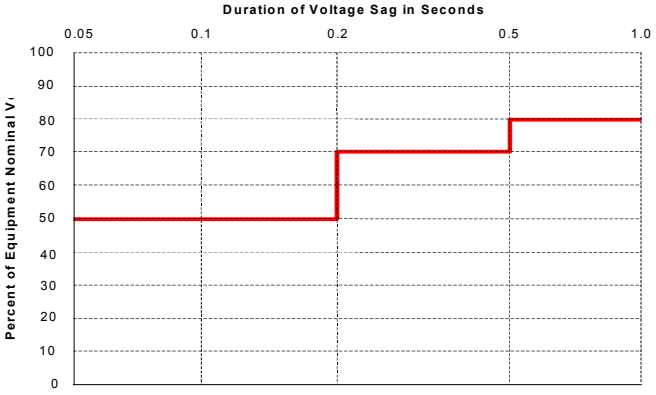


Figure A-1 The SEMI F47 Voltage Sag Ride-Through Curve

The specification states that Semiconductor processing, metrology, and automated test equipment must be designed and built to conform to the voltage sag ride-through capability per the defined curve. Equipment must continue to operate without interrupt (per SEMI E10) during conditions identified in the area above the defined line. In the

context of SEMI F47, interrupt means any assist or failure. An assist is defined as an unplanned interruption that occurs during an equipment cycle where all three of the following conditions apply:

- The interrupted equipment cycle is resumed through external intervention (e.g., by an operator or user, either human or host computer).
- There is no replacement of a part, other than specified consumables.
- There is no further variation from specification of equipment operation.

Furthermore, a failure is any unplanned interruption or variance from the specifications of equipment operation other than assists. Although no variation in the tool's process is the goal, this standard addresses these issues as related to the equipment operation only.

EPRI PEAC Corporation PQ Star℠ Certification for the Semiconductor Industry

Having conducted power quality tests on hundreds of devices and electrical equipment since 1992, EPRI PEAC Corporation is known worldwide for power quality testing expertise. Since April 1997, EPRI PEAC has conducted voltage sag testing on over 63 semiconductor processing tools. In order to serve the semiconductor industry, EPRI PEAC Corporation has established a certification program to test manufacturer equipment per established power quality standards. PQ Star℠ certification for the SEMI F47 standard (Specification for semiconductor Processing Equipment Voltage Sag Immunity) is now available for semiconductor equipment suppliers. EPRI PEAC utilizes the SEMI F42 test standard (Test Method for Semiconductor Processing Equipment Voltage Sag Immunity). With the PQ Star certification, EPRI PEAC Corporation offers a third party verification that the equipment tested meets this important new power quality standard.

For more information about the PQ Star℠ test program for the semiconductor industry or inquire about testing, contact Mark Stephens at mstephens@epri-peac.com

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