Pre and Post SEMI F47 Compliance Issues

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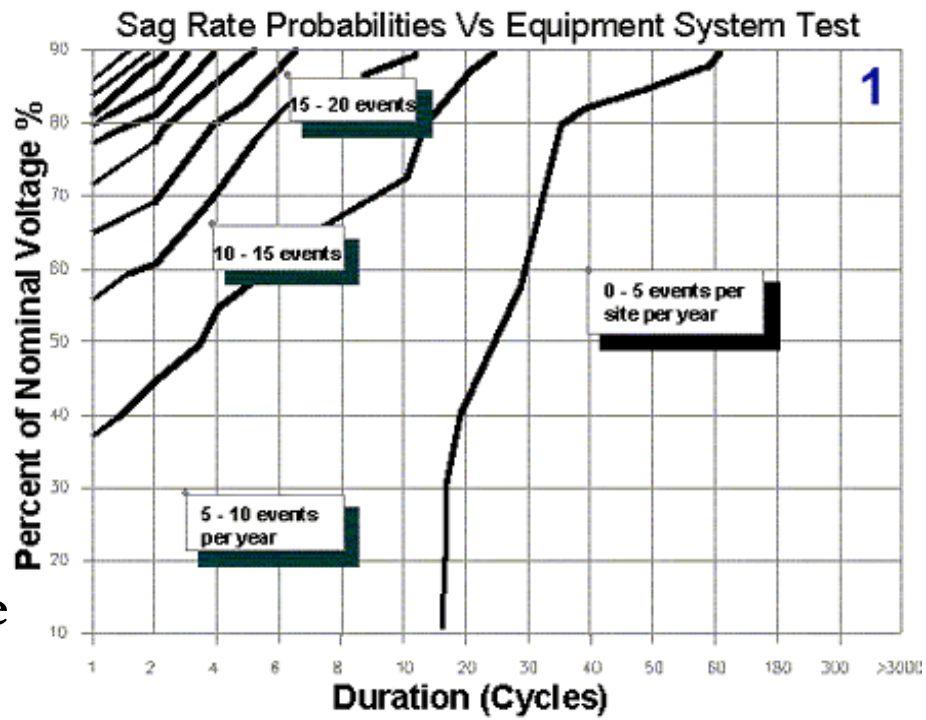
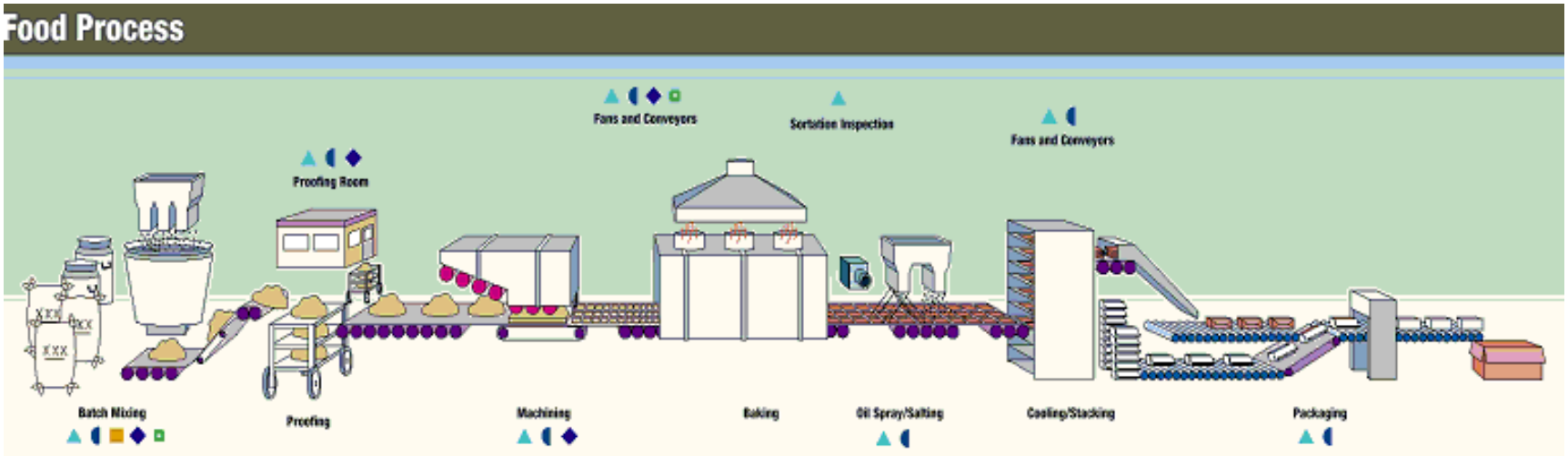
Goal of Power Quality Standards

- **Uniform Requirements for industry**
- **Improvement in Equipment Performance**
- **Goal for Utility Performance**
- **Provide Benchmark for PQ Measurements**
- **Societal Benefit for End User (lower cost of ownership)**
- **Comparison of PQ Performance between equipment**



The Ultimate Goal: Eliminating… The Weakest Link!



- **The process is as robust as its "weakest link."**

- **Process controls are in most cases are the weakest link.**
- **Managing PQ disturbances are often managing the weakest links in a process.**

Pre-SEMI F47 - EPRI Task 24

- **EPRI Began System Compatibility Research Project in 1996 entitled "Task 24: Power Quality in the Semiconductor Industry"**
- **Participants:**

–AMD
–Applied Materials
–ASM Europe
–Blake Technologies
–Central Hudson Gas and Electric
–CFM Technologies
–Duke Power
–EMRO, Inc.
–EPRI/ PEAC
–FOA Associates
–FSI International
–Green Mountain Power
–IBM Burlington
–IBM East Fishkill
–Lam Research Corporation
–Motorola
–National Semiconductor
–Public Service New Mexico
–Reliability Incorporated
–Rockwell Semiconductor
–Rudolph Technologies
–Salt River Project
–San Diego Gas and Electric
–SCP Global
–SEMATECH
–Stellar Dynamics
–Texas Instruments
–Texas Utilities Company

Objectives and Outcomes of Task 24

- **Identify the most critical processes and most vulnerable devices in the semiconductor-fabrication process along with the power requirements for these processes and devices, combining user experience and laboratory testing as needed.**
- **Develop appropriate system compatibility criteria and test protocols (considering IEC, IEEE, SEMI, and other related standards) that could establish baseline performance criteria for semiconductor-fabrication tools**
- **Make recommendations for improving the immunity of tools, applying power conditioning, and mitigating power quality problems in semiconductor-fabrication processes.**
- **All objectives were accomplished including the formulation of Two SEMI Standards and Three Guideline documents.**

Pre-SEMI F47 Time-Line

Task 24 Research and Testing

June 97

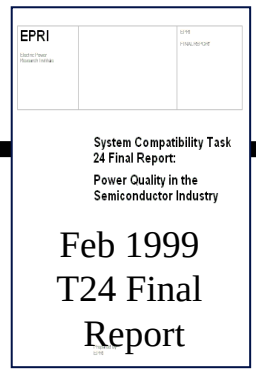
Nov 1998

33 Tools Tested By EPRI PEAC

Mid 1996

April 97
Workshop 1
Dallas

June 98
Workshop 3
Dallas



Feb 1999
T24 Final
Report

April 99
Workshop 4
Tempe

Sept 97
Workshop 2
Tempe

Sept 99
SEMI F47
Published

June 2000
Revision
Published
For
SEMI F42
And
SEMI F47

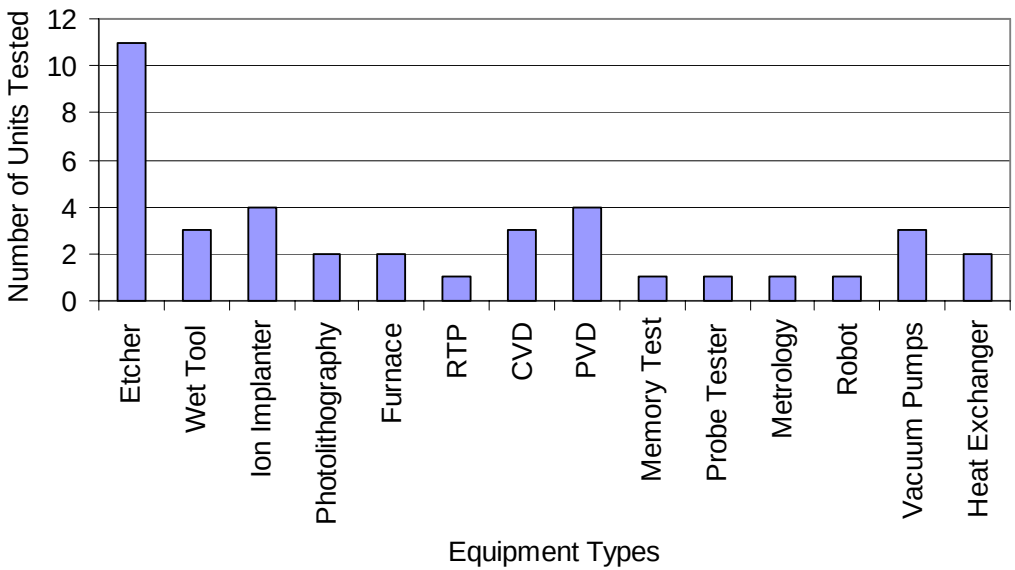
SEMI Task Force Standards Work

Oct 97

Oct 97
Approval for
Task Force
By SEMI

June 99
Test Methodology
SEMI F42
Published

Task 24 Research: Tools Tested



Tool Wafer Size	Number Tested
4 inch	4
6 inch	16
8 inch	8
300mm	5
Total	*33*

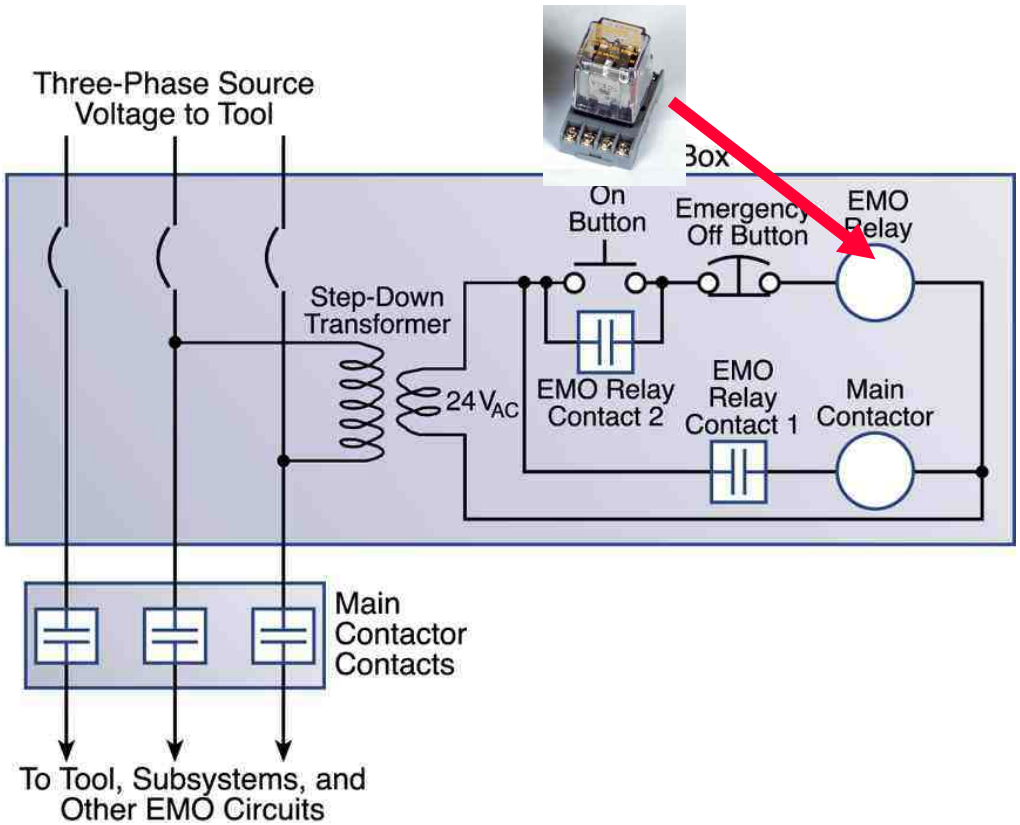
33 Tools Initially Tested

Task 24 Research: Most Common Reason Found for Tool Susceptibility Reasons

Voltage Sag Susceptibility Ranking	Weak Link	Overall Percentage
1	EMO Circuit: Pilot Relay (33%) and Main Contactor (14%)	47%
2	DC Power Supplies: PC (7%), Controller (7%), I/O (5%)	19%
3	3 Phase Power Supplies: Magnetron (5%), RF (5%), Ion (2%)	12%
4	Vacuum Pumps	12%
5	Turbo Pumps	7%
6	AC Inverter Drives	2%

Based on tests of 33 tools by EPRI PEAC with cooperation of tool suppliers, semiconductor manufacturers, and utility companies.

Emergency Off (EMO) Circuit (Simplified)

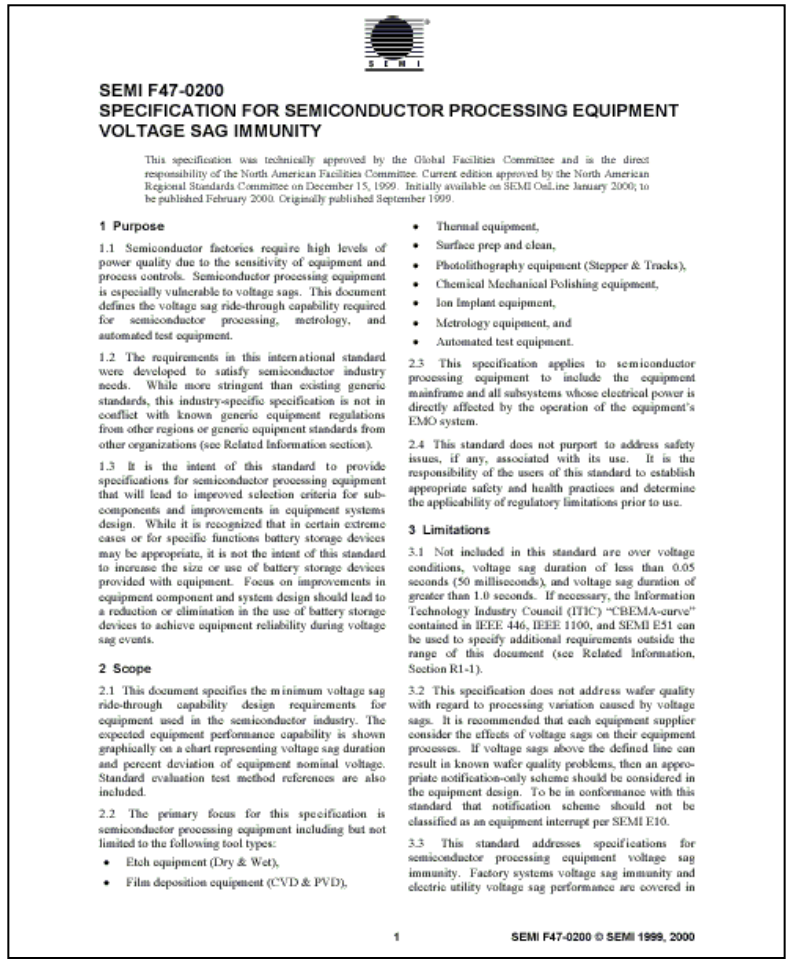


One of the simplest components and most critical circuits in relation to the tools ability to withstand voltage sags.

"Low Hanging Fruit" on The system Compatibility Tree

Original SEMI F47 Standard

- **SEMI F47 Intent: Lead to improved selection criteria for sub-components and improvements in equipment systems design.**
  - *Not intended* **to proliferate the use of battery based UPS systems**
- **Requirement: "..Equipment must continue to operate without *interrupt* during conditions identified in the area above the defined line.."**
- ***Interrupt* means no assist or failure (per SEMI E-10)**
  - **No unplanned interruption of equipment cycle (Assist)**
  - **No Equipment Component Failure**
- **Equipment based standard, not a process quality standard**



SEMI F47-0200
SPECIFICATION FOR SEMICONDUCTOR PROCESSING EQUIPMENT VOLTAGE SAG IMMUNITY

This specification was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on SEMI OnLine January 2000; to be published February 2000. Originally published September 1999.

1 Purpose

1.1 Semiconductor factories require high levels of power quality due to the sensitivity of equipment and process controls. 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.

1.2 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 (see Related Information section).

1.3 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.

2 Scope

2.1 This 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. Standard evaluation test method references are also included.

2.2 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, and
- Automated test equipment.

2.3 This specification applies to semiconductor processing equipment to include the equipment mainframe and all subsystems whose electrical power is directly affected by the operation of the equipment's EMO system.

2.4 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 Not included in this standard are over voltage conditions, voltage sag duration of less than 0.05 seconds (50 milliseconds), and voltage sag duration of greater than 1.0 seconds. If necessary, the Information Technology Industry Council (ITIC) "CBEMA-curve" contained in IEEE 446, IEEE 1100, and SEMI E51 can be used to specify additional requirements outside the range of this document (see Related Information, Section R1-1).

3.2 This specification does not address wafer quality with regard to processing variation caused by voltage sags. It is recommended that each equipment supplier consider the effects of voltage sags on their equipment processes. If voltage sags above the defined line can result in known wafer quality problems, then an appropriate notification-only scheme should be considered in the equipment design. To be in conformance with this standard that notification scheme should not be classified as an equipment interrupt per SEMI E10.

3.3 This standard addresses specifications for semiconductor processing equipment voltage sag immunity. Factory systems voltage sag immunity and electric utility voltage sag performance are covered in

1 SEMI F47-0200 © SEMI 1999, 2000

Original SEMI F47 Requirements

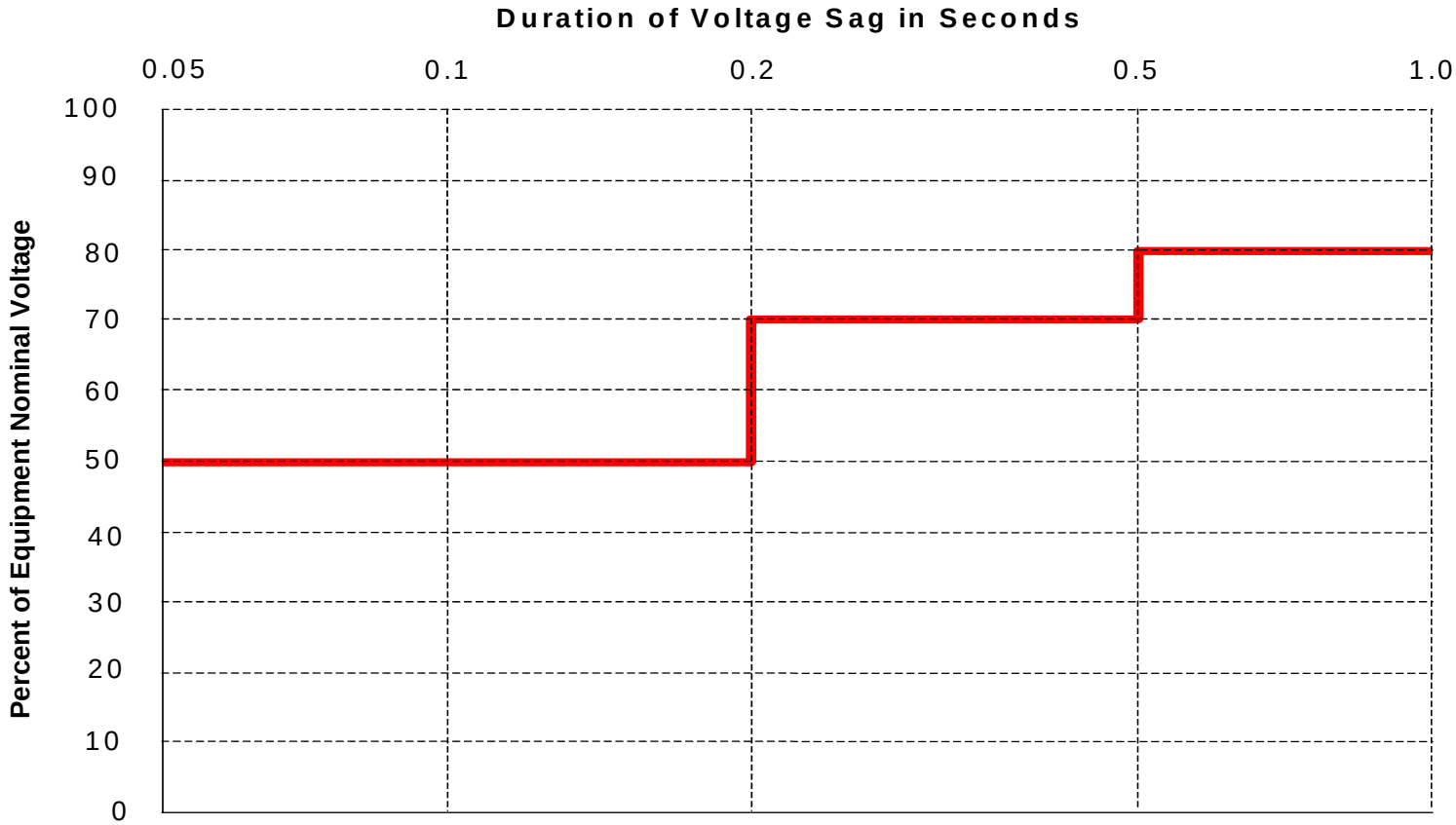
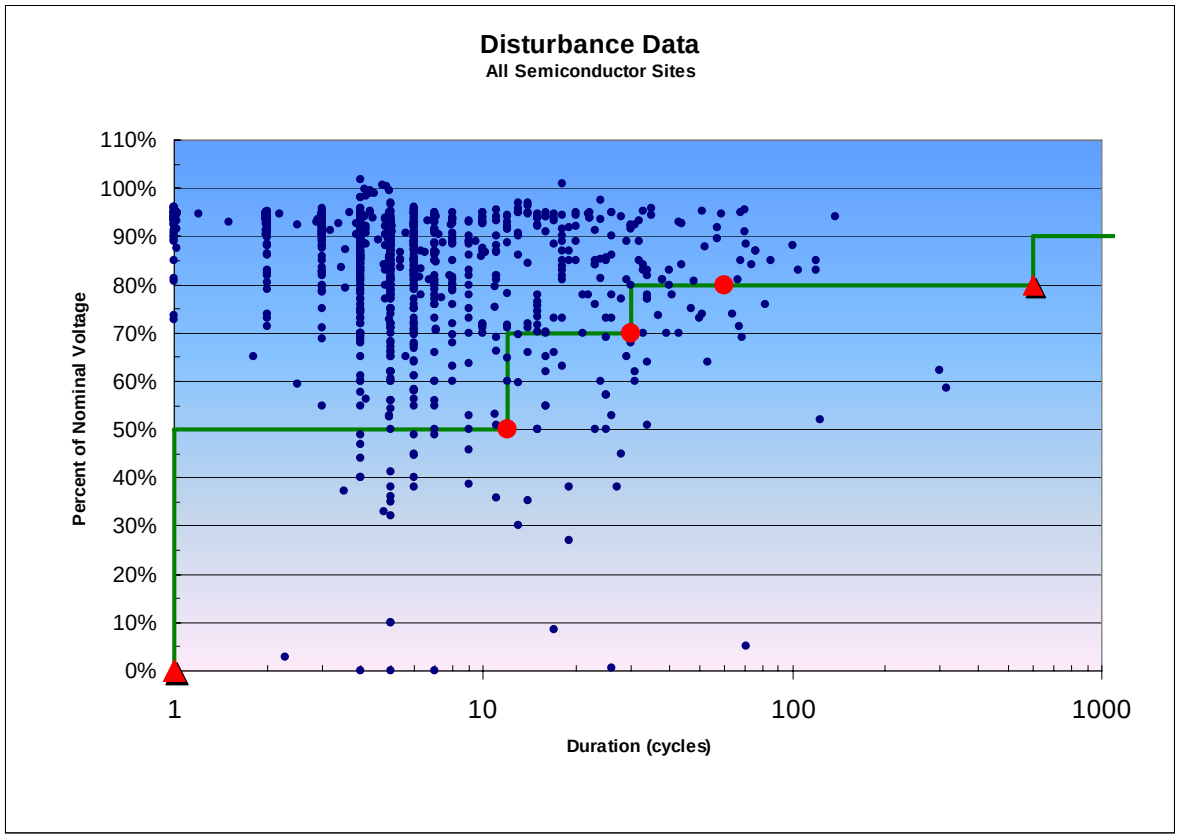


Figure 1

Required Semiconductor Equipment Voltage Sag Ride-Through Capability Curve

Note: Equipment must continue to operate without interrupt during voltage sags above the line.

New SEMI F47-0706

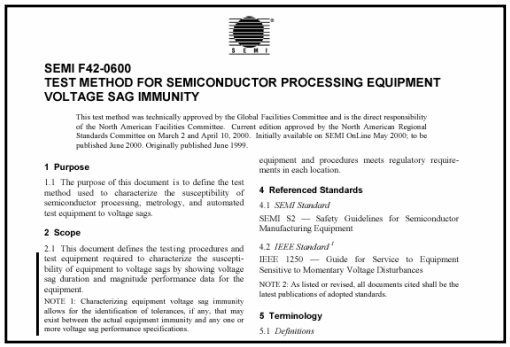


Required
Voltage Sag Immunity
Test Points (From Table 1)

Recommended Voltage
Sag Immunity Test Points
(From Table R1-1)

Other Documents Originally Created

(Note: New SEMI F47-0706 discussed in another Presentation)



SEMI F42-0600
TEST METHOD FOR SEMICONDUCTOR PROCESSING EQUIPMENT VOLTAGE SAG IMMUNITY

This test method was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on March 2 and April 10, 2000. Initially available on SEMI OnLine May 2000; to be published June 2000. Originally published June 1999.

1 Purpose

1.1 The purpose of this document is to define the test method used to characterize the susceptibility of semiconductor processing, metrology, and automated test equipment to voltage sags.

2 Scope

2.1 This document defines the testing procedures and test equipment required to characterize the susceptibility of equipment to voltage sags by showing voltage sag duration and magnitude performance data for the equipment.

NOTE 1: Characterizing equipment voltage sag immunity allows for the identification of tolerances, if any, that may exist between the actual equipment immunity and any one or more voltage sag performance specifications.

equipment and procedures meets regulatory requirements in each location.

4 Referenced Standards

4.1 *SEMI Standard*

SEMI S2 — Safety Guidelines for Semiconductor Manufacturing Equipment

4.2 *IEEE Standard*[1]

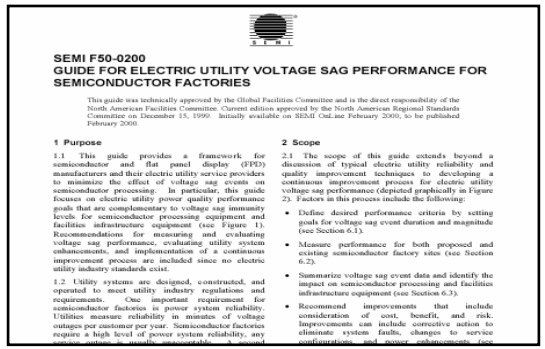
IEEE 1250 — Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances

NOTE 2: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 *Definitions*

SEMI F42 – Test Methodology (Superseded by SEMI F47-0706)



SEMI F50-0200
GUIDE FOR ELECTRIC UTILITY VOLTAGE SAG PERFORMANCE FOR SEMICONDUCTOR FACTORIES

This guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on SEMI OnLine February 2000; to be published February 2000.

1 Purpose

1.1 This guide provides a framework for semiconductor and flat panel display (FPD) manufacturers and their electric utility service providers to minimize the effect of voltage sag events on semiconductor processing. In particular, this guide focuses on electric utility power quality performance goals that are complementary to voltage sag immunity levels for semiconductor processing equipment and facilities infrastructure equipment (see Figure 1). Recommendations for measuring and evaluating voltage sag performance, evaluating utility system enhancements, and implementation of a continuous improvement process are included since no electric utility industry standards exist.

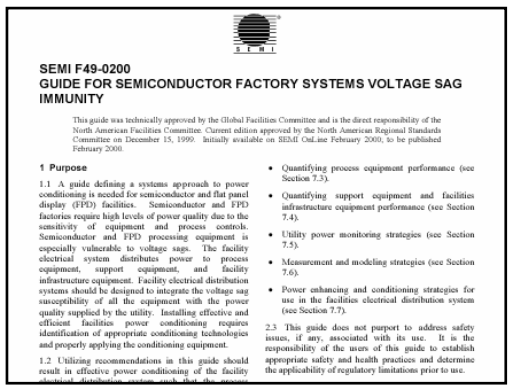
1.2 Utility systems are designed, constructed, and operated to meet utility industry regulations and requirements. One important requirement for semiconductor factories is power system reliability. Utilities measure reliability in minutes of voltage outages per customer per year. Semiconductor factories require a high level of power system reliability, any

2 Scope

2.1 The scope of this guide extends beyond a discussion of typical electric utility reliability and quality improvement techniques to developing a continuous improvement process for electric utility voltage sag performance (depicted graphically in Figure 2). Factors in this process include the following:

- Define desired performance criteria by setting goals for voltage sag event duration and magnitude (see Section 6.1).
- Measure performance for both proposed and existing semiconductor factory sites (see Section 6.2).
- Summarize voltage sag event data and identify the impact on semiconductor processing and facilities infrastructure equipment (see Section 6.3).
- Recommend improvements that include consideration of cost, benefit, and risk. Improvements can include corrective action to eliminate system faults, changes to service

SEMI F50- Guide for Electric Utilities



SEMI F49-0200
GUIDE FOR SEMICONDUCTOR FACTORY SYSTEMS VOLTAGE SAG IMMUNITY

This guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on SEMI OnLine February 2000; to be published February 2000.

1 Purpose

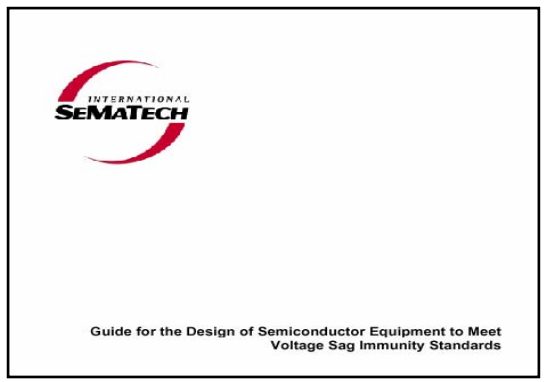
1.1 A guide defining a systems approach to power conditioning is needed for semiconductor and flat panel display (FPD) facilities. Semiconductor and FPD factories require high levels of power quality due to the sensitivity of equipment and process controls. Semiconductor and FPD processing equipment is especially vulnerable to voltage sags. The facility electrical system distributes power to process equipment, support equipment, and facility infrastructure equipment. Facility electrical distribution systems should be designed to integrate the voltage sag susceptibility of all the equipment with the power quality supplied by the utility. Installing effective and efficient facilities power conditioning requires identification of appropriate conditioning technologies and properly applying the conditioning equipment.

1.2 Utilizing recommendations in this guide should result in effective power conditioning of the facility

- Quantifying process equipment performance (see Section 7.3).
- Quantifying support equipment and facilities infrastructure equipment performance (see Section 7.4).
- Utility power monitoring strategies (see Section 7.5).
- Measurement and modeling strategies (see Section 7.6).
- Power enhancing and conditioning strategies for use in the facilities electrical distribution system (see Section 7.7).

2.3 This guide does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

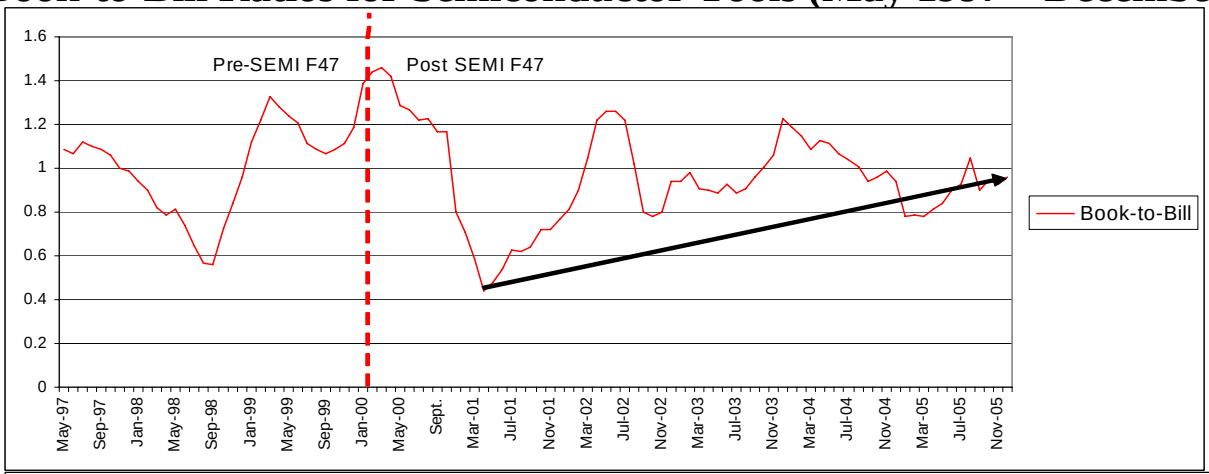
SEMI F49- Guide for Semiconductor Factory Systems

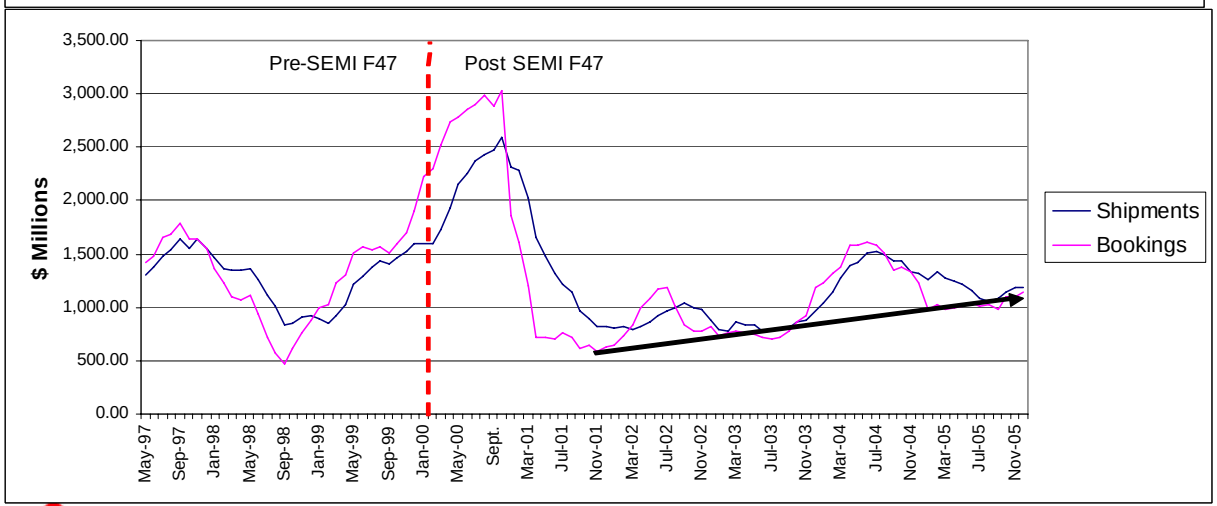


International SEMATECH Technology Transfer # 99063760B-TR

POST SEMI F47 Tool Orders

Book-to-Bill Ratios for Semiconductor Tools (May 1997 – December 2005)





- **Although there is an upward trend in book-to-bill, the sheer volume of tools being built and sold peaked in January 2001.**
- **The current levels of booking are roughly 1/3 magnitude of peak.**

Shipments and Bookings for Semiconductor Tools (May 1997 – December 2005)

Post SEMI F47 Time Line (Through 2004)

February 2000
SEMI F47
Finalized

EPRI PEAC Testing

EPRI PEAC Establishes PQ Star Program for SEMI F47 Compliance

April 2002
Over 50 Tools Tested

December 2003

Over 75 Tools, dozens of subsystems, and hundreds of components tested to SEMI F47 by EPRI PEAC

SEMI Power Quality Education Programs

SEMICON West 2002

March 2004: SEMICON China

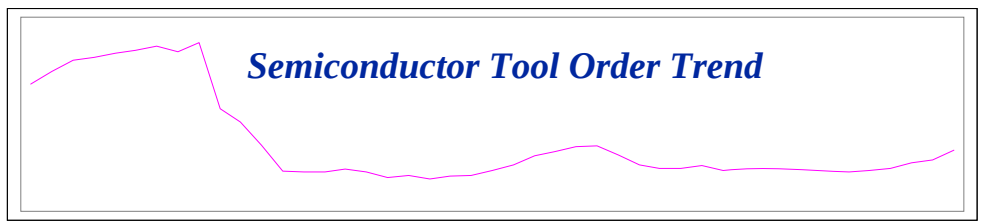
April 2004: SEMICON Europa

PSL

February 2000: Power Standards Lab Formed to Conduct SEMI F47 Testing

December 2003

Over 100 different types of semiconductor tools and components tested to SEMI F47 by PSL



Post SEMI F47 Progress

Collectively EPRI Solutions and PSL have evaluated over 200 Semiconductor Tools, as well as hundreds of subsystems and components.

Tool Supplier Compliance

- **There are over 38 Tool Supplier Companies Addressing SEMI F47.**
- **Each of the companies listed is known to be addressing SEMI F47 at some level.**
- **Most effort focused on 300mm Equipment.**

Accent Optical	KLA-Tencor	SVG Thermco
Advanced Energy	LAM Research	Therma-Wave
Alcatel	Leybold	Tokyo Electron Austin (TEA)
Applied Materials	Matrix	Tokyo Electron Kyushu (TKL)
ASM	Mattson Technology	Tokyo Electron Massachusetts (TEM)
ASML	Nanometrics	Varian Semiconductor Equipment Associates, Inc.
Axcelis	Newport Kensington	Veeco
BOC Edwards	Nikon	Verteq
Cymer	Novellus	
Dainippon Screen	Reliability, Inc.	
ESI	Rudolph Technologies	
FSI International	Schlumberger	
Ibis	Semitool	
IGC-Polycold	ST Micro	
Ion Systems	SVG Lithography	

Tool No.	Semiconductor Tool Type	Was SEMI F47 Compliance Achieved?	Was a Retest Required to Pass SEMI F47?	SEMI F47 Compliance Strategy (see Key)	Did Mfr Engineer Solution In-House?
34	Photolithography	No	N/A	N/A	N/A
35	Memory Test	No	N/A	N/A	N/A
36	Ion Implanter	No	N/A	2	No
37	Ion Implanter	No	N/A	2	No
38	Diffusion Furnace	Yes	No	1	Yes
39	Metrology	Yes	No	2,7	No
40	Copper Plating Wet Deposition	Yes	Yes	2	Yes
41	Ion Implanter	Yes	Yes	1	Partially
42	Ion Implanter	Yes	Yes	1	Partially
43	Ion Implanter	Yes	No	1	Partially
44	Etcher	Yes	No	3,4	No
45	Photo Track	No	N/A	N/A	N/A
46	Photolithography	No	N/A	N/A	N/A
47	Copper Plating Wet Deposition	Yes	Yes	2, 6	Partially
48	Diffusion Furnace	Yes	No	2,7	Yes
49	Ion Implanter	Yes	No	1	Yes
50	Rapid Thermal Processing	Yes	No	2,5,7	Partially
51	Metrology	Yes	Yes	5	No
52	Photo Track	Yes	No	2,5	Partially
53	Photo Track	Yes	No	2,5	Partially
54	Surface Conditioning	Yes	No	7	Yes
55	Surface Conditioning	Yes	No	2	Partially
56	Copper Plating Wet Deposition	Yes	No	2	Partially
57	Cluster Etch	No	N/A	N/A	N/A
58	Wafer Cleaning	Yes	No	1,8	Partially
59	Surface Preperation	Yes	No	7	Yes
60	Photo Track	Yes	No	5	No
61	Photo Track	Yes	No	5	No
62	Electro Chemical Deposition (ECD)	Yes	No	5 and 7	Partially
63	Chemical Management	Yes	No	7	Partially

Compliance History for tools Evaluated by EPRI Solutions Following the Implementation of the SEMI F47 Standard (As of December 2005)

Key:

1. **3-5kVA UPS on EMO and Sensitive Controls**
2. **Embedded Solutions – Robust AC Contactors and Relays or DC Powered Units**
3. **Batteryless Ride-Through Device on EMO circuit**
4. **Batteryless Ride-Through Device on Tool Vacuum Pump Control circuit**
5. **Batteryless Ride-Through Device on Tool Controller(s) or subsystems**
6. **Firmware Upgrade on Drive**
7. **Robust Power Supplies**
8. **Replaced Circuit Breaker on Subsystem Component**
9. **Separation of loads (critical and non-critical) so that Critical loads can be powered by conditioned power provided by the end user.**

Compliance History for tools Evaluated by EPRI Solutions Following the Implementation of the SEMI F47 Standard

Tool Number	*Semiconductor Tool Type*	*Was SEMI F47 Compliance Achieved*	*Was a retest required for compliance*	*SEMI F47 Strategy (see key on Page 5-2)*	*Did Mfg Engineer Solution In-house?*
64	Wet Cleaning	Yes	No	9	Partially
65	ECD	No	Yes	2,6	Partially
66	Implant	Yes	Yes	1.6.7.9	Yes
67	Chemical Wet Clean	Yes	No	1,2,7	Yes
68	Vacuum Pump	Yes	No	4	Partially
69	Implant	Yes	No	1	Partially
70	Rapid Thermal Processing Tool (RTP)	Yes	No	1,8	Partially
71	Deposition - Etch	Yes	No	1,5	Partially
72	Implant	No	N/A	9	Partially
73	Etch	Yes	No	1,2,5	Partially
74	ECD	Yes	No	1,2,5	Partially
75	Wet Bench	Yes	No	9	Partially
76	RTP	Yes	No	1,8,9	Partially
77	Surface Cleaning Tool	Yes	No	1,2,5	Partially

Key:

1. **3-5kVA UPS on EMO and Sensitive Controls**
2. **Embedded Solutions – Robust AC Contactors and Relays or DC Powered Units**
3. **Batteryless Ride-Through Device on EMO circuit**
4. **Batteryless Ride-Through Device on Tool Vacuum Pump Control circuit**
5. **Batteryless Ride-Through Device on Tool Controller(s) or subsystems**
6. **Firmware Upgrade on Drive**
7. **Robust Power Supplies**
8. **Replaced Circuit Breaker on Subsystem Component**
9. **Separation of loads (critical and non-critical) so that Critical loads can be powered by conditioned power provided by the end user.**

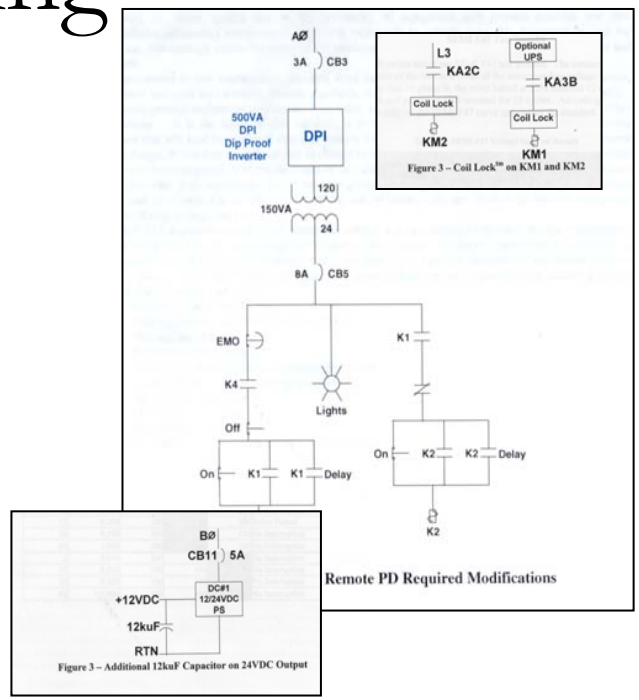
Key Statistics from EPRI Solutions Post SEMI F47 Testing

- ***Key Stat # 1: Only 20% of Tool Vendors Designed Compliance Solution without assistance***
  - Tool manufactures still require help in understanding how to design for SEMI F47 Compliance
  - 52% of the tools had to have some level of help to meet the standard
- ***Key Stat # 2: 80% of Tools Tested have been brought into compliance so far***
  - Majority of tool suppliers were able to meet the standard with assistance
  - 27% of the tools that received SEMI F47 certification did so without any power conditioning

SEMI F47 Testing

Key Statistics from EPRI Solutions Post SEMI F47 Testing

- ***Key Stat #3: Of those who were able to pass the test, 17% required a second round of testing of the modified tool design in order to achieve compliance***
  - **SEMI F47 tests naturally uncovers areas of the tool that are vulnerable to voltage sags**
  - **Many times problems are found and solutions are demonstrated at the same time**
  - **Other times solutions must be designed and retried at a later date (tool time issues)**



Example Design Modifications

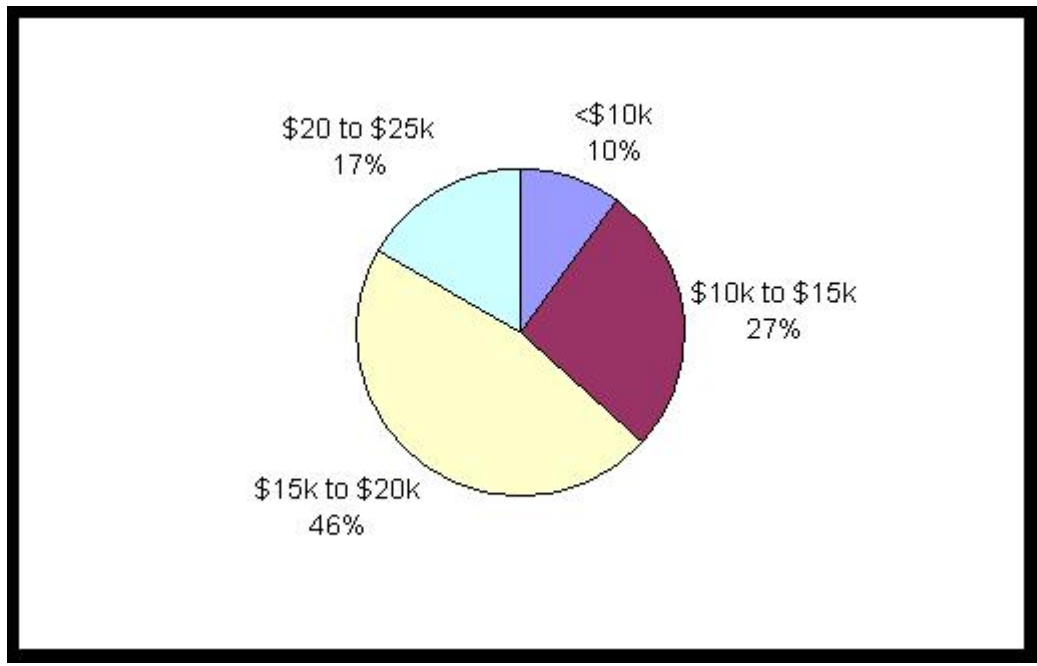
Key Statistics from EPRI Solutions Post SEMI F47 Testing

- **Key Stat #5: The typical cost of the solution hardware required to make the tools that passed SEMI F47 compliant was found to be $1,709.**
- Average testing and certification cost was $14.38k.
- Current Cost of testing is usually between $8.2k-$14k
- The solution usually involves either utilizing a power conditioner on the tools' sensitive control circuits or replacing sensitive control elements with units that are certified to meet the standard.

Tool Number	*Power Conditioning Cost**	*Testing and Certification Costs*	*Total Cost to Tool Supplier***
1	$ 300.00	$ 16,900.00	$ 17,200.00
2	$ 2,500.00	$ 15,900.00	$ 18,400.00
3	$ 2,500.00	$ 15,900.00	$ 18,400.00
4	$ 2,500.00	$ 15,900.00	$ 18,400.00
5	$ 2,325.00	$ 15,459.45	$ 17,784.45
6	$ 5,000.00	$ 13,238.60	$ 18,238.60
7	$ 2,500.00	$ 10,767.45	$ 13,267.45
8	$ 5,660.00	$ 18,686.00	$ 24,346.00
9	$ 2,760.00	$ 18,285.00	$ 21,045.00
10	$ 2,760.00	$ 18,285.00	$ 21,045.00
11	$ 300.00	$ 16,101.00	$ 16,401.00
12	$ 300.00	$ 16,101.00	$ 16,401.00
13	$ 2,900.00	$ 16,500.00	$ 19,400.00
14	$ 300.00	$ 15,200.00	$ 15,500.00
15	$ 300.00	$ 17,600.00	$ 17,900.00
16	$ 300.00	$ 8,500.00	$ 8,800.00
17	$ 2,760.00	$ 12,750.00	$ 15,510.00
18	$ 2,500.00	$ 16,212.70	$ 18,712.70
19	$ -	$ 12,750.00	$ 12,750.00
20	$ 300.00	$ 3,000.00	$ 3,300.00
21	$ 3,400.00	$ 21,800.00	$ 25,200.00
22	$ 1,200.00	$ 16,900.00	$ 18,100.00
23	$ 1,000.00	$ 8,000.00	$ 9,000.00
24	$ 1,000.00	$ 12,500.00	$ 13,500.00
25	$ 1,200.00	$ 18,900.00	$ 20,100.00
26	$ 1,500.00	$ 11,100.00	$ 12,600.00
27	$ 10.00	$ 13,368.00	$ 13,378.00
28	$ 1,750.00	$ 10,100.00	$ 11,850.00
29	$ 700.00	$ 11,728.00	$ 12,428.00
30	$ 750.00	$ 13,000.00	$ 13,750.00
Average Costs	***$1,709.17***	***$14,381.07***	***$16,090.24***

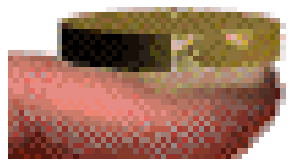
Breakout of Cost of Compliance

- **Forty-Six percent of the tools reached SEMI F47 compliance for between $15,000 and $20,000.**
- **Furthermore, for tools that required a second round of testing before compliance could be issued, the cost for compliance ranged from $20,000 to $25,000 per tool.**



In Reality…..

The Price of the Solution is small compared to Costs associated with Lost Product,Downtime and Overall Tool Price



Compliant Component Availability

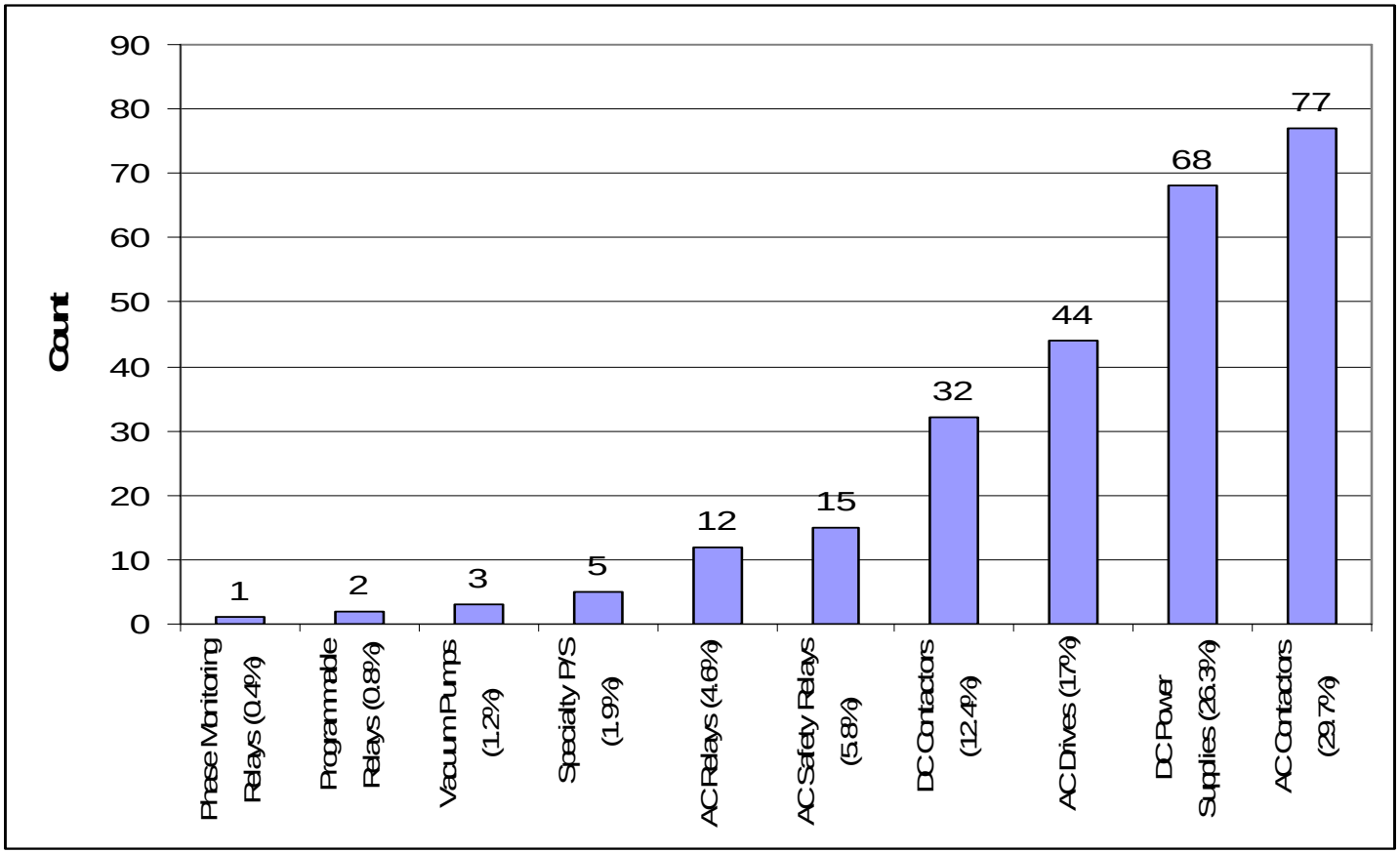
- **EPRI Solutions has tested hundreds and certified over 259 components to SEMI F47 as a part of our PQ Star Program.**
- **Other companies have certified components as well.**

Example Compliant Component Manufacturers

- **This is a partial list representing EPRI Solutions' work with component manufacturers.**
- **Other manufacturers have had compliance testing done as well.**

Company	Web Site	Known Compliant Products and Quantity
Alcatel	http://www.adixen-usa.com/	Vacuum Pumps (3)
Advanced Energy	http://www.advanced-energy.com/	Plasma Beam Generator (1) VHF Power Supplies (2) DC-to-DC Converter (1)
Allen Bradley/Rockwell Automation	http://www.rockwellautomation.com/index.html	AC Drives (32) Power Supplies (8)
Densei-Lambda	http://www.densei-lambda.com	Power Supplies (2)
IDEC	www.idec.com	Power Supplies (2)
Kepco	http://www.kepco.com/	Power Supplies (7)
Lambda EMI, Inc.	http://www.lambda-emi.com/	Magnet Power Supplies (1)
North West Power Integrations	http://www.npi-inc.com/product_category_ac_f47.shtml	Power Supplies (4)
Omron	http://oeiweb.omron.com/S8VS_newprod.shtm	Power Supplies (2)
Phoenix Contact	http://www.phoenixcon.com/	Power Supplies (13)
Power One	http://www.power-one.com	Power Supplies (6)
Puls	http://www.puls-power.com/	Power Supplies (6)
Siemens	http://siemens.com	AC Contactors (56) DC Contactors (32) Power Supplies (3)
Schneider Electric/ Telemecanique	http://www.schneider-electric.com/ http://www.telemecanique.com	AC Drives (12) Relays (12) Safety Relays (15) Programmable Relays (2) Phase Monitoring Relays (1) Contactors (21) Power Supplies (15)

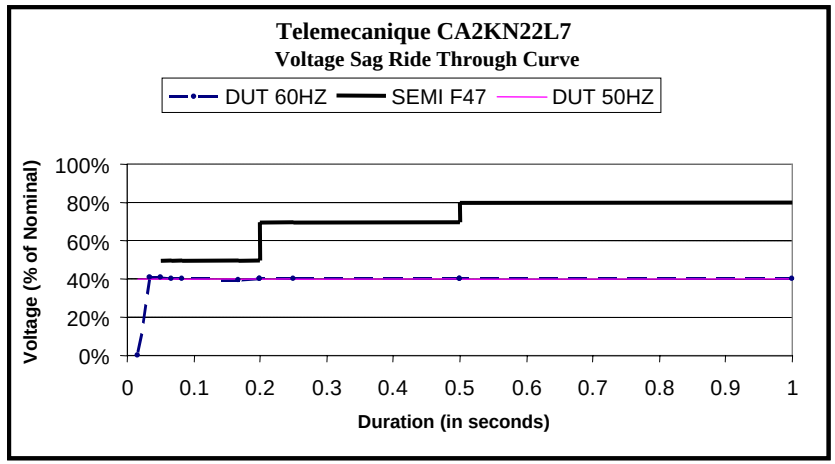
Compliant Devices Certified from EPRI Solutions (December 2005)



More devices have been shown to be compliant, but where not Part of compliance testing efforts (PLCs, servo drives, etc.)

Device Test Details

- **Tests conducted at 50 and 60 Hz.**
- **For DC Power Supplies, tests conducted at 50 and 60 Hz, multiple load levels, and at different input voltages (120/208).**
- **For drives also conducted at multiple input voltages, load levels, and frequencies.**



SEMI F47 Compliance Strategies

- **Use "Selective Power Conditioners" on susceptible loads**

CVT **DPI** **DySC** **CoilLock** **Low Voltage Ride Through Module**

- **Embed the Solution through proper design, configuration and component selection strategies**

Vacuum Pumps **Contactors** **DC Power Supplies** **Relays**

- **Utilize a *Combination* of both strategies**

Conclusions

- **Progress has been made in developing tools that are more robust to voltage sags.**
- **Tool vendors are beginning to understand the issues surrounding power quality and designing systems with voltage sags in mind.**
- **Semiconductor manufacturers believe the progress has not been fast enough (economy may be partly to blame in short term)**
- **Proactive component and voltage sag mitigation suppliers have stepped forth to have their products certified to the standard and/or integrated into tool solutions.**