Power Quality Site Audit

What to Measure and Why

A practical field guide for facility engineers, maintenance managers, and utility operations staff who need to identify, document, and resolve power quality problems.

Test Equipment + Field Services + Technical Advisory
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What Is a Power Quality Problem?

Power quality refers to the characteristics of the electrical supply at a given point in a system. A power quality problem exists when the voltage, current, or frequency deviates from what connected equipment needs to operate correctly.

Most facility operators know something is wrong before they know what it is. Common symptoms that prompt a power quality investigation:

- Variable speed drives faulting on overvoltage or DC bus disturbances
- UPS systems switching to battery for no apparent reason
- Lighting flickering or dimming during motor starts
- Unexplained equipment failures, particularly capacitors, transformers, or motor insulation
- Utility penalty charges for power factor or reactive power consumption
- Neutral conductors overheating in three-phase systems
- Electronic equipment lockups or resets that occur at predictable times

The Root Cause Problem

Most power quality investigations start with a symptom, not a cause. Without measurement data, you are guessing. The cost of a proper audit is almost always a small fraction of the cost of replacing failed equipment or tolerating recurring unplanned downtime.

The Six Power Quality Parameters

1. Voltage Sags (Dips)

A voltage sag is a short-duration reduction in RMS voltage to between 10% and 90% of nominal, lasting from 0.5 cycles to 1 minute. Sags are the most commonly reported power quality disturbance in industrial and commercial facilities.

Primary causes: utility system faults, large motor starts, transformer energization. A single fault on the transmission system 30 miles away can trip your production equipment. What to measure: RMS voltage magnitude (% of nominal), duration, and frequency of occurrence. IEEE 1159 provides classification; the ITIC curve defines what equipment should be able to tolerate.

2. Harmonics

Harmonics are voltages or currents at frequencies that are integer multiples of the fundamental frequency (60 Hz in North America). Harmonic distortion is expressed as Total Harmonic Distortion (THD), as a percentage of the fundamental.

Primary sources: variable frequency drives (VFDs), switching power supplies, arc furnaces, UPS systems, and electronic ballasts. Effects: overheating of transformers and neutral conductors, resonance with power factor correction capacitors (can cause catastrophic capacitor failure), interference with electronic controls.

Voltage Level	Max Individual Harmonic Voltage (%)	Max Total Voltage THD (%)
< 1 kV (LV)	5.0%	8.0%
1 to 69 kV (MV)	3.0%	5.0%
69 to 161 kV (HV)	1.5%	2.5%
> 161 kV (EHV)	1.0%	1.5%

Standard reference: IEEE 519-2014 defines recommended limits for harmonic current and voltage distortion at the point of common coupling.

3. Voltage Transients

Transients are very short-duration events involving very high peak voltages or currents. Two types matter in most facility investigations:

- Impulsive transients: Caused by lightning strikes. Can reach tens of thousands of volts. Typically damage equipment at the service entrance and distribution panel.
- Oscillatory transients: Caused by capacitor bank switching, transformer energization, or fault clearing. Typically 500 Hz to 5 kHz. Often the cause of variable speed drive nuisance trips.

4. Voltage Unbalance

Voltage unbalance occurs when the three phase voltages are not equal in magnitude or are not separated by exactly 120 degrees. A 2% voltage unbalance produces approximately 6-10% current unbalance in a three-phase motor. Current unbalance causes differential heating in motor windings, reducing insulation life. NEMA MG1 requires motors to be derated when unbalance exceeds 1%.

5. Power Factor

Power factor is the ratio of real power (kW) to apparent power (kVA). A power factor below 1.0 means the facility is drawing reactive current that flows without doing work but still heats conductors and transformers. Most utilities charge industrial customers for low power factor (below 0.90 or 0.95) through a demand penalty.

Important

Do not specify power factor correction capacitors without first measuring harmonic content. In a system with significant harmonic distortion, standard capacitors can resonate with system inductance, amplifying harmonic voltages to dangerous levels. Capacitor failures and transformer damage can result. Harmonic-survey first.

6. Voltage Flicker

Flicker is the perception of visual instability caused by rapid, repetitive voltage variations. Even voltage changes as small as 0.5% can cause visible lamp flicker at the right frequency. Primary causes: arc furnaces, resistance welders, motor starting. Measured using the IEC 61000-4-15 flickermeter algorithm (Pst value). Pst > 1.0 indicates visible flicker and is a violation of most utility interconnection agreements.

Planning Your Site Audit

Step 1: Define the Scope

- What symptoms are you investigating? Nuisance trips? Equipment failures? Utility penalty charges?
- Where is the problem manifesting? At specific equipment, in a specific area, or system-wide?
- Is the problem continuous, intermittent, or event-driven (tied to specific production cycles)?
- Do you need root cause analysis, ongoing monitoring, or both?

Step 2: Choose Your Measurement Points

- Service entrance (main switchgear or transformer secondary): Always measured first. Establishes the utility baseline.
- Main distribution panels and subpanels feeding problem areas: Identifies whether disturbances originate on the utility system or within the facility.
- At or near the problem equipment: Characterizes what the equipment actually sees.
- At major nonlinear loads (large VFDs, UPS systems, arc furnaces): Characterizes harmonic current injection from each source.

A Common Mistake

Measuring only at the service entrance and concluding the utility is clean misses internally generated disturbances. A facility with 20 large VFDs can have severe harmonic distortion at internal distribution panels even when the utility supply is perfect. Measure at both ends.

Step 3: Select the Right Instrument

For a proper site audit, your instrument must capture:

- True RMS voltage and current on all three phases simultaneously
- Harmonic content to at least the 50th harmonic (for IEEE 519 compliance analysis)
- Sags, swells, and interruptions per IEC 61000-4-30 Class A (utility-grade) or Class S (survey-grade)
- Transients with enough sampling rate to capture peak voltage (ideally > 200 kSa/s)
- Flicker per IEC 61000-4-15
- Long-term trending of RMS voltage, current, power, and harmonic levels over days or weeks

IEC 61000-4-30 Class A compliance is the standard for utility-grade measurement. If your results need to stand up in a dispute with the utility, use a Class A instrument.

Step 4: Set Your Monitoring Duration

Problem Type	Recommended Duration	Rationale
Harmonic characterization	At least 7 days	Captures weekday vs. weekend and day vs. night load variations
Voltage sag investigation	30 to 90 days	Utility faults are random; longer monitoring captures more events
Power factor / demand	30 days (full billing cycle)	Match the utility billing interval

Problem Type	Recommended Duration	Rationale
penalty		
Transient investigation	2 to 4 weeks with event trigger	Long enough to correlate events with external sources
Continuous permanent monitoring	Ongoing	For high-value loads or utility compliance points

Reading and Acting on Results

Benchmarking Against Standards

- IEEE 519-2014: Harmonic current and voltage limits at the point of common coupling
- ANSI C84.1: Voltage tolerance bands (Range A and B) for service entrance voltage
- IEEE 1159: Classification and characterization of power quality events
- NEMA MG1: Motor derating criteria for voltage unbalance

Common Problems and Remedies

Problem Identified	Common Remedies
High harmonic distortion (facility-generated)	Passive or active harmonic filters, 12-pulse or 18-pulse drives, K-rated transformers
Low power factor	Fixed or switched capacitor banks (after harmonic survey), active power factor correction
Voltage sags (utility-sourced)	Ride-through enhancement for sensitive equipment: UPS, dynamic voltage restorer (DVR)
Voltage unbalance	Redistribute single-phase loads, check for open delta transformers
Transient overvoltages	Surge protection devices (SPDs) at service entrance and panel level
Voltage flicker	Static VAR compensators (SVC) for large cycling loads; sometimes load scheduling is sufficient

Portable Analysis vs. Permanent Monitoring

Factor	Portable Audit	Permanent Monitoring
Purpose	Diagnose a specific problem	Ongoing visibility, trending, alarm notification
Duration	Days to weeks	Continuous
Cost model	One-time engagement	Capital investment in hardware + software
Best for	Investigating a new problem, baseline characterization	Critical loads, utility compliance points, recurring problems
Standards	IEC 61000-4-30 Class S acceptable	IEC 61000-4-30 Class A required for

Factor	Portable Audit	Permanent Monitoring
		utility contractual purposes

ProgUSA Power Quality Services

Power Quality Instruments

The CHK Power Quality MIRO PQ-45 is our flagship portable and permanent power quality analyzer. It is IEC 61000-4-30 Class A certified and captures all six parameters covered in this guide simultaneously. The CITRUS PC software provides reporting, trending, and standards-based analysis.

Power Quality Services Division

Our field services team handles investigations from initial measurement through root cause analysis and solution recommendation:

- Electrical risk screening: Initial site assessment to identify likely sources and define the monitoring plan.
- Thermographic inspections: Electrical infrared surveys to identify hot spots in distribution equipment.
- Power quality site audits: Full monitoring campaigns with Class A instruments and analysis reports benchmarked against IEEE 519, ANSI C84.1, and IEC standards.
- Arc flash risk assessment: A natural complement to power quality work since both require detailed knowledge of the electrical system.

Our Scope

ProgUSA Power Quality Services is a diagnostics and advisory service, not a general electrical contractor. We measure, analyze, and recommend. This keeps our focus on what we do best: helping you understand what is happening in your electrical system and what to do about it.

Ready to Start Your Power Quality Audit?

Whether you need the instruments to run your own program or a team to do it for you, ProgUSA has both. We supply CHK Power Quality analyzers and permanent monitoring systems to utilities, industrial facilities, and testing firms across the United States.

Our Power Quality Services division handles audits from initial screening through final report.

Instrument Selection	Power Quality Audit	Permanent Monitoring
Not sure which CHK analyzer fits your requirements? Tell us your application and measurement points. We'll configure the right system.	Our field team performs a full site audit and delivers an analysis report benchmarked against IEEE and IEC standards.	We supply and commission CHK permanent monitoring systems with centralized reporting for critical loads or utility compliance points.

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