Attracting Tomorrow

Power Quality and Electrical safety in Buildings

Focus: Hospitals and High rise buildings

Dr. Venkatesh Raghavan

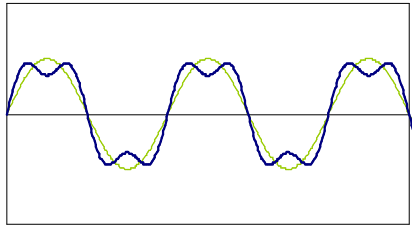
[TDK Electronics AG]
CAP Film PFC • [Product marketing]
[Munich]
[13 10, 2020]

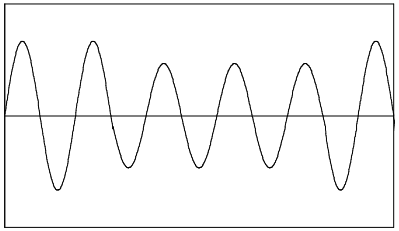
Contents

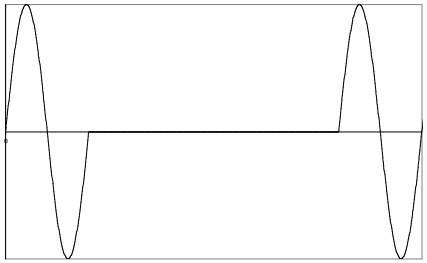
- Power Quality and Electrical safety – some aspects
- Why hospitals and high rise buildings require special attention?
- PQ issues, aspects and solutions for hospitals
- PQ issues, aspects and solutions for high rise buildings
- Summary
- Q & A

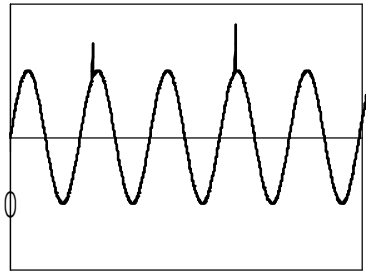
PQ and electrical safety – Main PQ aspects and implications

- Aspects
  - Harmonics
  - Unbalance
  - EMI / EMC
  - Interruptions
  - Neutral shifts
  - Reactive Power
  - Surges (current and voltage, transients, sags and swells)

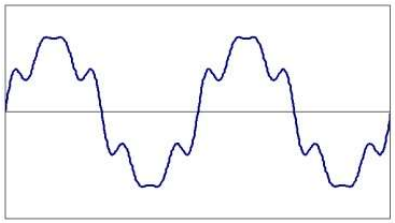








- Impact
  - Additional heating, fire hazards, lower reliability
  - Equipment failure
  - Equipment mal function
  - Compromised electrical safety



PQ and electrical safety

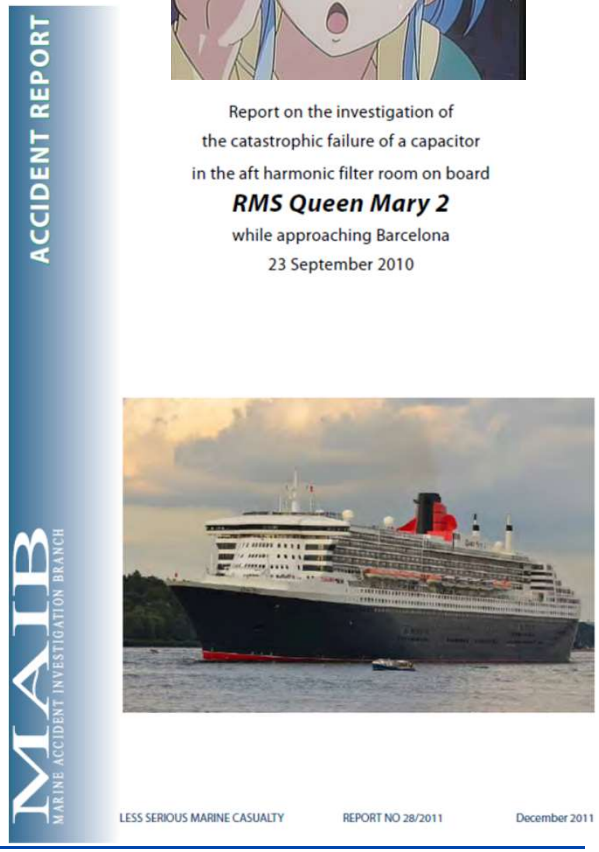
- Equipment
  - Damage / fire / explosion / failure
  - Reliability / ageing / premature failure / abnormal failure modes
  - Malfunction /

- Humans
  - Accidents (Minor to fatal)
  - Health hazard
  - Safety concerns

Why hospitals and high rise are special?

- Evacuation challenges!
  - Profile of evacuees
  - Access to service providers

- Special requirements
  - Quality and reliability of power supply
  - Sensitive instrumentation and EMC
  - High dependence of electrical power for routine activities
  - Back up power for emergency services



Hospitals

South Korean **hospital fire ’caused by electrical fault’**
The blaze was South Korea’s deadliest in more than a decade.
By Associated Press Reporters
January 27 2018 10:59 AM

A hospital fire that killed 37 people in South Korea was most likely caused by an electrical fault in the first-floor emergency room, police have said. A joint investigation carried out by police, fire services and forensic experts concluded that a fault in the electrical system in the ceiling of the emergency room’s pantry most likely sparked Friday’s blaze in the southern city of Miryang, said Kim Han-su, a police official there.

The blaze was South **Korea’s deadliest in more than a decade**. President Moon Jae-in visited the site on Saturday and vowed to raise safety standards for hospitals.
Officials say the six-floor facility did not have sprinklers because it was not big enough to be required by law to have such systems.

Police said 34 of the dead were women and 26 were aged 80 or older.

High rise buildings

Property insurance premiums could rise in UAE after fire accidents

Dubai specifically has seen a spate of fire accidents in recent years.

Dubai specifically has seen a surge in fire incidents at tall buildings in recent years. Most recently, a blaze at the Address Hotel Downtown Dubai on December 31 gutted the entire building.

DUBAI, UNITED ARAB EMIRATES, UAE - NOVEMBER 20, 2017:
Fire accident occured in Dubai building in front of Hotel Jumeirah.

By Wayne D. Moore
Published In November 2003

Tall buildings require different systems than “standard” buildings. This is true for fire alarm systems as well as electrical systems. So what defines a “tall” building? The International Building Code (IBC 2000) and the Building Construction and Safety Code, NFPA 5000TM-2002, define high-rise buildings as buildings 75 feet or greater in height measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story.

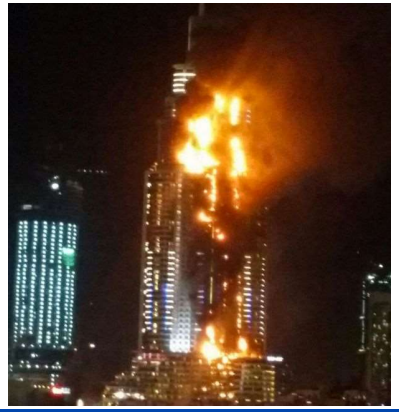
High rise buildings

DUBAI // An electrical short circuit on a spotlight was the cause of a fire that engulfed The Address Downtown Dubai hotel on New Year's Eve, according to police. A spark from cables connected to the light, which sat on a ledge between the 14th and 15th floors of the 63-storey tower, triggered the blaze at about 9.25pm.

Police have ruled out any foul play and said that the alarms did not sound immediately because the fire had started on the outside of the building, so internal alarms had yet to be triggered by smoke.

"The building also has projecting ledges, some located at the entrances of the hotel, some between the 14th and 15th floors and others on the top floors, the 48th floor and above. "These ledges have spotlights that are connected to cables via openings in the building, whose walls also contain wires connected to some balconies and other lights."

Fifteen people were injured, while one person suffered a heart attack while being removed from the building



https://youtu.be/lPCL3sNVBcM

High rise buildings

The fire that raged through a London apartment building on Wednesday night horrified engineers for more than its terrible human cost—at least 12 people died in the blaze at the 24-story tall Grenfell Tower, and London authorities expect to find more as they search the still-smoldering ruin. It was a disaster made even worse for its utter lack of unexpectedness. Residents had been warning about shoddy maintenance and smoking electrical equipment for at least four years.

But what investigators will have to figure out is exactly how the fire spread the way it did—because a fast-burning ignition that spreads from floor to floor of a tower block is exactly what modern building and fire codes are supposed to prevent. The mantra of high-rise fire protection is compartmentation, suppression, and evacuation, in that order. In London, the first two failed, but that's unusual. It's that third priority—getting out—that researchers around the world are still trying to solve.

Types of hospital loads and their PQ characteristics

- HVAC: Harmonics, VAR/pf,
- Lighting: Unbalance, VAR/pf, harmonics
- UPS : Harmonics, VAR/pf, Unbalance
- Servers / computers : Unbalance, harmonics, VAR/pf
- Lifts / escalators: Dynamic VAR, harmonics
- Medical equipment (MRI, CT scanners, ventilators, ..): Harmonics, EMI/EMC
- Fire fighting systems: VAR/pf, harmonics
- Security / access control: Unbalance, harmonics, VAR/pf
- Utilities: Harmonics, VAR/pf.
- Diagnostics and life support systems: unbalance, harmonics, EMI/EMC, VAR/pf

Need for power conditioning in hospitals

- Most hospital loads are single phase and hence create unbalance and flow of sequence components and hence require unbalance correction. The flow of neutral currents could increase the neutral voltage (neutral shift) leading to possible mal-function of certain equipment requiring a perfect zero voltage neutral reference. Unbalance correction is also essential if the utility tariff is based on kvah billing in order to minimize the energy costs. (4 core cables!)

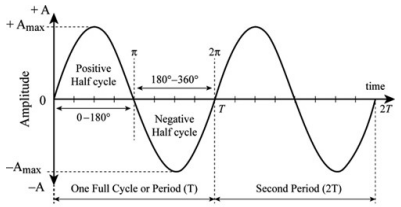
- Most loads are also non-linear and hence are characterized by a high harmonic distortion. Apart from energy loss, increase in kvah, non-compliance to standards / regulations harmonics could also cause mal-function of certain sensitive electronic equipment. Presence of high level of harmonic is also a safety issue due to excessing heating of power equipment / cables.! Hence harmonic mitigation is an essential part of power supply system in hospitals.

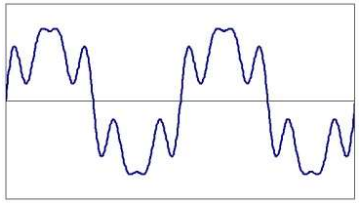
Need for power conditioning in hospitals

- Loads generally have a power factor in the range of 0.8 to 0.9 and hence require reactive power compensation in order to reduce energy loss, minimize kvah consumption, reduce currents an consequent heating etc.
- Most sensitive electronic instrumentation require a near perfect sinusoidal excitation and stable voltages and this can be to a large extent ensure though reactive power compensation, unbalance correction and harmonic mitigation, apart from voltage regulators and on-load tap changers.
- Though most equipment's used should be compliant with relevant EMI/EMC standards, it is preferable to minimize the present of high frequency harmonics and PWM switching frequencies to enhance the reliability / performance of connected electronic devices.

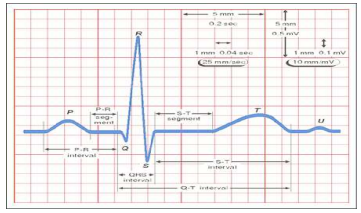
PQ issues in hospital and solutions

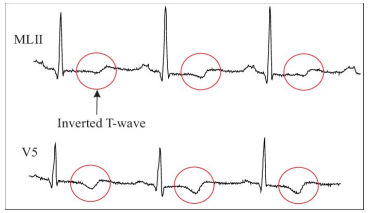
- Harmonics: Detuned PFC systems, passive tuned filters, AHF
- Unbalance: SVG, ASVG, AHF, single phase dynamic compensators
- VAR / pf: Detuned APFC panels, SVG, ASVG, AHF
- Voltage stability: DVR, UPS, OLTC, AHF
- Reliability: UPS, backup power supply, redundant power supply
- Neutral shift: SVG, AHF
- EMI / EMC: LCL filters, AHF with EMC
- Brown outs: DVR, UPS
- Transients (that could affect sensitive equipment): DVR, surge capacitors, LA
- **Choose appropriate and optimal power conditioning solutions with right specifications**
- The ECG (Electrical Characteristic Graph) of the hospital network is as important as the ECG (Electro Cardio Gram) of the patient!





OK Plant ECG Not OK





OK Patient ECG Not OK

Types of High rise loads and their PQ characteristics

- HVAC: Harmonics, VAR/pf,
- Lighting (internal, façade, decorative): Harmonics, unbalance, reactive power
- UPS : Harmonics, VAR/pf, Unbalance
- Servers / computers : Unbalance, harmonics, VAR/pf
- Elevators / Lifts / escalators: Dynamic var, harmonics
- Fire fighting systems: VAR/pf, harmonics
- Utilities: Harmonics, VAR/pf.
- Access control / security systems (UPS, SMPS): Harmonics, unbalance, VAR/pf
- Appliances: Unbalance, harmonics, VAR/pf
- Long cables: Additional losses, voltage drop, skin effect, proximity effect (multi cables in single ducts)

Some specific solutions

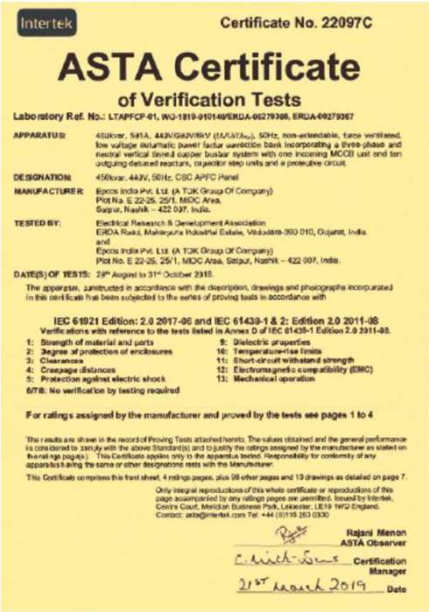
- Selection and application of appropriate power equipment and protective devices
- Rising mains / cable ducts
- Segregation of cables (Data, power), segregated bus ducts
- Good ventilation for cable ducts and Good ventilation for power equipment
- Internal HVDS and distribution step down transformers
- 4 core cables, Copper cables
- Sizing of power equipment (including PQ effects such as skin / proximity, unbalance, surges…)
- Compartmentalization / fire walls
- 100% redundancy
- Good operation and maintenance practices, PM to RCM

Application requirements and performance parameters

Application requirements	Performance parameters
High safety.	Type tested designs
	Separate PE and neutral
	Special integrated smoke alarm in PQ devices
	Quality of components, wires,
	Thermal design, touch potential,
	Robust first level protection
High reliability	Type tested designs
	Modular designs
	EMC compliance
	Appropriate sizing, selection, specifications
High availability. Mission critical	Modular designs with independent module operation
Low down time / low MTTR	Modular design. Interchangeability of modules
Ease of maintenance	Modular, type of construction
Patient / personal comfort	Low noise. Standards exist for ambient noise in hospitals
	Noise frequency away from sensitive human hearing frequency range.

EMI / EMC

- A must for hospital installation with sensitive electronic devices / medical instruments.
- Compliance to EN 61000 or equivalent standards is a must
- Immunity and Emission
- Radiated and conducted noise
- Effect of PWM switching frequency, Inverter topology
- Efficiency of input LCL filter
- Grade of components, PCB layout, wiring



Intertek

Certificate No. 22097C

ASTA Certificate

of Verification Tests

Laboratory Ref. No.: LTAPFCP-01, WO-1819-010140/ERDA-00279366, ERDA-00279367

APPARATUS: 450kvar, 5#1A, 440V/50/VRV (UA/UA/UA), 50Hz, non-extendable, force ventilated, low voltage automatic power factor correction bank incorporating a three-phase and neutral vertical tinned copper busbar system with one incoming MCCB unit and ten outgoing detuned reactors, capacitor step units and a protective circuit

DESIGNATION: 450kvar, 440V, 50Hz, CSC APFC Panel

MANUFACTURER: Epcos India Pvt. Ltd. (A TDK Group Of Company)
Plot No. E 22-25, 25/1, MIDC Area,
Satpur, Nashik – 422 007, India.

TESTED BY: Electrical Research & Development Association
ERDA Road, Makarpura Industrial Estate, Vadodara-390 010, Gujarat, India.
and
Epcos India Pvt. Ltd. (A TDK Group Of Company)
Plot No. E 22-25, 25/1, MIDC Area, Satpur, Nashik – 422 007, India.

DATE(S) OF TESTS: 29th August to 31st October 2018.

The apparatus, constructed in accordance with the description, drawings and photographs incorporated in this certificate has been subjected to the series of proving tests in accordance with

IEC 61921 Edition: 2.0 2017-06 and IEC 61439-1 & 2: Edition 2.0 2011-08
Verifications with reference to the tests listed in Annex D of IEC 61439-1 Edition 2.0 2011-08.

1: Strength of material and parts
2: Degree of protection of enclosures
3: Clearances
4: Creepage distances
5: Protection against electric shock
6: Dielectric properties
10: Temperature-rise limits
11: Short-circuit withstand strength
12: Electromagnetic compatibility (EMC)
13: Mechanical operation

6/7/8: No verification by testing required

For ratings assigned by the manufacturer and proved by the tests see pages 1 to 4

The results are shown in the record of Proving Tests attached hereto. The values obtained and the general performance is considered to comply with the above Standard(s) and to justify the ratings assigned by the manufacturer as stated on the next page(s). This Certificate applies only to the apparatus tested. Responsibility for conformity of any apparatus bearing the same or other designations rests with the Manufacturer.

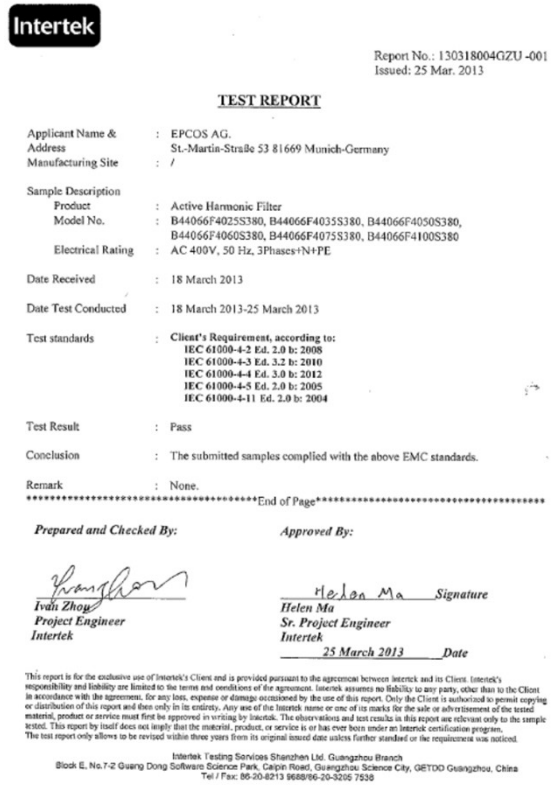
This Certificate comprises this front sheet, 4 ratings pages, plus 98 other pages and 13 drawings as detailed on page 7.

Only integral reproductions of this whole certificate or reproductions of this page accompanied by any ratings pages are permitted. Issued by Intertek, Centre Court, Meridian Business Park, Leicester, LE19 1WD England. Contact: asta@intertek.com Tel: +44 (0)116 263 0330

Rajani Menon
ASTA Observer

Certification Manager

21st March 2019 Date



Intertek

Report No.: 130318004GZU -001
Issued: 25 Mar. 2013

TEST REPORT

Applicant Name & Address	:	EPCOS AG. St.-Martin-Straße 53 81669 Munich-Germany
Manufacturing Site	:	/
Sample Description		
Product	:	Active Harmonic Filter
Model No.	:	B44066F4025S380, B44066F4035S380, B44066F4050S380, B44066F4060S380, B44066F4075S380, B44066F4100S380
Electrical Rating	:	AC 400V, 50 Hz, 3Phases+N+PE
Date Received	:	18 March 2013
Date Test Conducted	:	18 March 2013-25 March 2013
Test standards	:	**Client's Requirement, according to:** **IEC 61000-4-2 Ed. 2.0 b: 2008** **IEC 61000-4-3 Ed. 3.2 b: 2010** **IEC 61000-4-4 Ed. 3.0 b: 2012** **IEC 61000-4-5 Ed. 2.0 b: 2005** **IEC 61000-4-11 Ed. 2.0 b: 2004**
Test Result	:	Pass
Conclusion	:	The submitted samples complied with the above EMC standards.
Remark	:	None.

**********End of Page**********

Prepared and Checked By:

Ivan Zhou
Project Engineer
Intertek

Approved By:

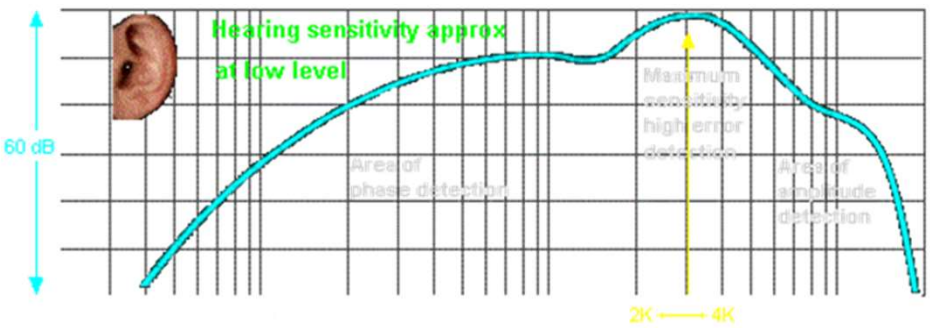
Helen Ma *Signature*
Helen Ma
Sr. Project Engineer
Intertek
25 March 2013 *Date*

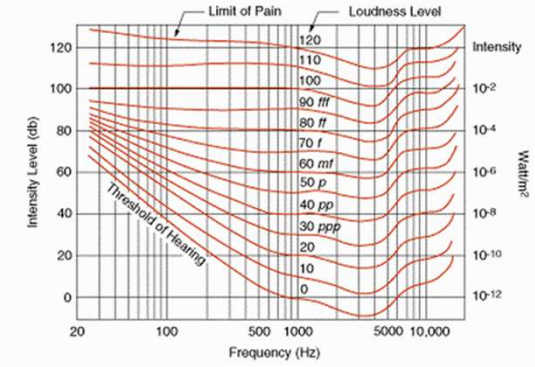
This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to permit copying or distribution of this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program.
The test report only allows to be revised within three years from its original issued date unless further standard or the requirement was noticed.

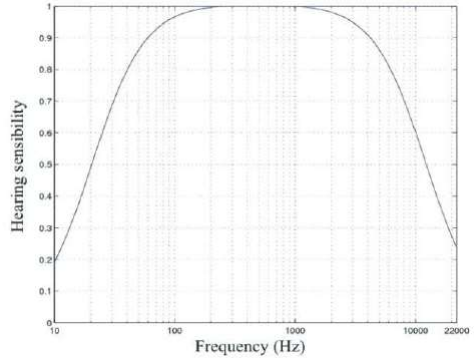
Intertek Testing Services Shanzhen Ltd. Guangzhou Branch
Block E, No.7-2 Guang Dong Software Science Park, Caipin Road, Guangzhou Science City, GETDD Guangzhou, China
Tel / Fax: 86-20-8213 9688/86-20-3205 7538

Equipment noise level

- Refer standards for noise level (<u>especially for hospitals</u>)
- Similar to flicker problem in the past, affecting humans!!
- Not just the amplitude of noise (dBA), but the frequency spectrum is important (> 16 kHz is better. Avoid 2 kHz to 10 kHz)
- Noise from inductors, active power conditioners, transformers,….even capacitors!

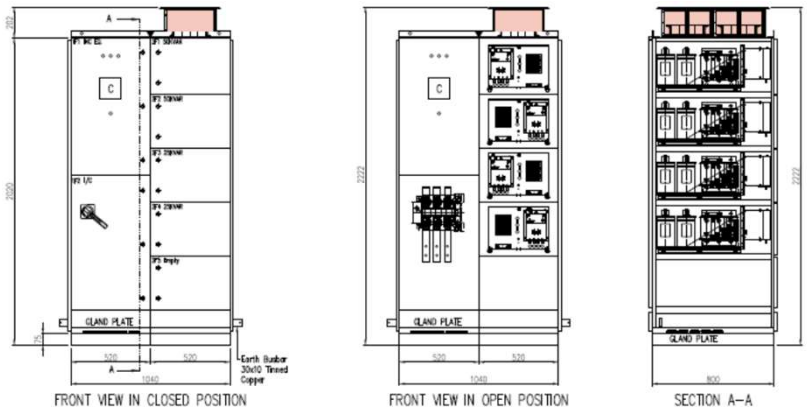






Compartmentalization and Modularity

- Low MTTR / High availability
- Containment of fault
- Integrated alarms
- Reliability of first level protection
- Use of high quality components / wires / cables



Summary

- Hospitals / Healthcare and high rise building require power conditioning
- The safety concerns in these applications are different from other installations for PQ devices
- It is important to select and apply the right / appropriate power conditioning solution to ensure not just technical compliance but also high level of reliability and safety
- Some of the application specific requirement include:
  - Certified for EMI/EMC performance (radiated and conducted noise, emission and immunity)
  - Low power loss, high power efficiency, lower operating temperature (also good ventilation)
  - Wide range of input voltages and ability to tolerate wide input / operating voltage
  - Type tested designs
  - Low audible noise and noise frequency away from sensitive human hearing frequency band
  - Compartmentalized / Modular design. Independent module operation.

www.tdk-electronics.tdk.com