➲ *Demonstration Project – Converter Station in Changji City, Xinjiang Province ±1100kV HVDC Filter Capacitor*

Solution of Reactive Power Compensation and Filtering

Eaton Cooper Power Capacitor

01 Eaton Cooper Capacitor

The research and production base of Eaton Cooper Shanghai Power Capacitor Co., Ltd. is located in Zhangjiang High tech Park, Pudong, Shanghai. Since its establishment in 2004, it has been committed to serving all power institutions and industrial users in the Asia Pacific region. Its products are exported to more than 30 countries and regions both domestically and overseas.

Annual Sales of Cooper Capacitors – 55,000MVar

Winding Length: 3.5 round trips from Earth to Moon

Power Compensation AS A GRID

We are committed to providing products and services that meet international standards and local usage habits for customers around the world

China ⊕ East Asia ⊕ EMEA ⊕ Latin America ⊕ ANZ

Countries and regions where products are sold each year	25+	East Asia	**Power Grid, Industry**
International standard coverage – IEC/IEEE/AS/NBR/BS etc.	100%	EMEA / Latin Amer	**IEC expansion strategy** **Region based product developed**
Ratio of overseas supply of annual production	1/2	ANZ	***Focus on customer needs, customize high-end*** **solutions**

EATON
Powering Business Worldwide

Eaton Cooper capacitors have advanced research and development laboratories, own a number of patents and unique technologies. The Cooper Thomas Edison R&D Centre is composed of nearly 100 scientific and technical personnel, engineers and scientists, equipped with research institutions such as material science laboratory, electric power laboratory, and ultra-high voltage laboratory. Research scope mainly on engineering innovation, and development of high-tech materials, new product development, technological innovation research and research experiments, etc.

The technical expert of Eaton Cooper capacitors, who has served as the secretary, general or special member of the Power Capacitor Branch of the International Institute of Electrical and Electronics Engineers for many years; with the rich resources, which strongly support the research and development of various power capacitors such as for HVDC, high-voltage series compensation, SVC, high-voltage filtering, compensation devices, low-voltage compensation and filtering.

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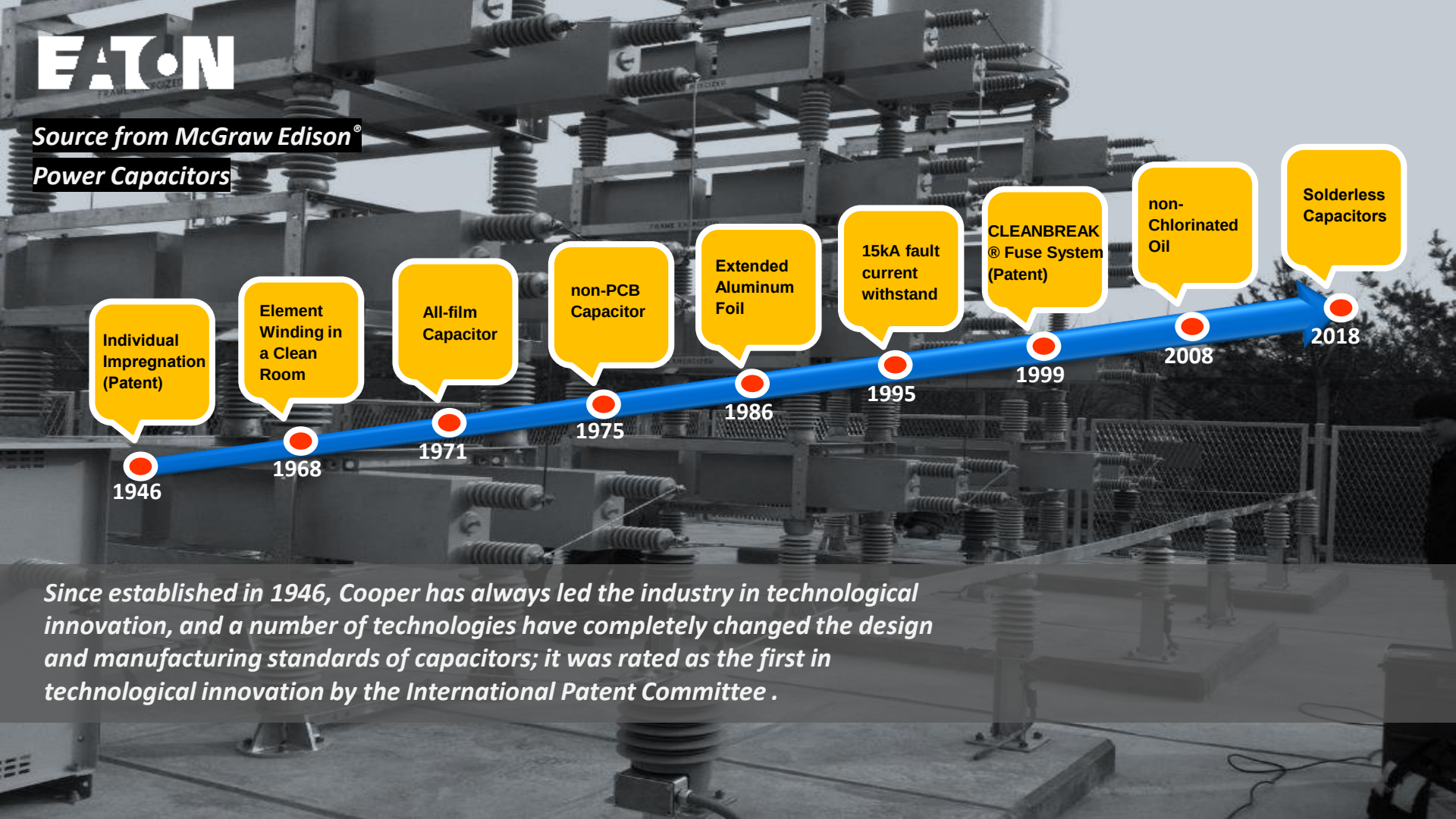
EATON
Source from McGraw Edison®
Power Capacitors
Individual Impregnation (Patent)
1946
Element Winding in a Clean Room
1968
All-film Capacitor
1971
non-PCB Capacitor
1975
Extended Aluminum Foil
1986
15kA fault current withstand
1995
CLEANBREAK® Fuse System (Patent)
1999
non-Chlorinated Oil
2008
Solderless Capacitors
2018
Since established in 1946, Cooper has always led the industry in technological innovation, and a number of technologies have completely changed the design and manufacturing standards of capacitors; it was rated as the first in technological innovation by the International Patent Committee .

02 MV/HV/HVDC Capacitor Bank

Major Products of Medium and High Voltage Capacitors

Power Capacitor Unit

- Capacity: 30~1200kvar
- Internal and external fuse capacitors
- Standards: IEC, ANSI, GB, DL, etc

FXD Capacitor Protection / Measurement Device

BLR Power Factor Controller

Harmonic Filter, Shunt Compensation Capacitor

- IEC, ANSI, GB, DL standards
- Voltage up to 750kV
- Internally Fused, Externally Fused and Fuseless Capacitor Bank

Series Compensation Capacitor
HVDC Filter Capacitor

- IEC/GB standards
- Voltage up to ±1100kV

Metal enclosed capacitor bank

- 3kV ~ 40.5kV
- Indoor or outdoor type

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Crown of Power Capacitor Application – HVDC Capacitor

Shunt Compensation and Filter Capacitor Bank in HVDC Projects

- The first set of complete group (2004) and unit (2019) noise reduced successfully in worldwide;
- The highest voltage project in the world (± 1100kV), with maximum harmonic content and maximum temperature difference (95 ℃) and zero fault operation.
- High altitude challenges at Qinghai Hainan Converter Station (2800 meters) and Sichuan Yazhong Converter Station (2500 meters)

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Eaton's HVDC References

±500kV, USA, 2006

±300kV, Sweden, 2004

±1100kV, China, 2018

±800kV, China, 2020

±800kV, China, 2017

±800kV, China, 2006

±600kV, Brazil, 2011

±800kV, China, 2008

±400kV, Saudi Arabia, 2007

±500kV, India, 2007

±205kV, India, 2001

±400kV, Australia, 2004

Highest Reliability Requirement for Power Capacitor Applications

High-voltage Series Compensation Capacitors

Xindu 500kV series compensation project, Shanxi

TP500kV series compensation project, Brazil

Sanbao 500kV series compensation project, Jiangsu

TEIAS 400kV series compensation project, Turkey
Collaborate with RXPE

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Typical Reference of Shunt Capacitor Bank

KEPCO, 150kV-50Mvar Shunt Capacitor, Korea

PLN, 150kV-50Mvar Shunt Capacitor, Indonesia

TNB, 132kV-60Mvar Shunt Capacitor, Malaysia

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Power Utility User Reference (CSPC)

China National Utility	China National Utility	Korea National Utility	Vietnam National Utility	Indonesia National Utility	Malaysia National Utility
Philippines National Utility	Philippines Regional Utility	Thailand Regional Utility	Cambodia National Utility	Australia National Utility	Australia National Utility
Jordan National Utility	Turkey National Utility	South Africa National Utility	Zambia National Utility	Brazil National Utility	Mexico National Utility

Application of Power Capacitors

– Capacitor Banks for Various Industrial Application

Alcoa Fjardaal Aluminum factory
Finland, high altitude, cold regions

Emirates Aluminum Smelter UAE
Aluminum, Metal Dust, Desert
High Temperature

Minera Escondida
Chile, 4400 meters, the world's
largest copper mine

Alibaba Networking Project Bar
Project, Alibaba, Tibet, 4900
meters above sea level

Lanzhou Aluminum Plant
Filter system solution, 155MVAR

Hydro Aluminium Australia
Australian Hydro Aluminum in a
strong sandstorm environment

SANTA FE PACIFICE Gold Mine,
South Africa

GILBERT K&M Metallurgy, Mexico

Powering Business Worldwide

03 Medium Voltage Metal Enclosed Capacitor Bank

#MECB Family

Flexible structure option to meet customized demand

Indoor Cabinet Type

Outdoor Prefabricated Cabin Type

Outdoor Cabinet Type

Outdoor Containerized Type

Product Parameters

- Voltage: 3~40.5kV
- Capacity: Up to 50,000kvar
- Protection: Unbalance Current, Open delta voltage
- Control: Manually / Automatically
- Switch: Vacuum contactor / Vacuum breaker

Structure Features

- Indoor / Outdoor Applications
- Solid structure, excellent Seismic
- Compact design enabling container shipping
- Automatic control, extendable

Electrical Features

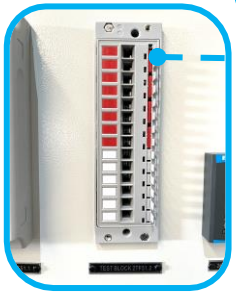
- Eaton capacitors ensuring reliable performance
- Verification studies and type test ensuring outstanding performance

Powering Business Worldwide

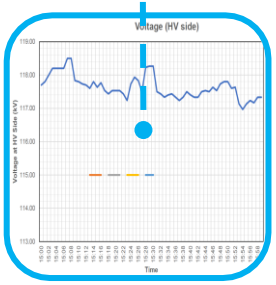
Advanced functions / features

IEC 61850 Redundancy Enabled

Withdrawable Cap Switch



Test Terminal



Controller for
Solar Application

Electric Mechanism
Earth Switch

Containerized Type

Pressure Switch

Powering Business Worldwide

#MECB
Digital Upgrade

Digitalization enables safer and trouble-free operation

EX-DMi

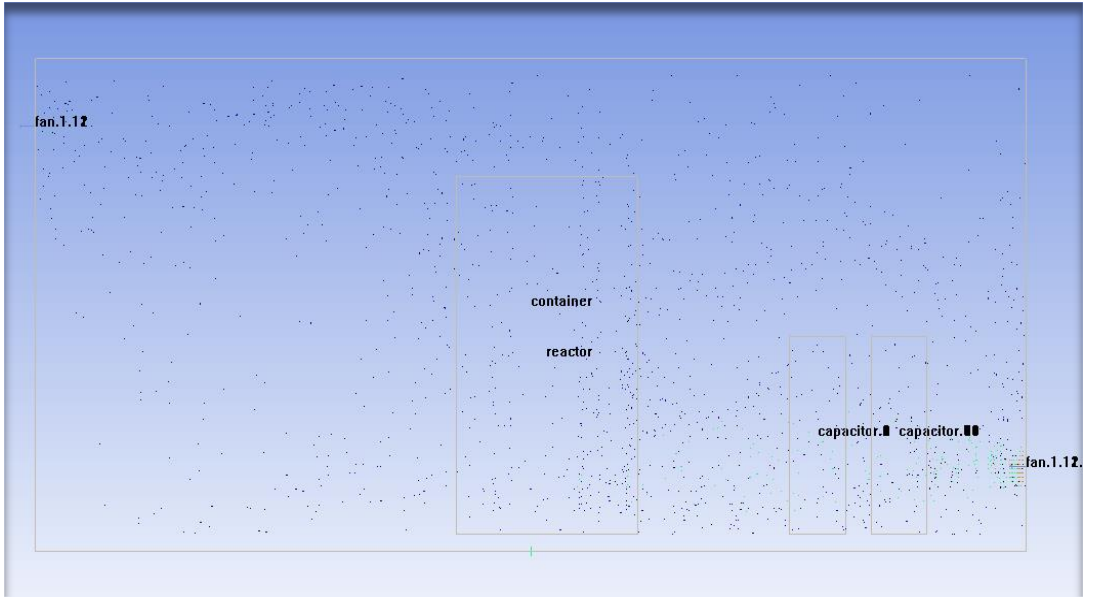
Medium-voltage **Digital**
Metal Enclosed Capacitor Bank

- Wireless Temp Sensor
- iCloud Database
- Smart Switching
- Arc Flash Protection
- Instant Installation

Powering Business Worldwide

Technical Advantages _ Heat Dissipation Design

- **Professional heat dissipation design, fully ensuring operating life**
- **Professional air duct simulation design**
- **Using a turbocharged fan in conjunction**
- **Proficient in thermal stability requirements of capacitor units**
- **More than 10 years of experience in high-temperature and thermal environments**



Thermal simulation ensures that the designed air duct and cooling fan selection meet the operating temperature requirements.

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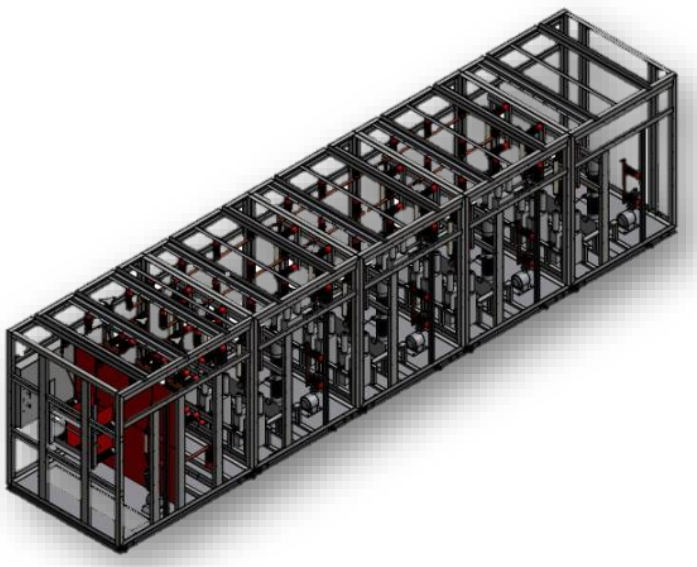
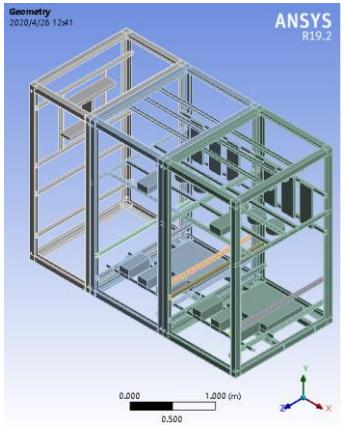
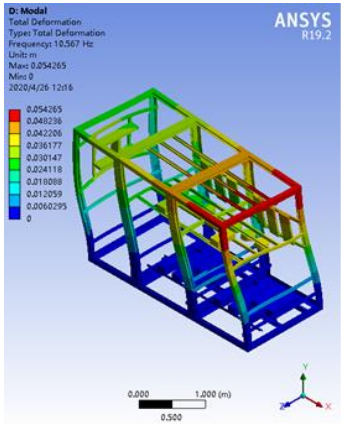
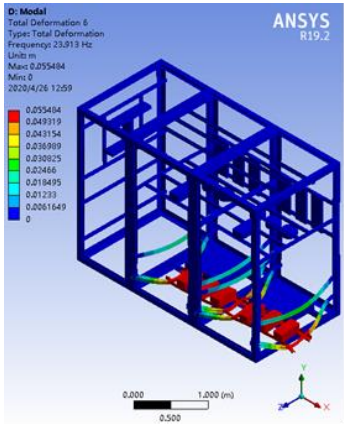
Technical Advantages _ Structural Design



- **High reliability architecture and cabinet structure design**
- **All structures have undergone finite element seismic verification**



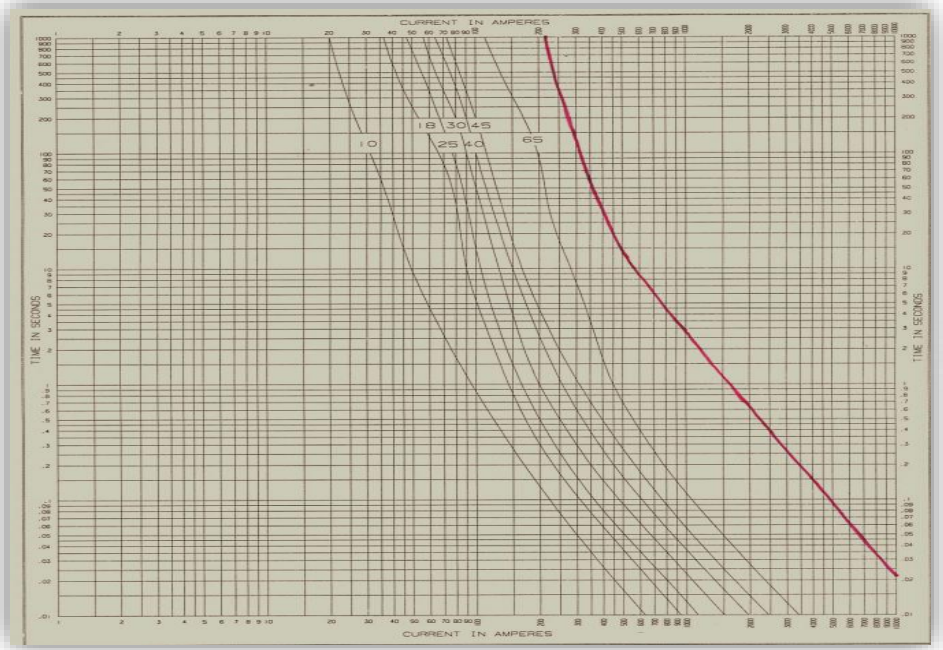


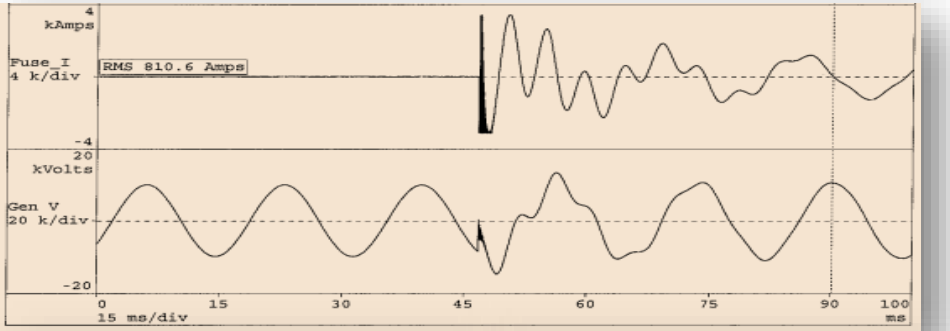


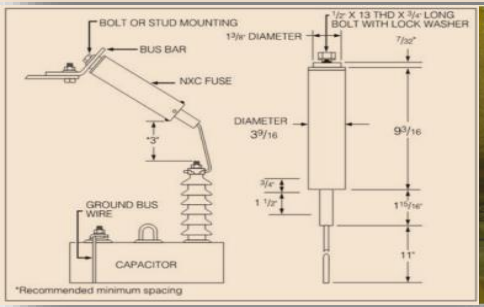
Structural stress analysis under dead weight load, wind load and Seismic wave load

EATON
Powering Business Worldwide

Technical Advantages _ Capacitor Specific Current Limiting Fuse







Cooper Bussmann capacitor specific current limiting fuse ensures that the fuse curve matches the explosion-proof energy curve of capacitor tank.

#MECB
Leading Tech

Technical Advantages _ High Quality Components from Eaton Family

Capacitor

Vacuum Contactor

Vacuum Circuit Breaker

Fuse

Power Factor Controller

Protection Relay

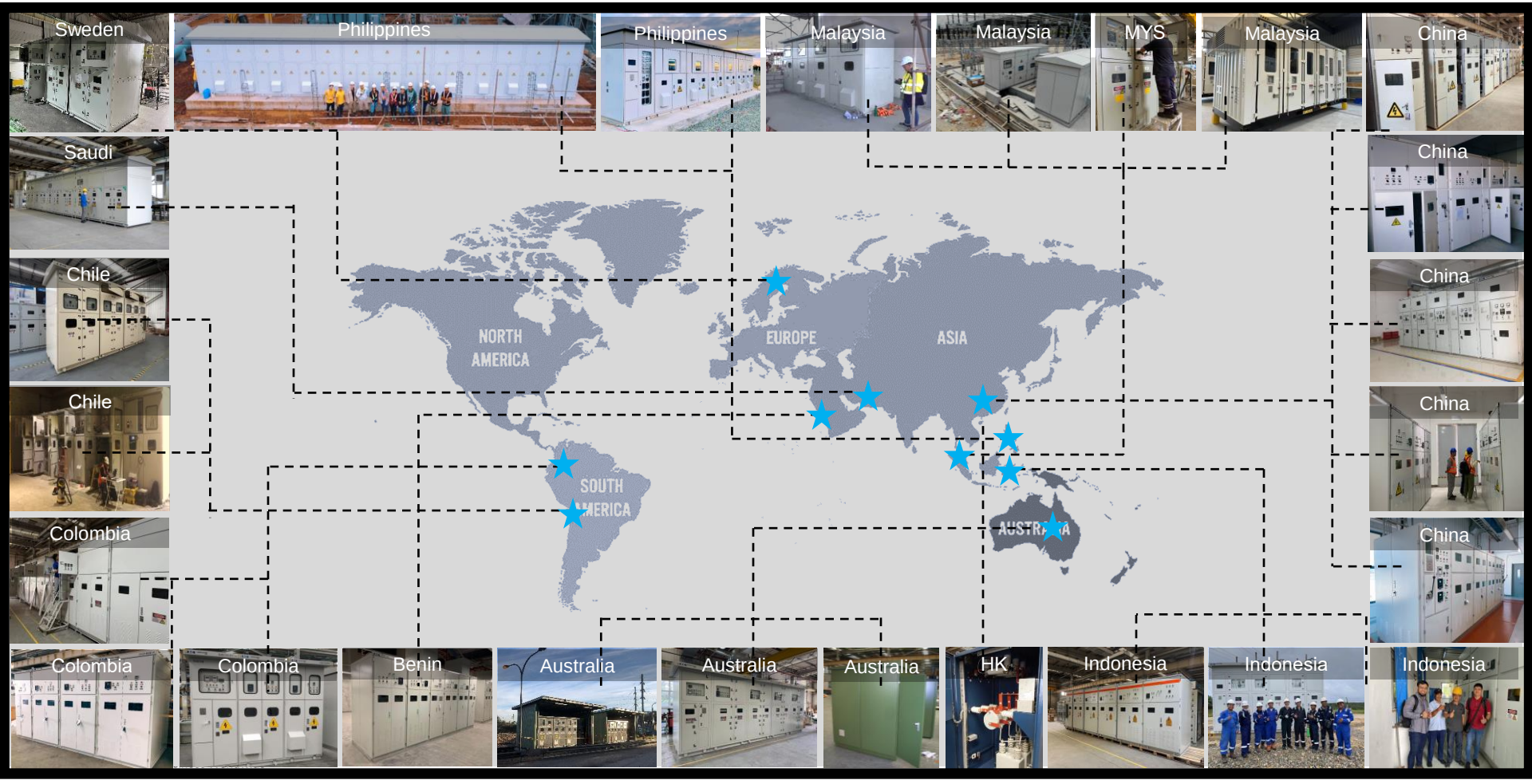
Low-voltage components

Full range of components from Eaton family to ensure the stability and reliability of capacitor bank operation.

Powering Business Worldwide

MECB Reference All Over the World

★ *Typical Reference (partial) by destination*

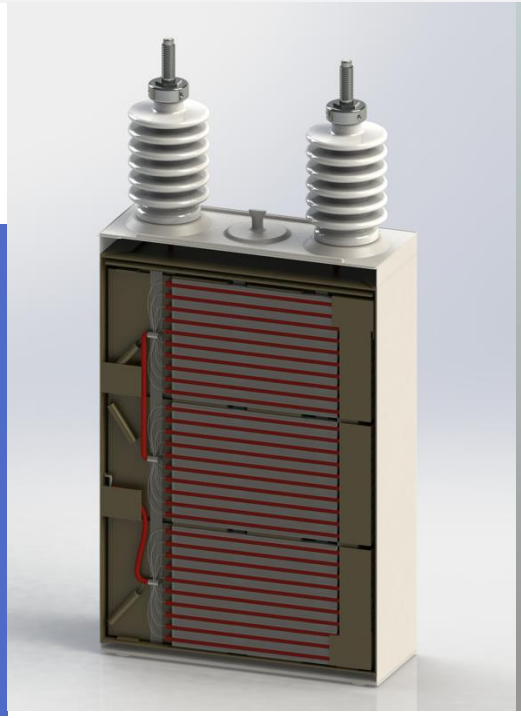


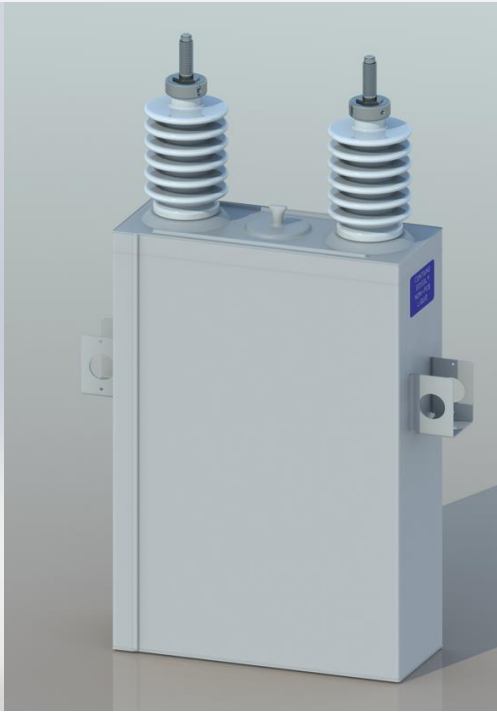
04 Capacitor Core Technology

Why Choose
Eaton Cooper Power Capacitor?

Unique Design & Advanced Processing

- Advanced Internal Fuse Technology
- Edisol Environmentally Friendly Oil
- Individual Closed-Loop Impregnation
- EX ® Patented Mechanical Connection
- Unified, Definite Tank Rupture Curve





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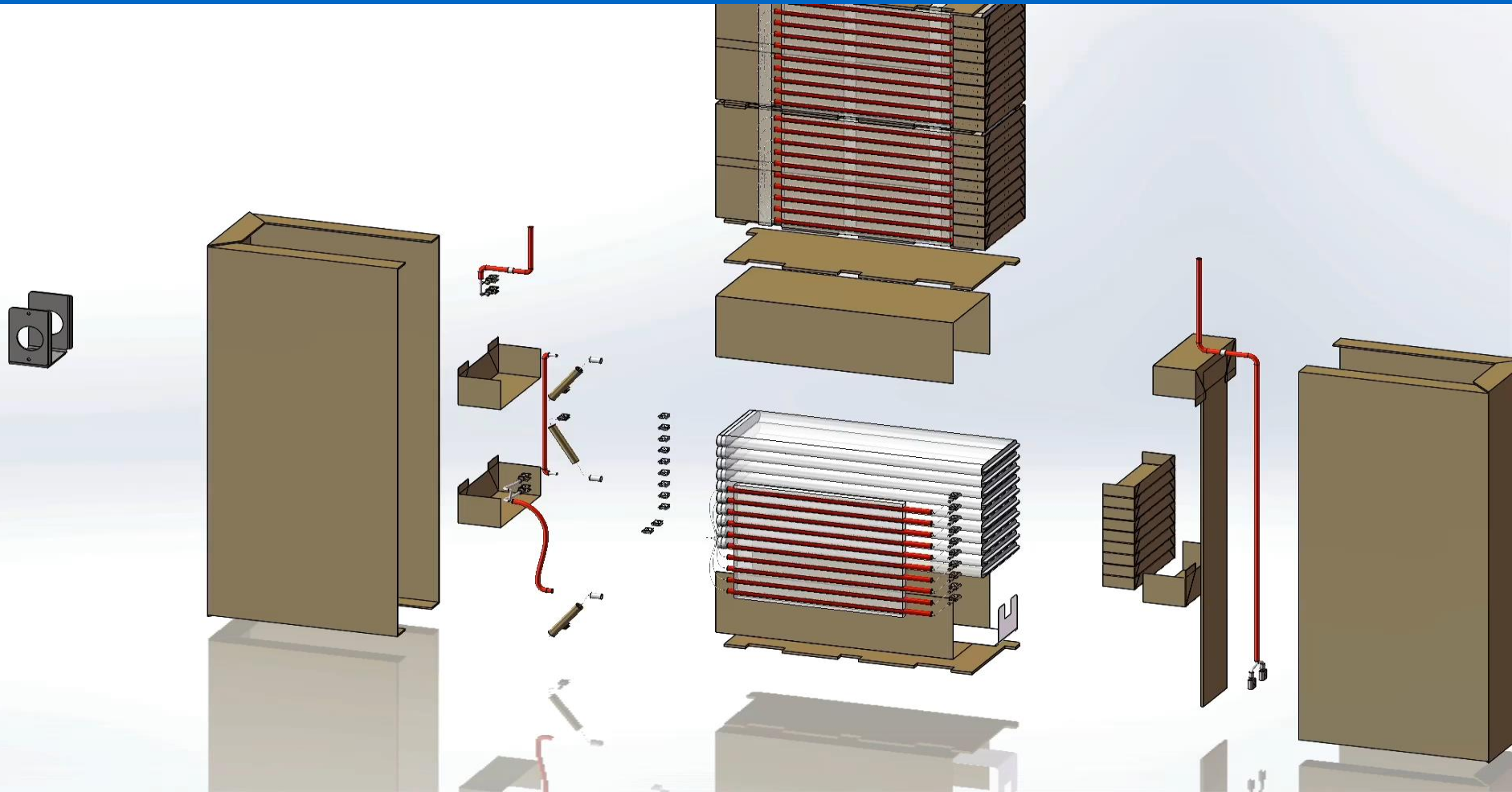
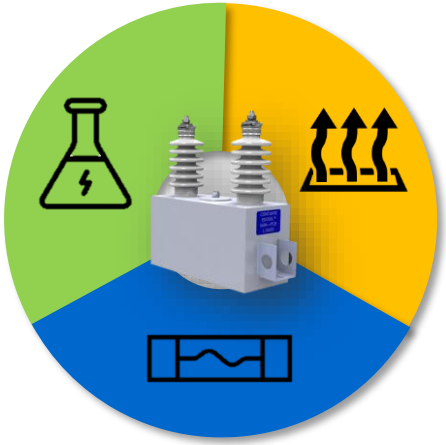
Composition of Capacitor Unit



Three Key Technical Characters for Capacitor

Dielectric Fluid

- Superior Electrical Performance
- Balance between low and high ambient temperature operation
- Environmentally friendly



Losses

- Lower Losses
- Lower temperature rise
- Longer working life

Fusing System

- **Reliable**: rapid fusing required to remove faulted element from service
- **Safe**: to minimize gassing and damage to the failed element and adjacent dielectric
- **Clean**: to eliminate the generation of carbon arc by-products in the dielectric fluid, and to prevent fluid contamination

Power of 7 Rule

It is commonly accepted that the life of an all-film capacitor dielectric system is **halved** for **every 7℃ temperature rise**.

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Technical Features - Dielectric Fluid

Edisol® Capacitor Fluid

- Patent additive, significantly improving the stability of impregnating agent under electric field, with excellent overvoltage resistance
- PCB free, biodegradable and environmentally friendly insulation oil with high ignition point
- High gas absorbtion and low gas release, combined with Cooper's patented independent vacuum pressure oil impregnation system, ensure the adequacy of capacitor impregnation

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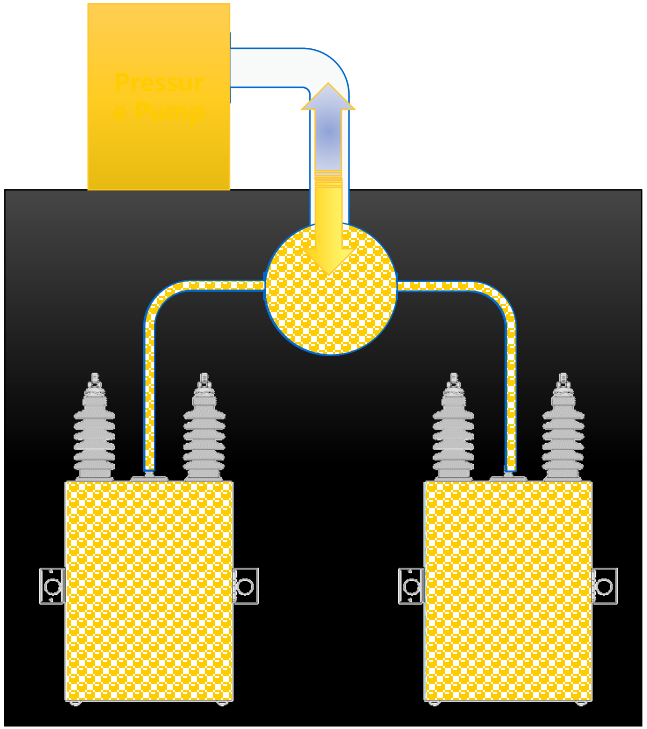
Technical Features - Dielectric Fluid

Cooper Patented Independent Vacuum Oiling Process



Pre-dry

- Remove moisture and air inside the capacitor tank
- Perform leakage testing on each capacitor

Impregnation

- Perform another vacuum treatment
- Conduct independent leak testing again
- Inject Edisol impregnating oil

Positive Pressure

- Apply micro positive pressure to the inside of the capacitor

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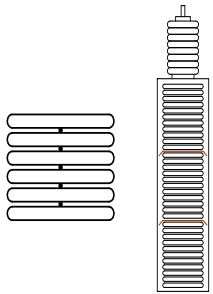
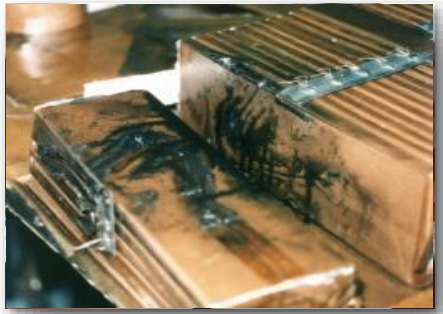
Technical Features – Internal Fuse

CLEANBREAK® Internal fuse system

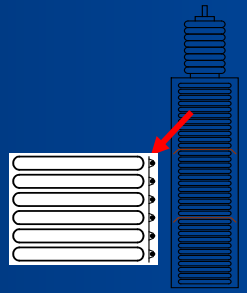
Internal fuse system





Traditional internal fuses:

- Heat Generation by Internal Fuse
- Contamination of Fluid by Fuse Operation
- Potential damage to adjacent Element and insulation material by Fuse Operation
- Potential damage to adjacent Fuse by Element Failure
- Soldered Electrical Joints



EATON's CLEANBREAK® Fusing System:

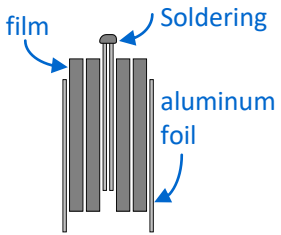
- Fuses are individually mounted within a polymer fuse tube.
- This design also eliminate the generation of extensive carbon arc in the dielectric fluid.
- This significantly improves the dielectric performance by preventing fluid contamination and promotes proper clearing of element fuse.

Powering Business Worldwide

Technical Features – Mechanical connections

EX® Mechanical Crimping Connection System

Internal connection



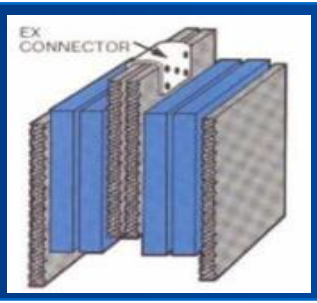
Traditional soldering processes:

The high impedance of the contact point causes local heating at the soldering point and increases the loss of the capacitor;

The high temperature during soldering leads to local deformation of the polypropylene film;

The connection strength of welding points is weak;

Flux is a highly corrosive chemical that can cause damage to the film and impregnating agent when left in capacitors。



Cooper EX ® Mechanical crimping connection system:

Tighter connection of components

The impedance between components in each layer is significantly reduced, ensuring low loss of capacitors

Stronger than other connection methods, significantly improved component performance, capable of withstanding higher instantaneous currents and partial discharge impacts

The connection between each component can be tested to ensure the reliability of the connection.

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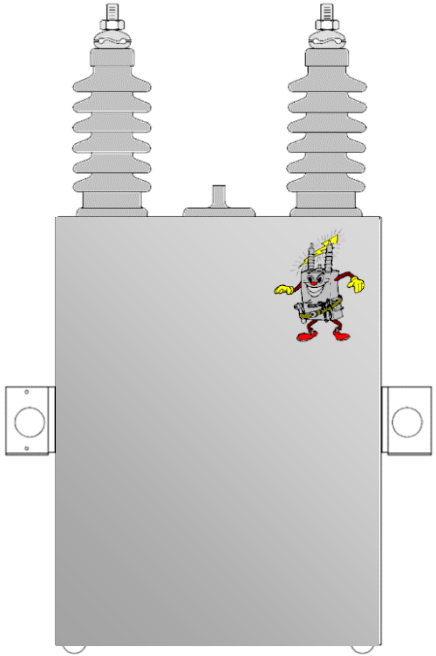
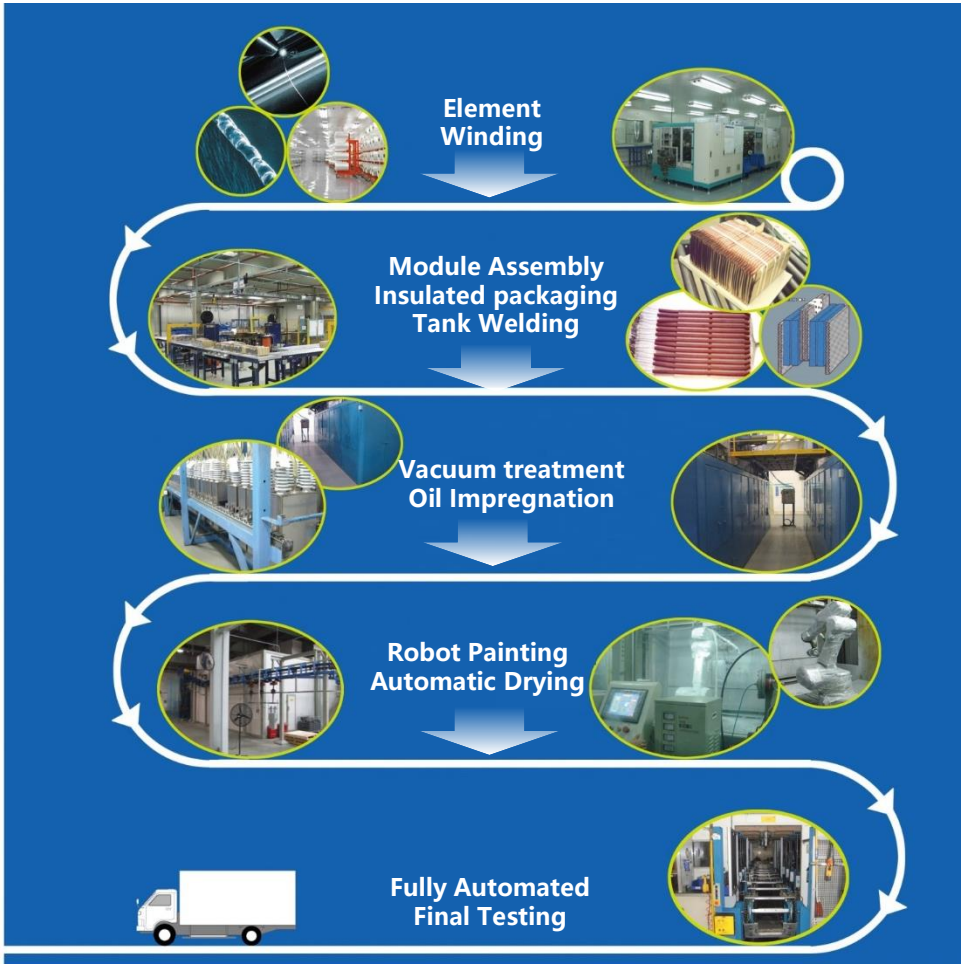
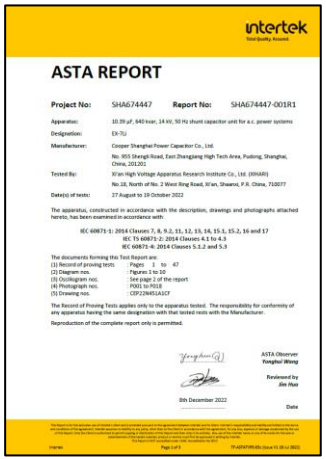
Manufacturing Process

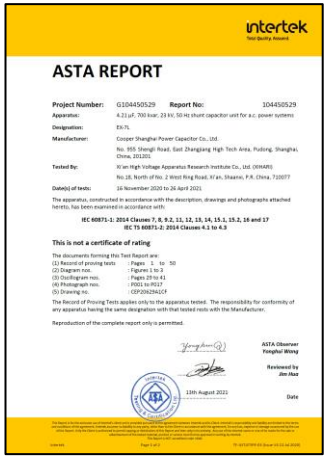




Powering Business Worldwide

New type test reports for MV/HV cap units





Lab Certification	STL	STL	iLac-MRA	iLac-MRA	iLac-MRA
Type	EX-7Li (I/F)	EX-7L (U/F)	EX-7Li (I/F)	EX-7Li (I/F)	EX-7Li (I/F)
Rating	14kV-640kvar	23kV-700kvar	7.968kV-600kvar	6.95kV-420kvar	10.392kV-420kvar
Language	EN	EN	EN/CHS	EN/CHS	EN/CHS
Standard	IEC 60871-1/4	IEC 60871-1/4	IEC 60871-1/4	IEC 60871-1/4	IEC 60871-1/4

Continuous investment on type test reports to increase competitiveness

Powering Business Worldwide

MV/HV Capacitor Typical Reference

05 Capacitor Bank Application in Solar Projects

Powering Business Worldwide

Application in Solar Project

Why is capacitor needed in solar plant?

The operation of various equipment in solar power plants will inevitably lead to reactive power losses and harmonics, which will have an adverse impact on the operation of the power system.

The main source of reactive power in solar plant:

- Collecting lines and transmission lines
- Step-up transformer
- Inverter

The role of capacitors in solar plant:

- Reactive power compensation ➔ Power factor correction
- Harmonic filtering ➔ Reducing system harmonic

The estimated capacity of the capacitor bank in a solar plant:

5%~15% of the total power generation capacity of solar farms.

Application in Solar Project

Project Information

- Application: Outdoor type open rack bank
- Rating: 33kV – 10Mvar, C-type filter
  33kV – 4Mvar, filter
- Product: Medium voltage filter capacitor bank
- Project Location: Australia
- Project Info: Lilyvale Solar Farm
- Year: 2018
- Manufacturer: Eaton's Cooper Shanghai Power Capacitor Co., Ltd.

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Application in Solar Project

Project Information

- Application: Outdoor type open rack bank
- Rating: 33kV – 4.5Mvar, C-type filter
  33kV – 8Mvar, C-type filter
- Product: Medium voltage filter capacitor bank
- Project Location: Australia
- Project Info: Goonumbla Solar Farm
- Year: 2019
- Manufacturer: Eaton's Cooper Shanghai Power Capacitor Co., Ltd.

Powering Business Worldwide

Application in Solar Project

Project Information

- Application: Outdoor type metal enclosed bank
- Rating: 22kV – 3000kvar * 6 steps
- Product: Medium voltage shunt capacitor bank
- Project Location: SAN Miguel, Philippines
- Project Info: Renewable Energy - Solar Plant
- Year: 2020
- Manufacturer: Eaton's Cooper Shanghai Power Capacitor Co., Ltd.

Powering Business Worldwide

Application in Solar Project

Project Information

- Application: Outdoor type open rack bank
- Rating: 33kV – 21Mvar, C-type filter
- Product: Medium voltage filter capacitor bank
- Project Location: Australia
- Project Info: GRS Bluegrass Solar Farm
- Year: 2021
- Manufacturer: Eaton's Cooper Shanghai Power Capacitor Co., Ltd.

Powering Business Worldwide

Application in Solar Project

Project Information

- Application: Outdoor type open rack bank
- Rating: 33kV – 12Mvar, double tuned filter
  33kV – 8Mvar, high-pass filter
- Product: Medium voltage filter capacitor bank
- Project Location: Australia
- Project Info: Edenvale Solar Farm Project
- Year: 2022
- Manufacturer: Eaton's Cooper Shanghai Power Capacitor Co., Ltd.

Powering Business Worldwide

Application in Solar Project

Project Information

- Application: Outdoor type open rack bank
- Rating: 33kV – 9Mvar
- Product: Medium voltage shunt capacitor bank
- Project Location: Malaysia
- Project Info: LSS Chuping, Perlis
- Year: 2023
- Manufacturer: Eaton's Cooper Shanghai Power Capacitor Co., Ltd.

MECB for Green – Outdoor auto-switched MECB to support solar station's power factor correction

Energy Transition Success Case

Copying to more overseas solar applications…

Project : 75 MW Pinugay Solar Power Plant, Philippines

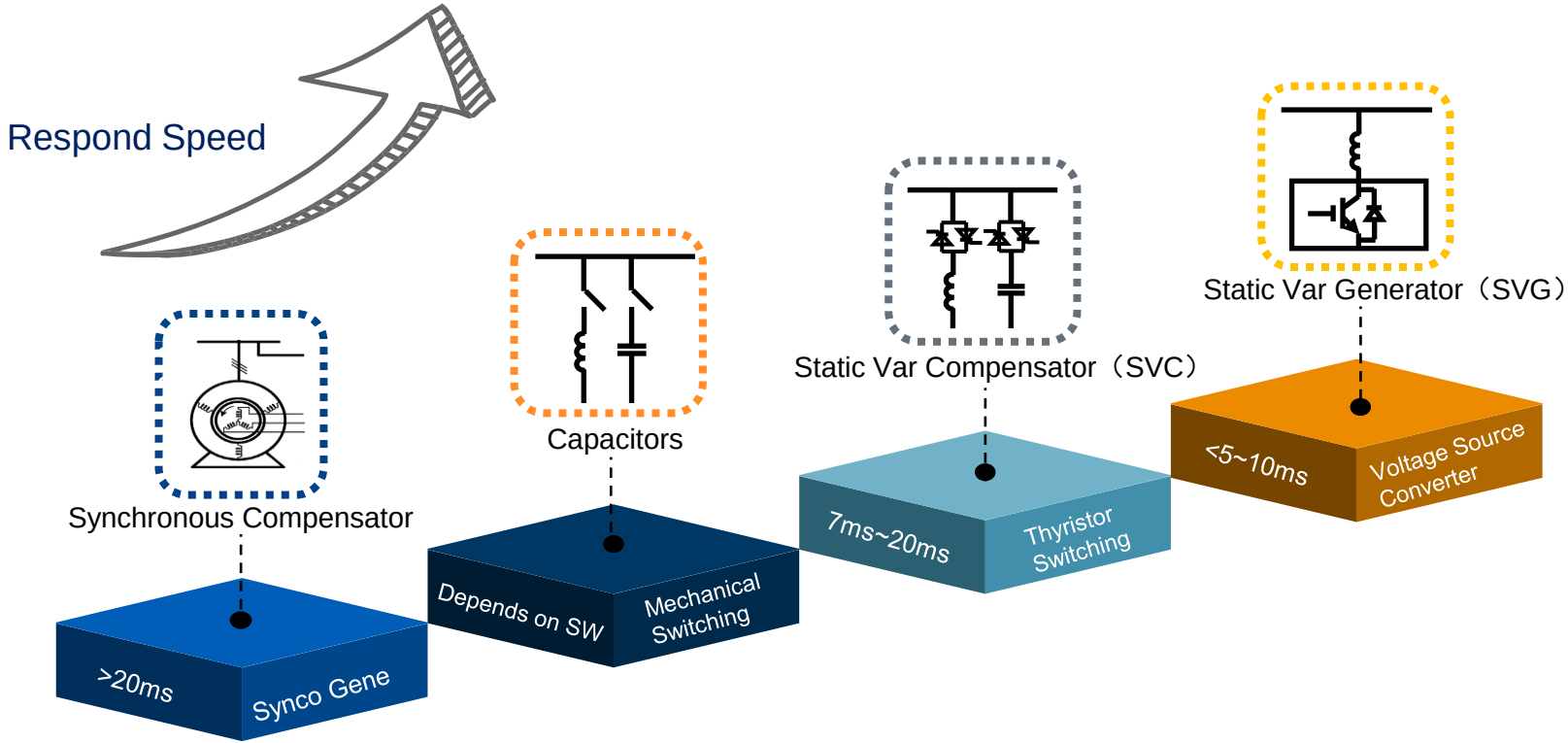
Product : Outdoor MECB, 34.5kV – (1000+2000+4000+8000)kvar

Latest: Successfully energized on Oct 10, 2023

Owner	Contractor	Local Consultant	Capacitor Vendor
GBP GLOBAL BUSINESS POWER	CEEC 中国能建 ENERGY CHINA | 广东省电力设计研究院有限公司	SOLENERGY SYSTEMS INC.	EATON Powering Business Worldwide

06 Medium Voltage SVG (STATCOM)

Reactive Compensation Development Route



Function and Application of MV SVG / STATCOM

Working Principle

- IGBT high-speed full-controlled power electronic devices
- The instantaneous current of the system is compared with the predicted current to release or store the current of the capacitor
- Realize dynamic compensation of reactive power

Solved Issues

- Dynamic reactive power compensation
- Voltage fluctuation
- Voltage flicker
- Three-phase imbalance
- High and low voltage ride through

Applicable industry

- Metallurgy
- Chemical industry
- Wind / Solar
- Rail
- Power grid

Powering Business Worldwide

Type EX-TGi

SVG/STATCOM

Main Parameter

Voltage	6~35kV
Capacity	≤± 100Mvar
Response Time	<5ms
Cooling Method	Water cooling / Forced air cooling / Natural cooling
Average Losses	0.8~1.0%
Equipment Structure	Indoor Cabinet / Indoor Rack Type / Outdoor Container Type
Adjustment Method	Automatic continuous smooth adjustment of capacitive and inductive reactive power

Powering Business Worldwide

Type EX-TGi SVG/STATCOM

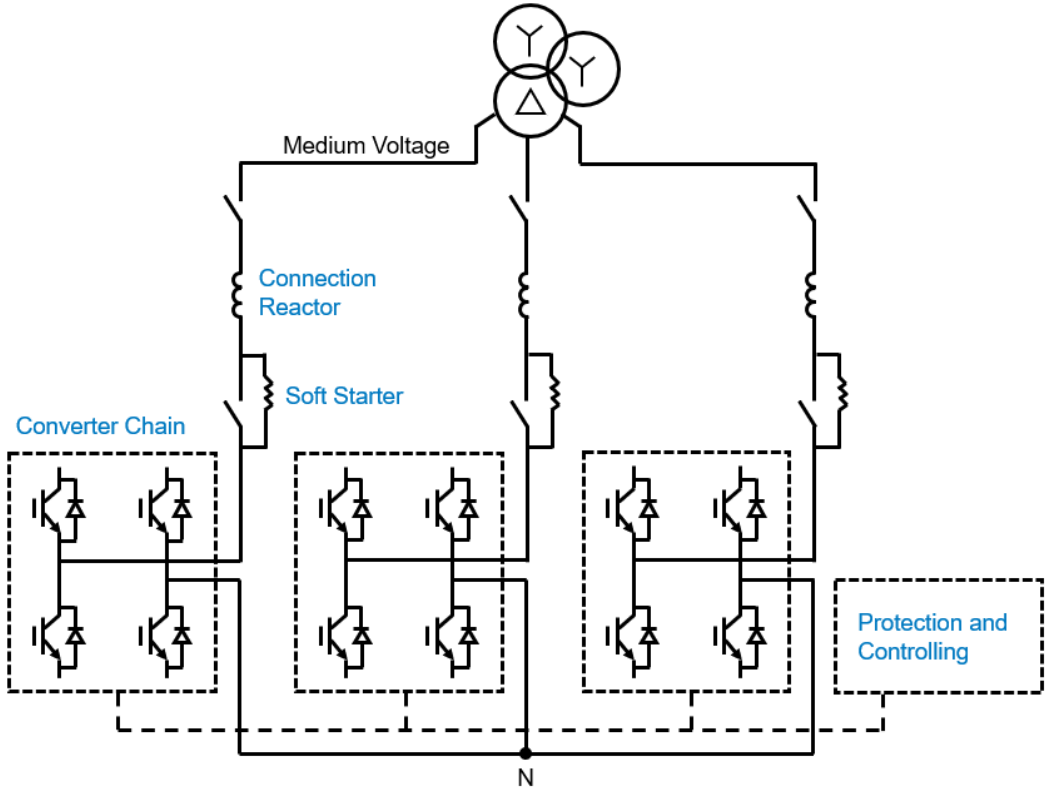
Main Components

Connection Reactor

Soft Starter

Converter Chain

Protection and Control



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Operation Mode

Item	SVC(TSC)	SVC(MCR)	SVC(TCR)	SVG/STATCOM
Reactive Compensation	By Step	Continuous	Continuous	Continuous
Operation Scope	Capacitive	Capacitive& Inductive	Capacitive& Inductive	Capacitive& Inductive
Response Time	<20ms	<20ms	<100ms	<5~10ms
Affected by System Resistance	Yes	Yes	Yes	No
Footprint	Large	Large	Large	Small

Type EX-TGi SVG/STATCOM

Utility

- Increase dynamic voltage support
- Prevent large scale collapse
- System damping

Wind / Solar Farm

- Recover voltage during low voltage ride through

Metallurgy

- Improve power factor
- Smooth voltage fluctuation caused by impulse loads

Port

- Improve power factor
- Eliminate harmonics

Railway

- Reactive compensation
- Solve three-phase unbalance

Mining

- Reactive compensation
- Smooth voltage fluctuation caused by heavy loads

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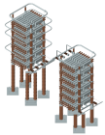
Capacitor ▸▸ Reactive Power Compensation and Filter Expert

HV
66~1100kV


TAL/TBB
HVDC Filter


HV Noise
Abatement Filter


TCB
Series Capacitor


Internally Fused
HV Cap Bank


Externally Fused
HV Cap Bank


Fuseless
HV Cap Bank

MV
3~35kV


EX-VKi
MV Open Rack


EX-DMi
Indoor MECB


EX-DMi-K
Motor Starter


EX-DMi-O
Outdoor MECB


EX-DMi-X
Container MECB


EX-DMi-H
Semi-enclosed


EX-TGi
MV SVG


EX-7L
MV Cap Unit


EX-9a
MV Reactor


EX-9c
I^2t limiting Fuse


EX-9d
MV NXC Fuse


EX-9e
Expulsion Fuse


FXD620
Protection Relay


BLR Power Factor
Controller

LV
100~900V


CELA/CELS
APF/SVG


CELA/CELS
APF/SVG


CELH
Module Cap


CELD
Dynamic Voltage
Recover


CELB
LV Cap MECB


CELF
LV Filter MECB


Thyristor Switch
(Std Duty)


EPLCR
LV Cap Unit


EPLCR-N
LV Cap Unit


CELR
LV Reactor


CELR-N
LV Reactor


CELP
LV PF Controller


CELU
Harmonic Protector


Thyristor Switch
(Heavy Duty)

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Thank you for your support and trust !

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