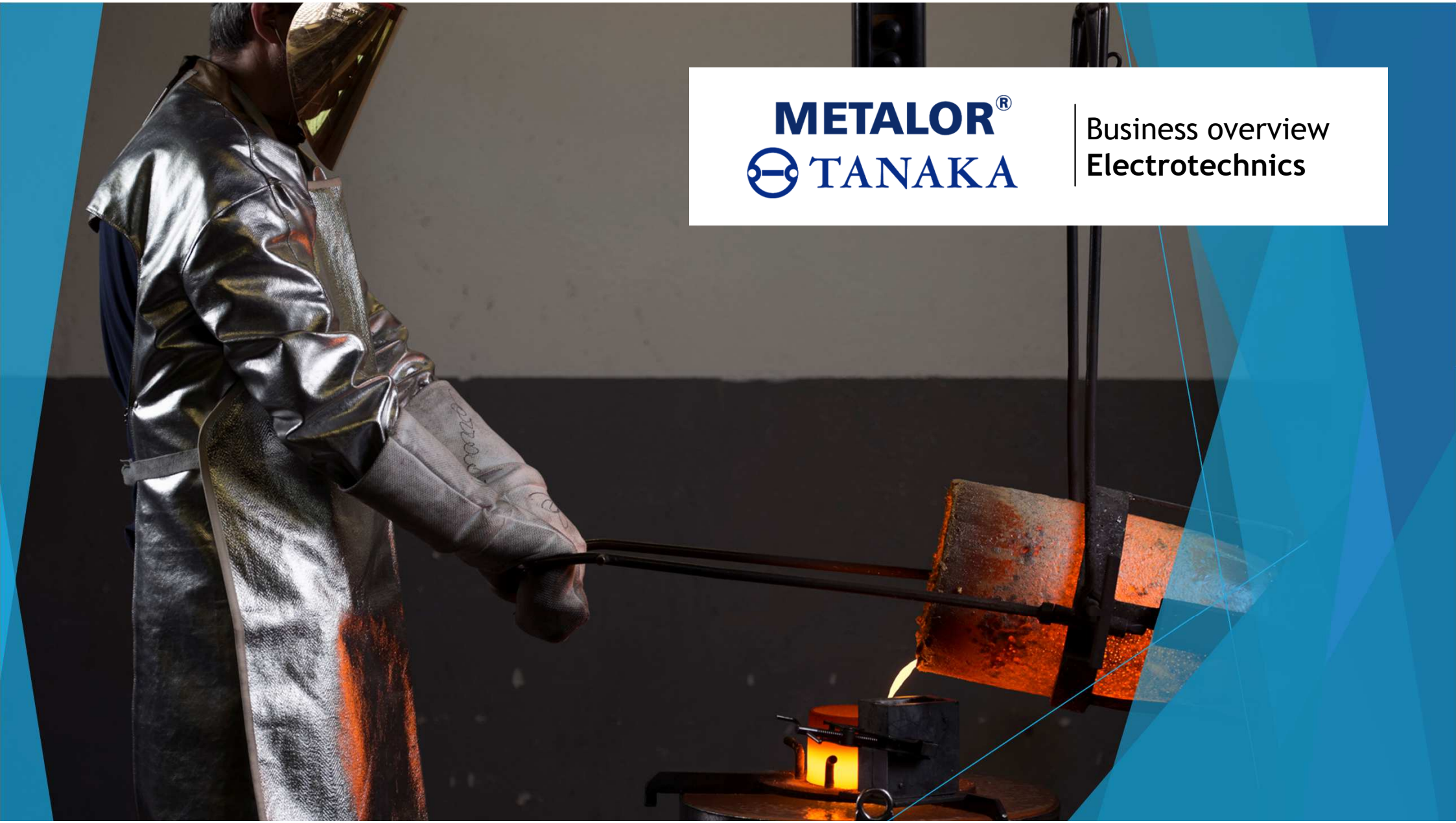




Business overview
Electrotechnics



Metalor Technologies | A Swiss success story

1852
1950



The foundation

In 1852, Martin de Pury & Cie founded the company in Le Locle (Switzerland), specialized in gold casting and watch case manufacturing.

In 1864, the factory, then employing five people, was bought by the Banque du Locle. In 1918, it was taken over by the Swiss Bank Corporation (SBS), when it had about thirty employees.

In 1936, the company was renamed **Métaux Précieux SA Metalor**, a name that would last for 65 years.

1950
1980



Swiss developments

Headquartered in Neuchâtel for already more than 10 years, the main Metalor factory saw in the 1950s the expansion of its premises through the construction of a Chemical plant dedicated to the development of gold, silver and PGM refining.

Recycling of industrial scraps from watch and jewelry manufacturing.

1980
1998



Expertise broadening

As from the 1980s, expansion of chemical and metallurgical activities:

- Refining of mining, industrial and banking products
- Production of precious metal salts and powders
- Electrical contacts manufacturing

In 1987, a new plant was built in Marin Switzerland, reinforcing the refining activities and the chemical production.

Shareholders:
SBS until 1997, then UBS

- 1981 SAMEC acquisition in Courville, France
- 1989 acquisition of Leach and Gardner's refining business in the United States
- 1997 Acquisition of Chemet's silver powder business in the USA

Metalor Technologies | A Swiss success story

1998
TODAY



- 2002 Acquisition of E-CLAL
- 2003 Opening of the Suzhou plant in China
- 2007 Acquisition of Johnson Matthey's refining business in Hong Kong
- 2009 Acquisition of AMI Doduco's contact business in the USA and Mexico
- 2011 Acquisition of NECC's plating business in Japan and Korea
- 2013 Opening of the Singapore refining plant
- 2014 Opening of the Wuzhong (Suzhou) plant for Electrotechnics
- 2016 Opening of the San Luis Potosi plant in Mexico

Industrial expansion

As of 2001, the name **Metalor Technologies** became the company's corporate name.

Development of the plating activity, in particular through the acquisition of Engelhard CLAL (Advanced Coatings) and Contacts (Electrotechnics).

Shareholders:

Private investors	1998 to 2009
Astorg (Private Equity)	2010 to 2016
Tanaka Kikinzo	2016 to present



Metalor Technologies | In Short, who we are

"A global leader in precious metals"



Precision technology provider
with key competences in
chemistry, metallurgy and
materials processing

Trusted partner serving the
top market leaders in each of
our 3 business segments

12

Production and R&D
sites globally

3

Business Groups

>5'000

Customers globally

7

Precious Metals :

Gold, Platinum,
Palladium, Silver,
Rhodium,
Ruthenium, Iridium

US\$ 2.6 Billion
Lease lines with over
15 major banks

>165

Years of expertise in
precious materials

>1,500

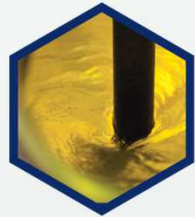
Employees,
39 nationalities

Metalor Technologies | Business structure & markets

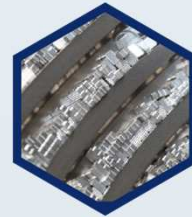
METALOR GROUP



REFINING
Business Group



ADVANCED COATINGS
Business Group

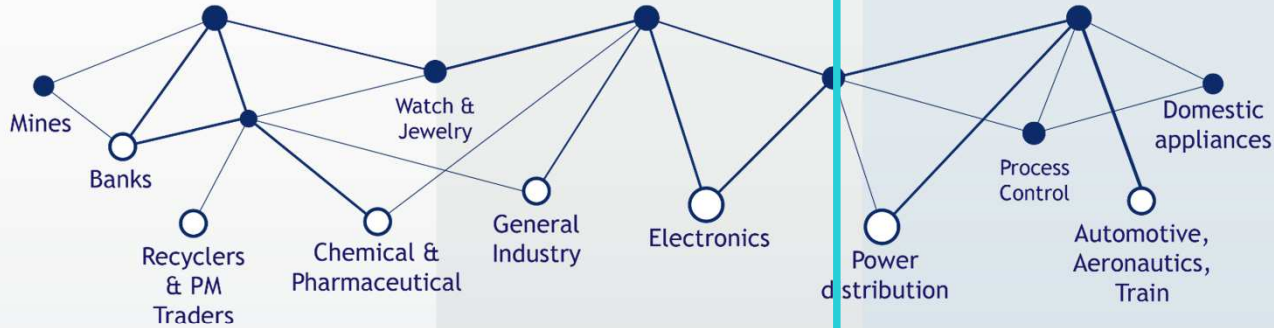


ELECTROTECHNICS
Business Group



TREASURY

Hedging and financing solutions



- Evaluation & refining services
- Bullion & investment products
- Fine metals, alloys & chemicals

For industrial and financial markets

- PM salts and electrolytes
- PM flakes and powders

For electroplating, conductive inks & photovoltaic applications

- Silver based strips and wires
- Rivets & tips
- Assemblies

For breakers, contactors, relays, switches, fuses and sensors

- 24h / 5 days a week trading
- More than 250 MUSD cash
- Tailor-made solutions

Trading desks in CH, US, HK & China

Metalor Technologies | Our global network, sustainably located



23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.9331	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
41 Nb Niobium 92.9063	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.757	52 Te Tellurium 127.6	53 I Iodine 126.905	54 Xe Xenon 131.29
73 Ta Tantalum 180.9478	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.222	78 Pt Platinum 195.084	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium 209	85 At Astatine 210	86 Rn Radon 222
105 Sg Seaborgium (263)	106 Bh Bohrium (264)	107 Hs Hassium (265)	108 Mt Meitnerium (266)	109 Ds Darmstadtium (267)	110 Rg Roentgenium (268)	111 Cn Copernicium (269)	112 Uut Ununtrium (270)	113 Fl Flerovium (271)	114 Uup Ununpentium (272)	115 Lv Livermorium (273)	116 Uuq Ununseptium (274)	117 Uus Ununseptium (275)	118 Uuo Ununoctium (276)

Metalor Technologies | Precious Metals...

“A precious metal is a rare, naturally occurring metallic chemical element of high economic value and unique properties”



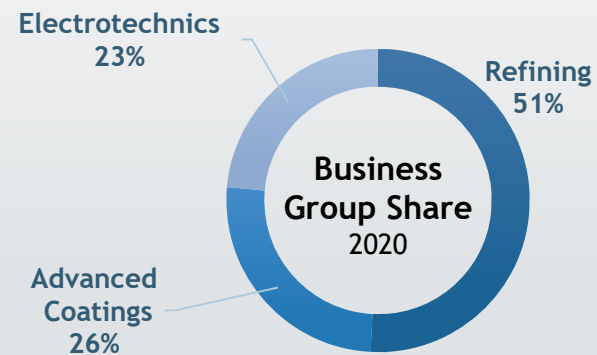
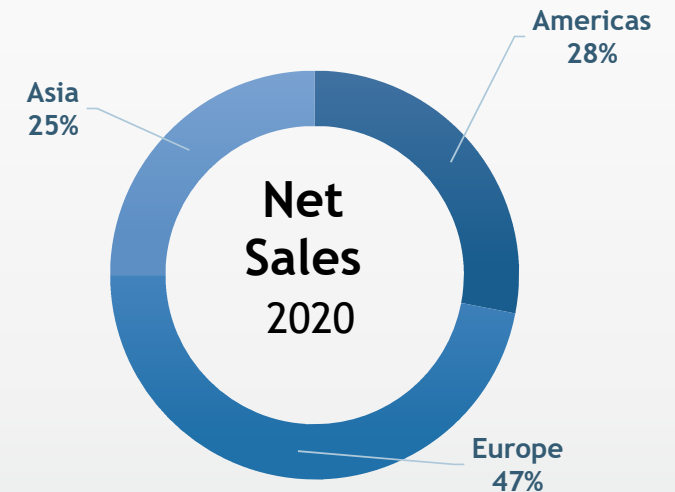


GROUP KEY FIGURES

Metalor Technologies | Group key figures

Metalor Group Net Sales (2020, in K CHF)

Americas	93'636
Europe	156'801
Asia	83'584
TOTAL	334'021





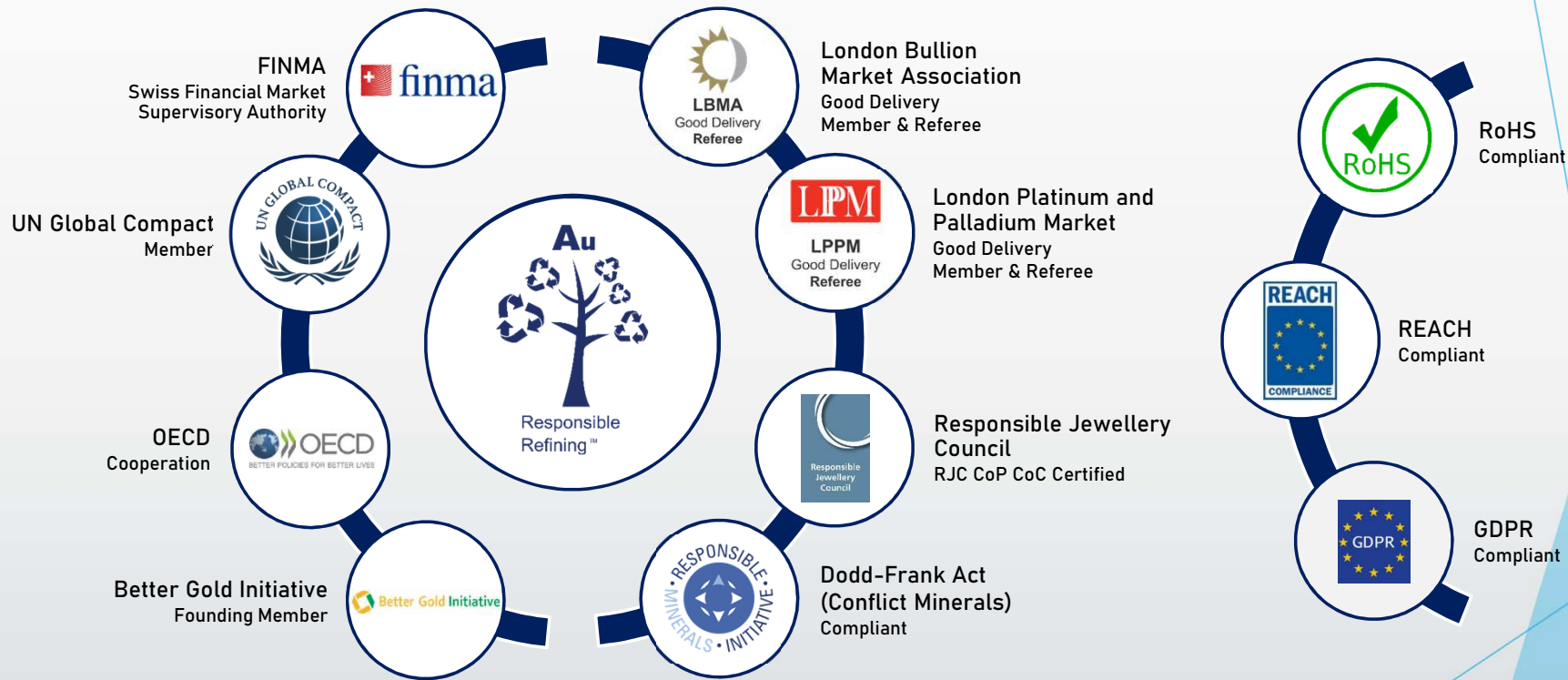
SUSTAINABLE SUPPLY CHAIN

METALOR[®]
TANAKA

Metalor Technologies | Compliant Business Practices

“Responsible Products and Services”

”



Metalor Supply Chain Due Diligence Policy

Strict Internal Customer Management Processes (KYC)

Products and Services compliance



ELECTROTECHNICS BUSINESS GROUP

Tanaka Kikinzoku (Gold & Silver) | Products, applications, end-markets

❑ Products:

- Wires and Rivets
- Cladded-strips, Micro-profiles
- Brazing materials/joining technologies

❑ Materials:

- Cadmium-free materials (except at Heesung JV) , AgSnO₂In₂O₃, AgNi, (no AgW, AgCW, AgC)

❑ Processes:

- Casting, Internal oxidation, high precision multiple cladding, automated rivet manufacturing and sorting

❑ Applications:

- Switches and relays

❑ End-markets:

- focus on automotive and electronic, aerospace, medical. Not in MHV (except brazing materials), mainly in LV low intensity

❑ Footprint:

- Mainly in North East Asia (Japan, South Korea, Taiwan, China)

Iwate Plant
(clad
materials)



Tomioka Plant
(casting, rivets)



Complementary to Metalor ET

Metalor Technologies | Electrotechnics Business Group

The Metalor Electrotechnics products are the heart of the electrical switchgear devices.

Leader on his market, Metalor manufactures an extensive range of products including powders, wires, strips, multi-strips, rivets, tips, and contact assemblies.

Silver is at the center point of the Electrotechnics products, while in some specific applications palladium, platinum and gold are also used.

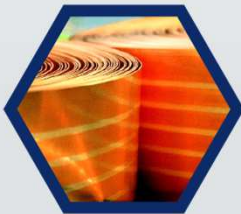
With a large range of processes and equipment, Metalor offers optimized manufacturing solutions with highly automated process.

Major Products

Rivets & tips



Silver based strips and wires



Assemblies



Applications

Safety

- Circuit Breaker
- Switches
- Fuses
- Thermostats

Control

- Relays
- Contactors
- Push Buttons

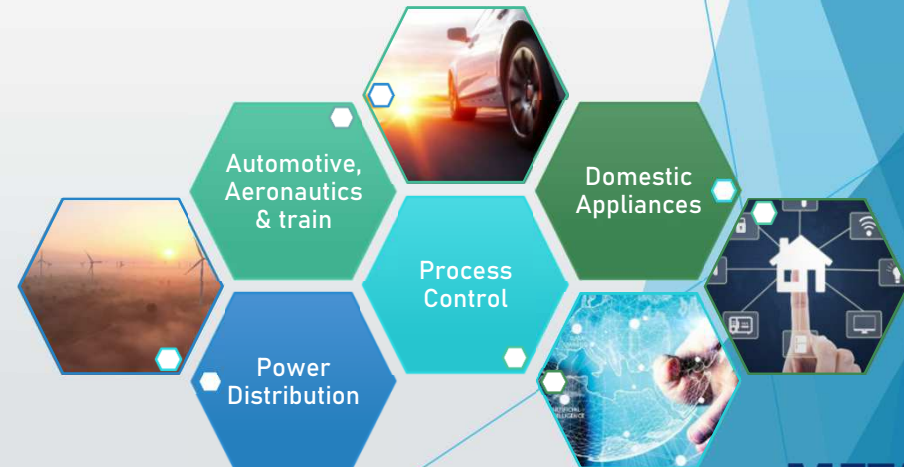
Monitoring

- Slip Rings
- Sensors

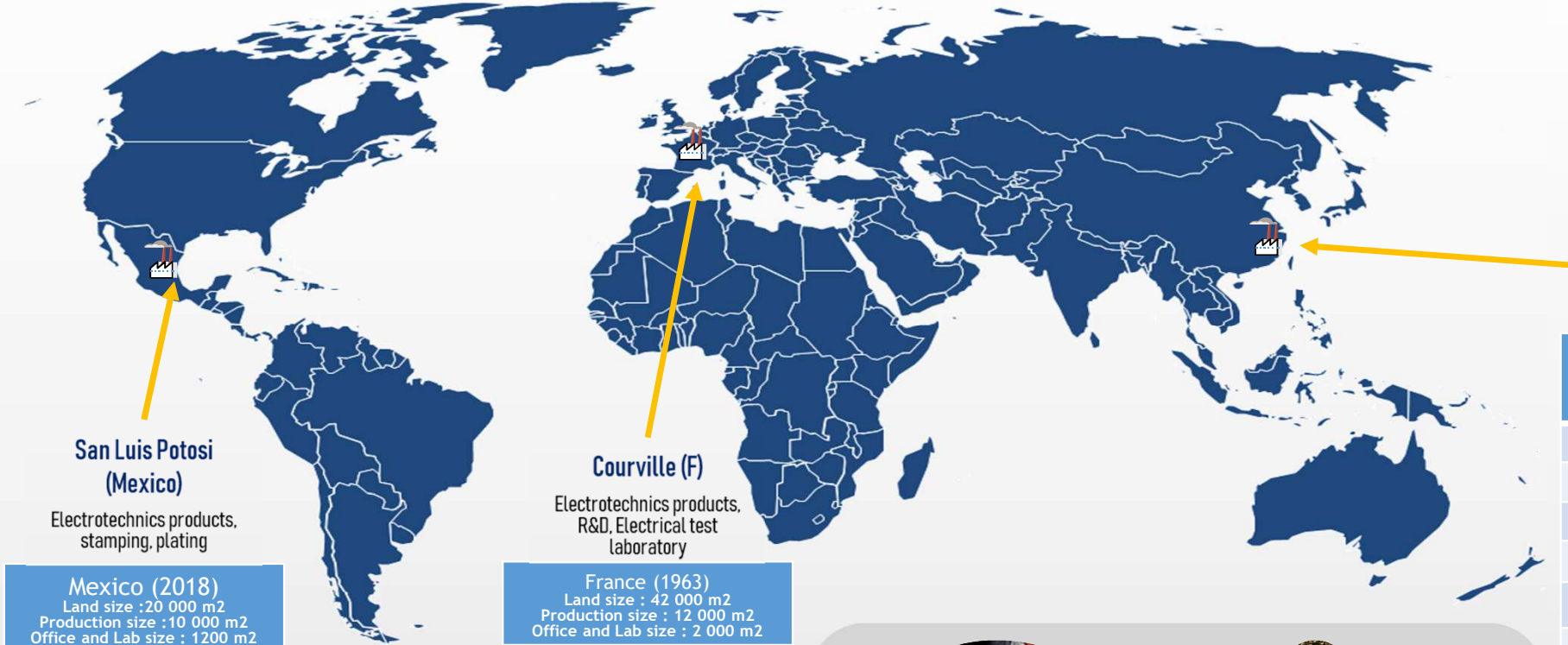
Operating range

- Low-med Voltage
- 1 to 100 000 Amps

End Markets



Electrotechnics | Footprint



San Luis Potosi (Mexico)

Electrotechnics products, stamping, plating

Mexico (2018) Land size : 20 000 m ² Production size : 10 000 m ² Office and Lab size : 1200 m ²

Powder mixing
Extrusion / Die Compaction
Infiltration/Brazing
Stamping
Manual Assemblies
Rivets
Plating

Courville (F)

Electrotechnics products, R&D, Electrical test laboratory

France (1963) Land size : 42 000 m ² Production size : 12 000 m ² Office and Lab size : 2 000 m ²
--

Powder mixing /Extrusion
Die Compaction
Infiltration/Brazing
Stamping
Auto Assemblies
Rivets
Multistripes
Microprofiles/Xlay

Wuzhong (China)

Electrotechnics products, R&D

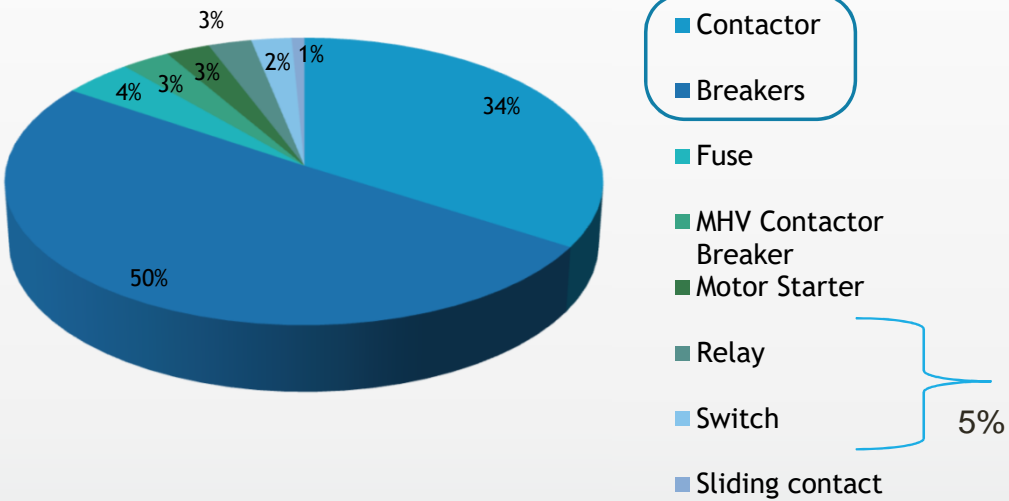
China (2014) Land size : 28 000 m ² Production size : 10 000 m ² Office and Lab size : 5 000 m ²

Powder mixing / Extrusion
Die Compaction (Bi-layer)
Stamping
Manual Assemblies
Auto Assemblies
Rivets/Rivet assemblies
Microprofiles/Xlay



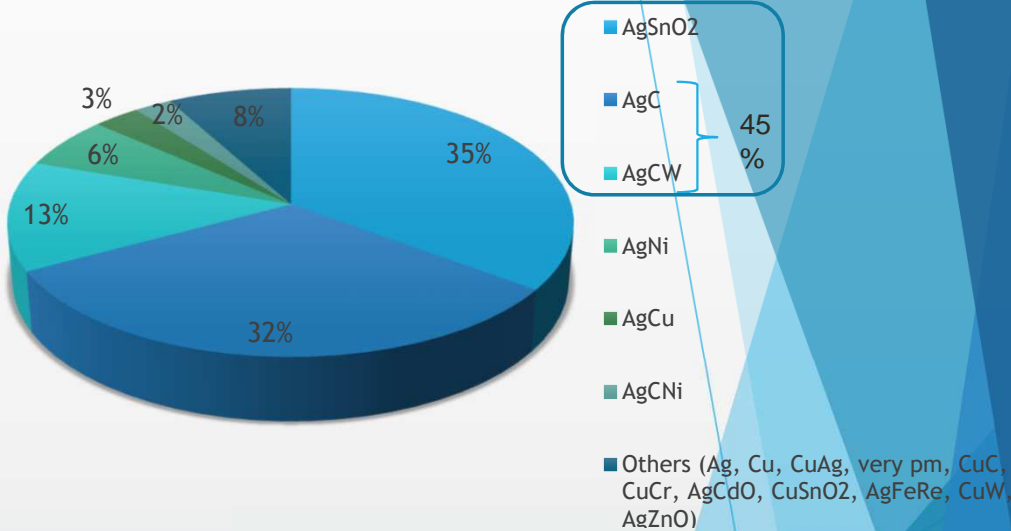
Electrotechnics | Sales XPM segmentation

By End application



Low voltage Breakers and Contactors are predominant (84%)
Complementary to Tanaka (Relays and Switches)

By Material

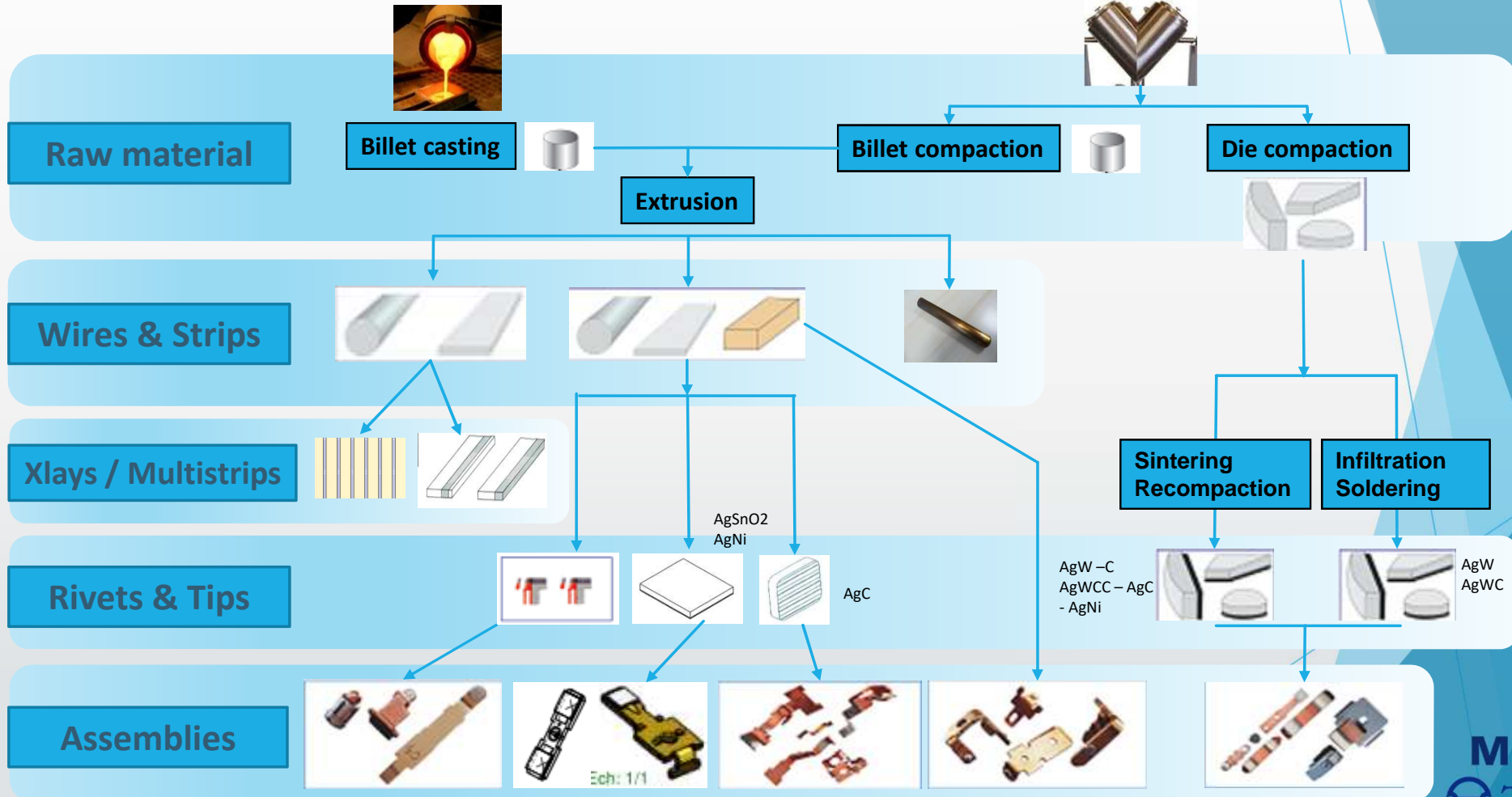


AgSnO₂, AgC and AgCW are predominant (80%)
Complementary to Tanaka (where AgC and AgCW are marginal)

Electrotechnics | PRODUCTION FLOW CHART

Casting (Ag or doped Ag), 10%

Powder metallurgy, 90%



Electrotechnics | Materials

Maximum Switching Current	Very Low current	1	10	100	1000	10 000	100 000 A
Sliding contacts	Pd Ag Pt Pd Ag Au Pt Au Ag						
Switches for Domestic Applications		Ag - Ag Cu - Ag Ni (0.15)	Ag Ni (10)	Ag CdO Ag SnO2 Ag Fe2O3			
Light Switches		Ag - Ag Cu - Ag Ni (0.15)		Ag CdO - Ag SnO2 - Ag Fe2O3			
Miniature Circuit Breakers			Ag CdO - Ag ZnO - Ag SnO2		Ag C - Cu / Ag C - Ag Ni		
Auxiliary Switches		Ag Ag Cu Ag Ni (0.15)	Ag Ni Ag Fe Re Ag Fe2O3				
Contactors - Relays		Ag Ag Cu Ag Ni (0.15)	Ag Ni - Ag Fe2O3	Ag SnO2 Ag CdO Ag ZnO			
Industrial Circuit Breakers			Ag CdO Ag ZnO Ag SnO2	Ag C / Ag Ni - Ag C / Ag Fe Re - Ag C / Ag Fe2O3		Ag W Ag WC Ag WC C	
Vacuum Interrupters Contactors Circuit Breakers						Cu Cr - W Cu - W C Cu - W Ag - W C Ag	

A large range of materials for Low and Medium Voltage applications

Electrical tests laboratory

METALOR[®]

Overview



2 storey building, 300m²
Based in Courville, France
since 2004
Dedicated to contactors



2,5 MVA transformer
Assigned voltage 3x400V - 50Hz
Tests according IEC 60947-4-1



3 Temperature rises test benches
Up to 700A



4 electrical durability test benches
Rated current up to 500A



Making tests up to 3kA
Making/Breaking tests up to 3kA

Temperature rises test benches

3 benches



Up to 50A
3 positions



Up to 400A
3 positions



Up to 700A
3 positions

Temperature rises test benches

Performed Measurements



Temperature rises on terminals



Temperature rises on moving contacts



Voltage drops and contact resistances

Electrical durability test benches

4 benches, AC1-AC3-AC4 tests

	Opening current	Closing current	Opening voltage	Closing voltage	Cos Phi
AC1	Depends on device	Depends on device	1	1	1
AC3	1 x In	6 x In	0.16666 6	1	0.35
AC4	6 x In	6 x In	1 x V	1x V	0.35

Electrical durability test benches

4 benches, AC1-AC3-AC4 tests



AC3 - AC4
Up to 40A
10 positions



AC3 - AC4
Up to 250A
12 positions



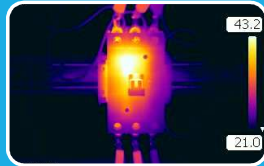
AC3 - AC4
Up to 500A
12 positions



AC1
Up to 1000A
12 positions

Electrical durability test benches

Analysis carried out during tests



Thermal camera controls
Temperature rises tests



Contacts erosion evolution by
weighing



Causes of failure - optical analysis

Electrical durability test benches

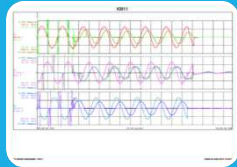
Making / breaking tests possibilities



Making current up to 3kA
Breaking current up to 3kA



Currents measurement
Supply and arc voltages measurement



Arc voltage analysis

Expertise and advices

15 years experience in contactors testing
improved Metalor knowledge



Influence of contact materials
Influence of carrier material



Impact of contacts geometry
Impact of brazing process, brazing alloy



Importance of contactors design

Expertise and advices : examples

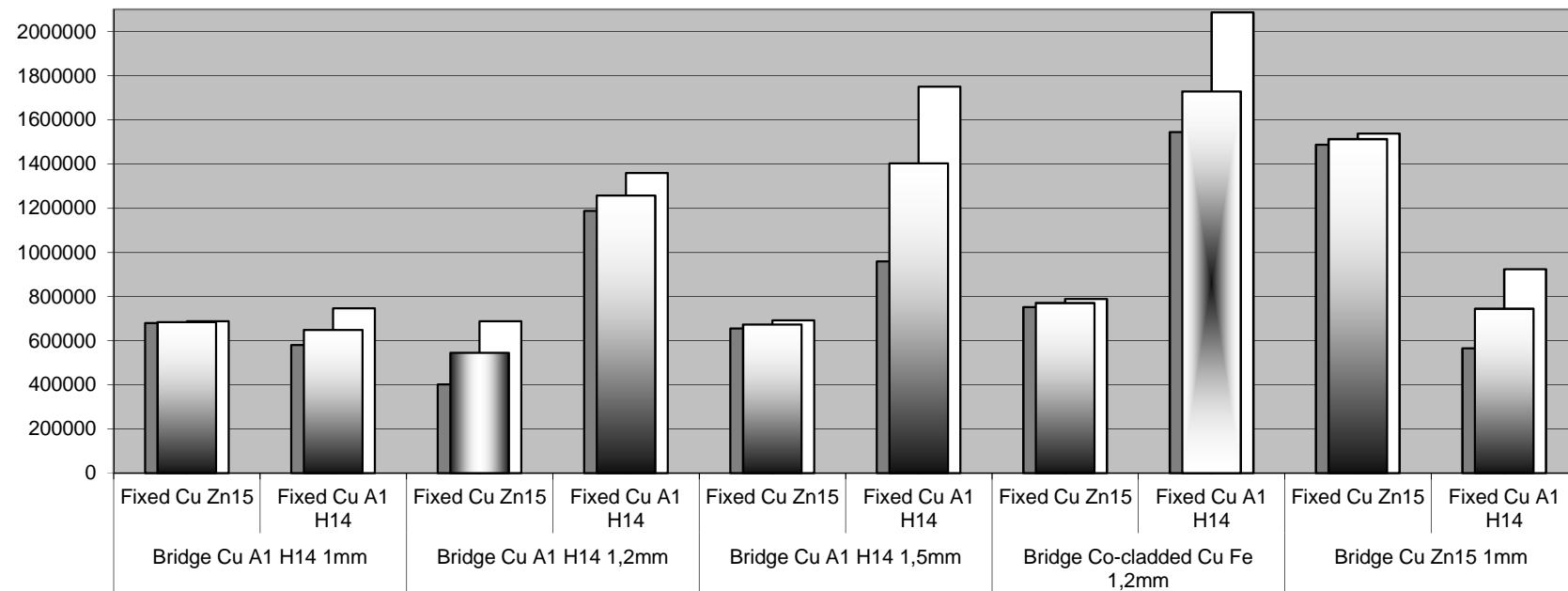
St Malo ICEC2008

Contact material =

AgSnO₂ EMB14

(14% oxides - 2% dopant)

Durability AC3 Min, mean and max results - I_e=37A - Electrical switching frequency = 1000c/h



Expertise and advices : examples

Newport Holm2013 Guideline for contactors

Contact force density (mN/A)	Temperature rise (K)		Number of cycles with thermal runaways
	Average	Max	
57	61	114	5
70	42	65	0
Gain	19K 31%	49K 43%	Thermal runaways eliminated

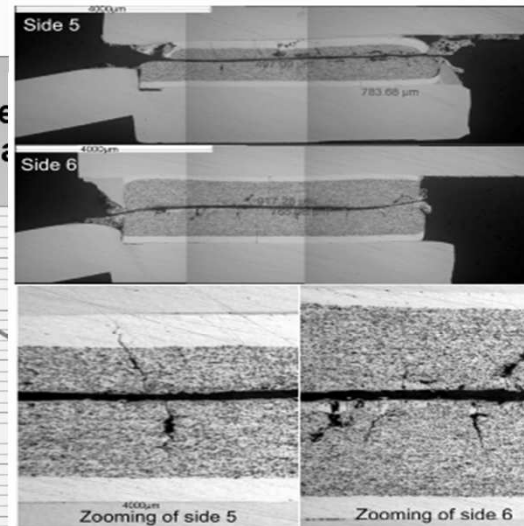
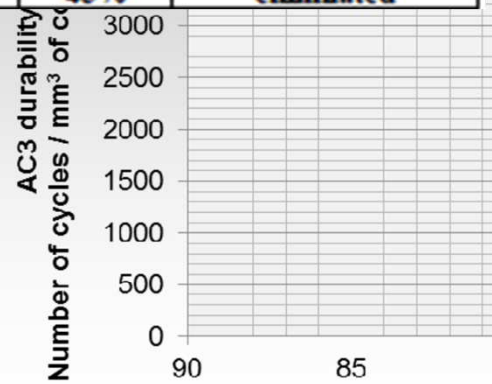
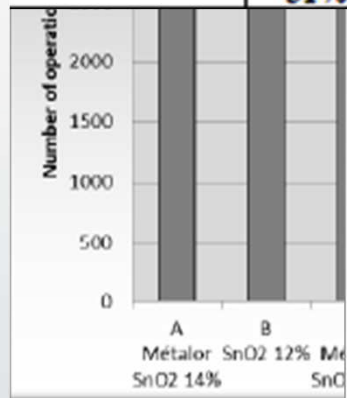


Fig. 15. Presence of cracks with contact force density of 57mN/A

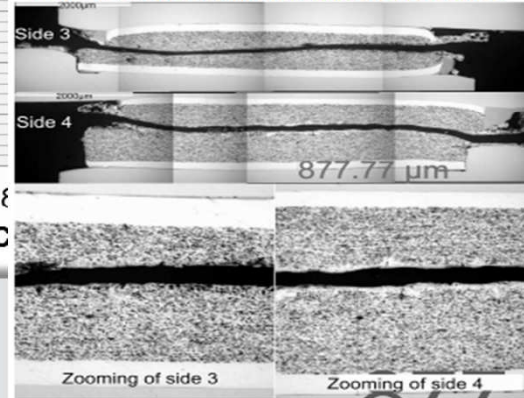
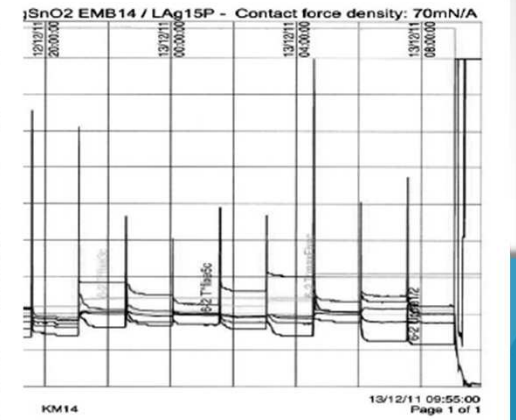
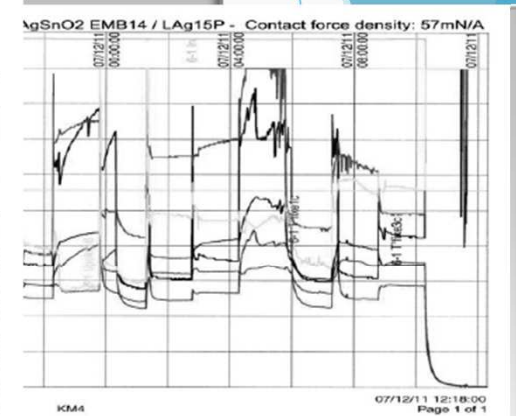
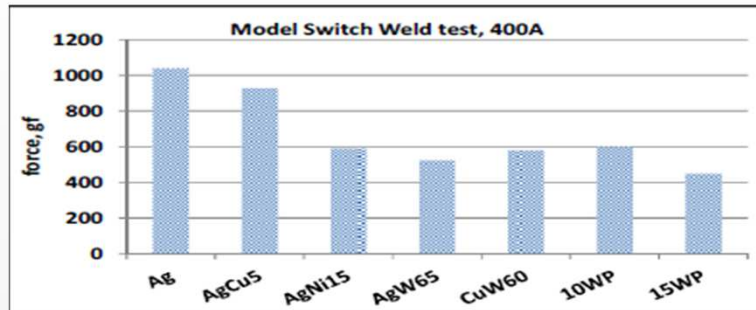


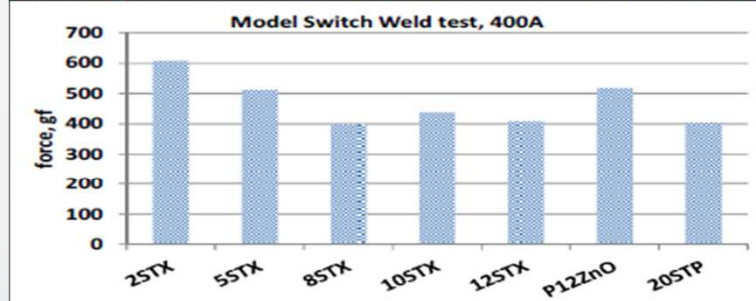
Fig. 16. No cracks with a contact force density of 70mN/A



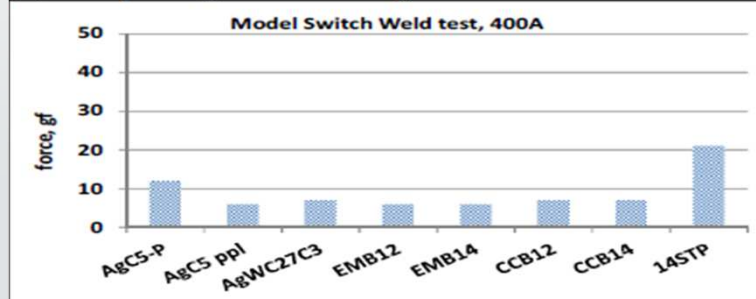
Expertise and advices : examples



(a) Group 1: High weld force relative to 10WP and 15WP



(b) Group 2: Ag/MeO showing oxide content effects



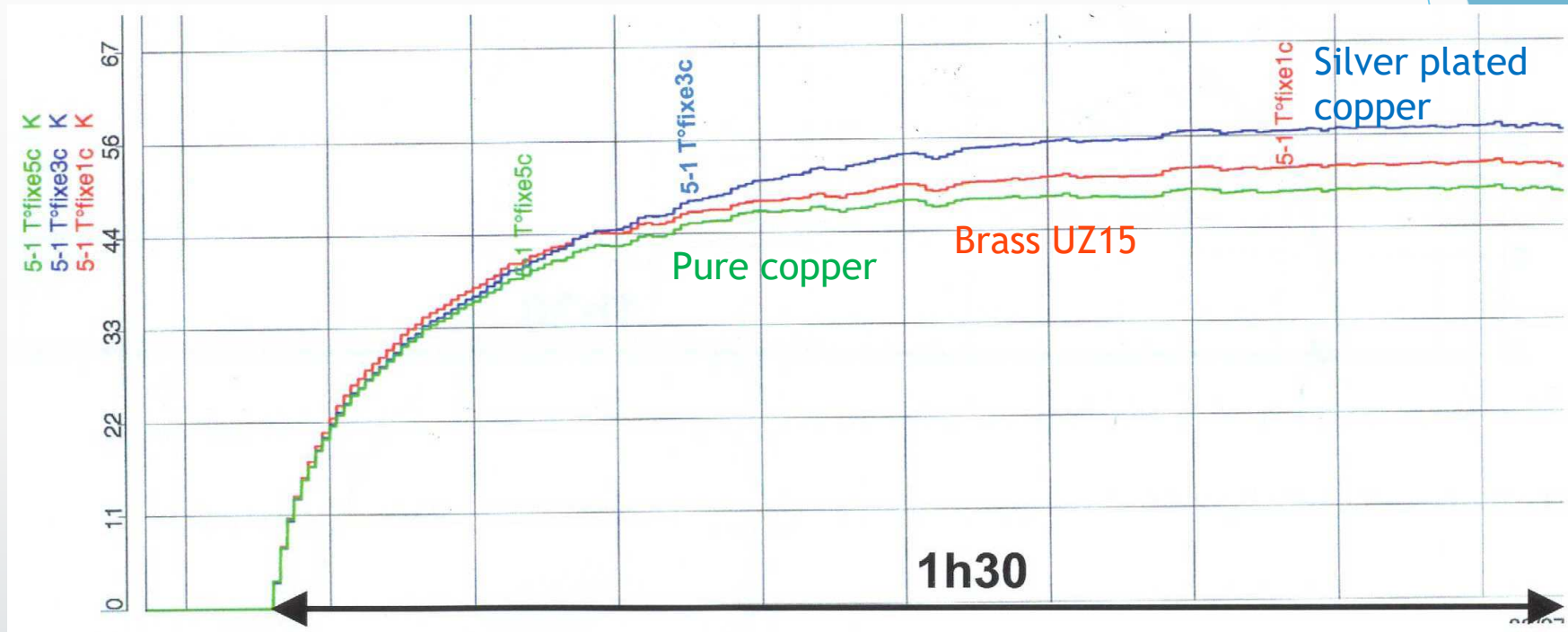
(c) Group 3: low weld force Ag/MeO comparable to Ag/C and Ag/WC/C

Dresden ICEC2014

Moving Contact material
= AgW 50/50

Expertise and advices : examples

Edinburgh ICEC2016
Silver reduction



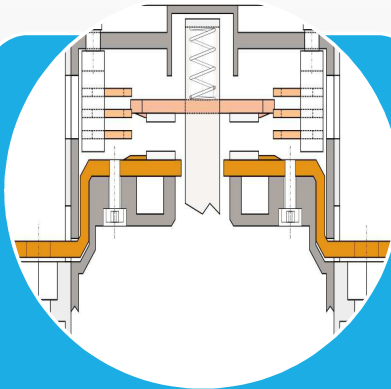
In this case: 200 k contactors, meaning 1,2 million carriers
So... a saving of 144 kg of silver!

Collaborative projects

Metalor can support you in your projects



To ban unsafe materials



To develop new contactors

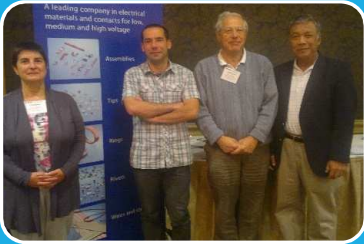


To optimize existing device
(Performance-cost saving)



Lab at your disposal for other projects

Technical papers at conferences



IEEE HOLM 2013, Newport, RI, USA

Design guideline of contactors, optimal use of assembled contacts



IEEE HOLM 2014, New Orleans, LA, USA

Reduction of AgSnO₂ contact resistance by changing the brazing method and corresponding improvement of an 18.5kW contactor



ICEC 2016, Edinburgh, UK

Reduction of the silver quantity required for contactors power contacts

Projects for the lab

METATEC

- switching machine for material ranking

High speed
camera

- For arcs studies

Profiler

- For surface damages studies

For more information,
please contact METALOR
team on our Web site:
www.metalor.com



Metalor Technologies | Electrotechnics Business Group

THANK YOU

METALOR[®]
 **TANAKA**