NEW & INNOVATIVE APPLICATIONS
for METALS

COPPER

Joint Seminar
International Copper Study Group
International Lead and Zinc Study Group
International Nickel Study Group

April 28, 2010 Lisbon

Japan Mining Industry Association
Katsuhiko Masuda

NEW & INNOVATIVE APPLICATIONS
COPPER

special thanks to:

- International Copper Association (ICA)
- Japan Copper Development Association (JCDA)
- Japan Copper Development Association
  The Japanese Electric Wire & Cable Makers’ Association (JWCA)
- Mitsubishi Materials Corporation (MMC)
- Mitsubishi Cable Industries, Ltd. (MCI)
- Mitsubishi Shindoh Co., Ltd. (MSC)
NEW & INNOVATIVE APPLICATIONS

COPPER

- ANTIMICROBIAL for Touch Surfaces
- LEAD-FREE BRASS for Safer Water & Environment
- FISH CAGE for Sustainable Aquaculture
- OPTIMIZED CABLE SIZING for Reduction of CO₂
- HIGH TECH WIRE for Electrical Energy Efficiency

ANTIMICROBIAL for Touch Surfaces

Japan Copper Development Association
U.S.EPA officially certified copper’s antimicrobial property. I have the privilege of reporting this wonderful news to the Japanese media as part of simultaneous release world-wide. As exemplified by ancient Egypt’s in plumbing, mankind benefitted from copper’s antimicrobial property for thousands of years. JCDA with full support of ICA and Kitasato University already confirmed copper’s effectiveness in preventing hospital infection at the University Hospital through world’s first in-situ trial. With this breaking news, I sincerely hope copper will find further opportunities to improve hygienic environment in public buildings and homes.

(March 2007 Mr.Ide, as Chairman Japan Mining Industry Association & JCDA)
Excellent Antimicrobial Property

JCDA PROMOTIONAL BROCHURE “Ten Yen Coin”

Copper’s Excellent Antimicrobial Properties

Copper has outstanding antimicrobial properties against various microorganisms which cause problems in our daily lives. This section introduces the excellent antimicrobial properties of copper which have been implemented.

10 Yen Coin Brochure

Copper’s Excellent Antimicrobial Properties

In 1994, pigmepic E. coli O157 spread rapidly in Japan and caused a panic which led to a steep decline in food service industry sales O157, which can be transmitted via various foods, needs to be watched carefully regardless of the source. It has been confirmed through an experiment that copper is effective against O157.

In this experiment, E. coli O157 was placed on a petri dish with a square copper sheet and a brass sheet. The square copper was placed on the petri dish. The result showed that the growth of the bacteria was blocked around the copper sheet and blocked around the brass sheet. Also, there were no microbes growing underneath the sheets.

O157 inhibition is particularly promising because coagulase-negative staphylococci can cause anywhere in our daily lives.

International Copper Association, Ltd.
Antimicrobial Tests on 10 & 5 Yen Coins

A: S. aureus      B: E. coli      C: P. aeruginosa

Copper's antimicrobial Property

Control vs Copper:
- Control: Only 90 minutes
- Copper: Only 90 minutes

Incubation period (minutes)

Graph showing the antimicrobial property of copper and control.
ANTIMICROBIAL for Touch Surfaces

Mr. Akihiko Ide, President
Mitsubishi Materials Corp

Dr. Takeshi Sasahara PhD ICD
Department of Microbiology & Parasitology, Kitasato University
School of Medicine

Kitasato University Hospital

Sampling Methods & Sites:
- Dermatology Ward (Skin Infection)
- NICU (New Infant Care Unit)
- ICU (Intensive Care Unit)

<table>
<thead>
<tr>
<th>Sampling Method</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stamp method</td>
<td>Flooring</td>
</tr>
<tr>
<td>Swab method</td>
<td>Door handles</td>
</tr>
<tr>
<td>Push Plates</td>
<td>Sinks</td>
</tr>
<tr>
<td>Brass</td>
<td>Wagon table</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
</tr>
</tbody>
</table>
Bacteria’s Tested and Sampling Methods

Bacteria tested for

- Escherichia coli
- Pseudomonas aeruginosa
- Staphylococcus
- Staphylococcus aureus
- General bacteria (Bacillus spp., Staphylococcus spp., Micrococcus spp.)

Sampling methods:

- Stamp: 25 cm² area pressed with food-stamp plates
- Swab: 100 cm² areas swabbed with 3M quick swab

Kitasato Trial Summary

Copper and brass used in the ward are especially effective for disinfection against microbes like general bacteria and staphylococci including MRSA. In particular, they are significantly effective for the disinfection on dry surfaces.

Dr. Takeshi Sasahara PhD ICD
Department of Microbiology & Parasitology, Kitasato University
School of Medicine
First Copperized Medical Facility in the World

Ochiai Clinic dabbed “Brass Clinic” opened October 2009. Dr. Ochiai: “I am hopeful copper’s antimicrobial property will prevent spread of new influenza or other infectious diseases.”

The Clinic  3D Schematics  Dr. Ochiai & Dr. Keevil

Nikkei CNBC “Copper helps improve the Medical Environment” aired in March this year.

Mr. Ken Takahashi, the Architect

“I chose copper for its antimicrobial property”
More hospitals going Copper with a smile

Two generations of Dr. Chiyotanda. Owner of Chiyoda Hospital, largest private hospital in Miyazaki, testing copper for the new hospital under construction.

More Hospital Trials Underway

Shin-Yokohama Spine Clinic Kanagawa Dental College

Jin Clinic Yamato City

Dr. Sasahara from Kitasato advising clinics
LEAD-FREE BRASS
for Safer Water & Environment

Mitsubishi Shindoh Co., Ltd.

GETTING LEAD OUT OF BRASS

Conclusion

- Low lead content (<0.25%) requirements 01 Jan 2010
  - California
  - Vermont (Requires warning labels 01 Jan 2009)

- NSF 61 pass/fail criteria for lead
  - Reduces to 5 ppb 01 July 2012
  - Optional Annex G Method for lead content

- NSF can help you demonstrate compliance today
  - Evaluations to NSF 61 Annex G
  - Verification Letters for lead content
  - Footnote < 0.25% lead compliance in NSF 61 Listings
LEAD-FREE WATER from ECO BRASS

1. Environmentally Friendly
   Use silicon instead of lead. Silicon is abundant and does not create a burden on the environment

2. Easier Recyclability
   Versatile alloy that can be machined, forged, and cast, doing away with the need for purpose alloys for different jobs, making recycling a much easier task.

3. High Performance
   A material that exceeds in corrosion resistance, strength, and other properties compared to conventional brass.

Mr. Hashida, President, Mitsubishi Shindoh
Mitsubishi Materials Seminar House
World’s first antimicrobial building with all ECO BRASS door handles inaugurated April 2010

FISH CAGE for Sustainable Aquaculture with UR30 copper alloy wire Mitsubishi Shindoh
TYPICAL SYNTHETIC NETS

- Net fouling & antibiotics are hazard to both the environment and human health
- Stress and limited oxygen intake results in higher fish mortality rate & slower growth giving way to high usage of antibiotics.

COPPER SOLUTION for CHILEAN SALMON FARM PROBLEMS

<table>
<thead>
<tr>
<th>High Use of Antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress</td>
</tr>
<tr>
<td>Limited oxygen intake</td>
</tr>
<tr>
<td>Resulting in higher fish mortality rate</td>
</tr>
<tr>
<td>Slower growth</td>
</tr>
<tr>
<td>Copper Solution</td>
</tr>
</tbody>
</table>
CHILEAN PROJECT  EcoSea

EcoSea introduces copper mesh for aquaculture pens

The product focuses on copper applications that can help reduce the environmental impact of aquaculture. EcoSea's copper mesh addresses two main areas in aquaculture: the maintenance of fish health and the reduction of pollution from aquaculture ponds.

Norway
Scotland
Ireland
Faroe
Western Canada
Eastern Canada
Japan
250 Cages
28 Cages
14 Cages

A GLOBAL SOLUTION

UR30 Market

Actual
Potential

Norway
Scotland
Ireland
Faroe
Western Canada
Eastern Canada
Japan
250 Cages
28 Cages
14 Cages

Australia

Chile
14 Cages
A GLOBAL SOLUTION

Tasmania, Australia          Camanchaca, Chile

Photos property of Van Diemen Aquaculture

Collaborating with ICA

- Chilean “EcoSea” commercialized
- Test pen installed in New Hampshire
- Pens installed in Panama
- Preparations under way for installations elsewhere.
Proven Japanese Technology

Woven and installed by Ashimori Industries

UR30 COPPER NETS

after 2-1/2 years

healthy fish

no fouling
ICA STUDIES ON ENVIRONMENTAL BENEFITS OF COPPER CAGES

Environmental Performance of Copper Alloy Mesh in Marine Fish Farming: The Case for Using Solid Copper Alloy Mesh

The global aquaculture industry has grown by an average of 10% per year since 1990 and since 2018, according to the Food and Agriculture Organization of the United Nations. It is expected that this growth will continue, driven by the need for sustainable food production and the increasing demand for seafood. The use of copper alloy mesh in marine fish farming has been shown to provide several benefits, including improved water quality, reduced disease outbreaks, and lower energy consumption.

The case for using solid copper alloy mesh

1. Improved water quality
2. Reduced disease outbreaks
3. Lower energy consumption
4. Increased productivity

Reduction in CO2 emissions

The use of copper alloy mesh in marine fish farming not only provides environmental benefits but also contributes to reducing CO2 emissions. Copper alloys are known for their ability to naturally reduce the growth of biofouling organisms, such as barnacles and algae, which reduces the need for chemical treatments and ultimately leads to lower CO2 emissions.

A Happy Japanese Fish Farmer

The use of copper alloy mesh in marine fish farming has been shown to improve the living conditions of fish, leading to increased productivity and profitability for farmers. This is particularly evident in Japanese fish farming, where the use of copper alloy mesh has led to significant improvements in fish health and growth rates.
UR30 Cost Benefits

- 50% more fish and 10~15% faster growth
- Retains value at end of life & recycled with no landfill costs.
- No net changes over 4 years
  - No regular cleaning and antifouling impregnation costs
  - No cost for disposal of biofouling on nylon nets
  - No net change and "backup net" costs
  - No fish loss from stress, parasites, escapes, predators
- No expensive predator perimeter net required

Environment & Health Benefits

Lower Life Cycle Environmental Impacts

- No landfill of biofouling on nylon nets
- No carbon release from regular cleaning
- 100% recyclable
- No parasites - No antibiotics – Healthy fish
- Prevents possible antibiotics health risk
COPPER for Happy Moments

Van Diemen Fish Farm in Tasmania

Frank Kane, President ICA

OPTIMIZED CABLE SIZING for Reduction of CO2

The Japanese Electric Wire & Cable Makers’ Industry Association in collaboration with JCDA & ICA
Focus on “Low-Voltage CV-T” cables for the following reasons:

- Highest volume power cable in terms of conductor volume (3 times larger than “Power Transmission and Distribution Cables”)
- High operation rate comparing with “VVF” cables used at private houses.
- Low-Voltage CV-T causes a great amount of electricity loss.
If the conductor size of all “Low-Voltage CV-T” is optimized, loss at user’s premises will be halved from 42 billion kWh (4%) to 21 billion kWh (2%).

This means reduction of 0.7% of total CO₂ emissions in Japan by optimizing conductor size of “Low-Voltage CV-T”.

### Volume of Power Cables in operation in Japan (from Power Plants to User’s premises)

<table>
<thead>
<tr>
<th>Application</th>
<th>Type of Cable</th>
<th>Accumulated Length</th>
<th>Volume of Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Utilities</td>
<td>Transmission Line</td>
<td>90 thousand km</td>
<td>1.2 million tons</td>
</tr>
<tr>
<td></td>
<td>ACSR (Aluminum)</td>
<td></td>
<td>(Include Aluminum as copper equivalence)</td>
</tr>
<tr>
<td></td>
<td>Extra high voltage CV</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Distribution Line</td>
<td>1.3 million km</td>
<td>4.5 million tons</td>
</tr>
<tr>
<td></td>
<td>High-voltage CV</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OC, OW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside Plant &amp; Buildings</td>
<td>Low-voltage CV-T</td>
<td>1.7 million km</td>
<td>4.5 million tons</td>
</tr>
<tr>
<td>Inside Private Houses</td>
<td>VVF</td>
<td>27 million km</td>
<td>1.5 million tons</td>
</tr>
</tbody>
</table>
**Expected Conductor Size Optimization Effect**

**Significant reduction of CO₂ emissions**
Reduction of CO₂ emissions by optimizing the conductor size of “Low-Voltage CV-T” cables is equal to 0.7% of total CO₂ emissions in Japan.

**Increase of copper demand**
Additional 4 million tonnes of copper is required in 20 years to optimize the conductor size of all “Low-Voltage CV-T” cables in Japan.
- 0.2 million tonnes annually × 20 years
- = 4 million tonnes

**Estimated Global Contribution**

Once the “Ecological current rating” is established as the global standard and conductor size of all related power cables are optimized globally:

- Total Global CO₂ will reduce by 0.3%
- Copper demand shall increase by 20 million tonnes

(Values are estimated by JCMA based on self-defined conditions.)
### Electricity generated, rate of power source and CO₂ emissions for the major countries of the world

<table>
<thead>
<tr>
<th>Country</th>
<th>Electricity generated (trillion kWh)</th>
<th>Rate of power source (%)</th>
<th>CO₂ emissions (kg/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>1.10</td>
<td>Coal 27, Oil 41, LNG 11, Nuclear 3, Hydro 3</td>
<td>0.495</td>
</tr>
<tr>
<td>USA</td>
<td>4.28</td>
<td>Coal 27, Oil 11, LNG 3, Nuclear 17</td>
<td>0.625</td>
</tr>
<tr>
<td>China</td>
<td>2.30</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.783 (Mainly coal)</td>
</tr>
<tr>
<td>Russia</td>
<td>0.95</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.460</td>
</tr>
<tr>
<td>Canada</td>
<td>0.63</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.250 (Mainly Hydro)</td>
</tr>
<tr>
<td>India</td>
<td>0.70</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.780 (Mainly coal)</td>
</tr>
<tr>
<td>Germany</td>
<td>0.62</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.569 (New energy 5%)</td>
</tr>
<tr>
<td>France</td>
<td>0.58</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.092 (Mainly nuclear)</td>
</tr>
<tr>
<td>Great Britain</td>
<td>0.40</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.562</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.40</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.084 (Mainly hydro)</td>
</tr>
<tr>
<td>Korea</td>
<td>0.39</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.542</td>
</tr>
<tr>
<td>Italy</td>
<td>0.30</td>
<td>Coal 19, Oil 9, LNG 40, Nuclear 1, Hydro 10</td>
<td>0.581</td>
</tr>
<tr>
<td>Total</td>
<td>12.85</td>
<td>Total 12.85</td>
<td>0.573 (Weighted average)</td>
</tr>
</tbody>
</table>

*CO₂ emissions by power source (kg/kWh): Coal 0.975, Oil 0.742, LNG 0.564, Nuclear 0.022, Hydro 0.011, New energy 0.032.*

### Reduction of CO₂ emissions by optimizing conductor size in the major countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Electricity generated (trillion kWh)</th>
<th>Distribution voltage of transmission lines (V)</th>
<th>Rate of transmission loss reduction by low-voltage cables (%)</th>
<th>Reduction of transmission loss (trillion kWh)</th>
<th>Reduction of CO₂ emissions (million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>1.10</td>
<td>330</td>
<td>2.07</td>
<td>0.008</td>
<td>0.020</td>
</tr>
<tr>
<td>USA</td>
<td>4.28</td>
<td>300</td>
<td>2.07</td>
<td>0.008</td>
<td>0.073</td>
</tr>
<tr>
<td>China</td>
<td>2.30</td>
<td>330</td>
<td>2.07</td>
<td>0.008</td>
<td>0.025</td>
</tr>
<tr>
<td>Russia</td>
<td>0.95</td>
<td>300</td>
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<td>300</td>
<td>2.07</td>
<td>0.008</td>
<td>0.003</td>
</tr>
<tr>
<td>Total</td>
<td>12.85</td>
<td>Total 12.85</td>
<td>Total 12.85</td>
<td>Total 12.85</td>
<td>Total 99.7</td>
</tr>
</tbody>
</table>

The reduction of CO₂ emissions "99.7 million tons (about 100 million tons)" correspond to 0.3~0.4% of the total CO₂ emissions "27.1 billion tons" around the world.
Expected Conductor Size Optimization Effect

**Economic contribution to users**

By optimizing the conductor size, users can reduce the electricity cost by reducing the loss at cables. Though initial cost is higher for larger conductor size, users can save on “Life cycle cost”

<table>
<thead>
<tr>
<th>Cost Estimation</th>
<th>CV-T 38㎟</th>
<th>CV-T 100㎟</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Initial cost</td>
<td>900</td>
<td>2,360</td>
<td>(1,460)</td>
</tr>
<tr>
<td>(2) Annual Running cost</td>
<td>460</td>
<td>175</td>
<td>(285)</td>
</tr>
<tr>
<td>(3) Running cost (for 20 years)</td>
<td>9,200</td>
<td>3,500</td>
<td>5,700</td>
</tr>
<tr>
<td>(4) Life cycle cost (1)+(3)</td>
<td>10,100</td>
<td>5,600</td>
<td>4,500</td>
</tr>
</tbody>
</table>

Years required for recovery of initial cost: 5 years

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Standardization Roadmap

- Committee formed in JSA in April 2009 to establish IEC standard for “Ecological current rating” under direction of METI.

- “Ecological current rating” is defined as a load that minimizes the power loss. Conventional “Ampacity rating” is only a safety standard. As CV-T 38 mm² “Ecological current rating” is 64A versus Ampacity rating of 155A, conductor size needs to be doubled for the cable to operate at 155A load with minimum power loss.

- Rough Schedule of standardization is as follows:
  - Establish JCS in 2010
  - Establish IEC in 2012
HIGH TECH WIRE for Electrical Energy Efficiency

MEXCEL MAGNET WIRE

Mitsubishi Cable Industries, Ltd

MEDIS Electro-Deposition Process

- The only process for producing magnet wire through Electro-Deposition.
- Very uniform and thin insulation can be formed.
- Thicker insulation is formed at corners for durability.
Cross Sections of Magnet Wire by MEDIS Process (MEXCEL)

Rectangular type

Square type

MEXCEL application

For higher efficiency, weight saving and compact size requirements:

Coil for Surface Mounted Devices (SMD):
Lap top PC, Game machines such as PS3, Nintendo X-BOX
Coil for trigger transformer of HID lamp

Edge-wise coiling
Compact and Lighter Weight

- Higher filling factor for better efficiency.
- Minimize total weight of motor or generator.
- Contributing to reducing carbon emission.

Cross sections showing different ways wires can be bundled together.

Example of bundle wire for use in a motor stator (image photo)

- Bundled wires
- Filling a narrow stator slot
**MEXCEL Bundled Wire**

Reduced the skin effect and the eddy current at high frequency for better motor performance

Higher conductor density compared to traditional litz wires

- Each wire is insulated and bonded together to form a bundle
- Insulation of whole bundle

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**More to Come**

Ms Naoko Yamazaki completes her Space Station Mission last week with high-tech COPPER socks

Next generation of higher performance heat exchangers with a small diameter COPPER multi-channel tube
So, next time you are in a tempura restaurant, or having delicious chocolates or oysters, think, COPPER.

Cacao and oyster contain high copper content: 30 mg per kilo.

Thank you for supporting COPPER.