COPPER™ TOUCH

THE HARD SCIENCE

BEHIND WHY COPPERTOUCH WORKS

COPPER and COPPER ALLOYS as ANTIMICROBIALS

Introduction

Many Metals Cause Death of Microbes (Mercury, Silver, Bismuth, Copper….). Copper is unique. In its solid form, it is an effective antimicrobial in reasonable time frames while being physically inert to mammals. It is an essential micronutrient (United States Recommended Daily Allowance of 0.9 mg/day) ingested as copper ions as part of a normal diet or supplement. In its un-ionized solid forms, copper is durable and wear resistant. As such, it can be formed into various useful configurations while maintaining its antimicrobial properties.

Historic Uses

While our ancestors may not have related “antimicrobial” activity to their use of copper, they realized that water held or carried in buckets made of copper or copper alloys was not slimy when compared to water held or carried in buckets made of wood. Copper piping provided water of greater clarity and less odor than many other piping materials. And copper has been/is used in roof construction or placed in strips at the higher level rows of roofing shingles to reduce or eliminate mold growth on the roofs. Copper is also used, particularly in brass form, to prevent bio-marine fouling.

Examples of Microbes Killed by Solid Copper or Copper Alloys:

- *Enterobacter aeorgenes*
- *Staphylococcus aureus*
- *Pseudomonas Aerugnosa*
- *Drug Resistant Staphylococcus aureus*
- *Clostridium difficile*
- *Influenza A virus*
- *Adenovirus*
- *Fungi*

Effectiveness of Microbial Kill with Solid Copper

The results of the 216 GLP tests, involving three test protocols, two to three lots of six different alloys, and six bacteria*, are summarized in Table 1. In both the Efficacy as a Sanitizer test and Residual Self-Sanitizing test (wear test), a reduction in live bacteria greater than 99.9% is seen in all seventy two tests when compared to S304. In the Continuous Reduction of Bacterial Contaminants test, a reduction of greater than 99.9% is found in sixty-three out of the seventy-two tests, again when compared to S304. In the remaining nine tests, reductions ranged from 99.3% to 99.9%. In summary, a reduction greater than 99.9% was seen on 207 out of 216 tests.

The reduction seen in the remaining nine tests ranged from 99.3% to 99.9%. These results indicate that the antimicrobial response of copper alloys is effective, enduring and reproducible.

Table 1: Average Percent Reduction of Bacterial Contamination (Good Laboratory Practice Studies) NOTE: 60% copper content was the lower limit of testing.

	Group	Alloy	%Cu	*S.aureus*	*E.aerogenes*	MRSA	*P.aeruginosa*	*E. coli*O157:H7
Efficacy as a sanitizer	I	C110	99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	II	C510	94.8	>99.9	>99.9	>99.9	>99.9	>99.9
	III	C706	88.6	>99.9	>99.9	>99.9	>99.9	>99.9
	IV	C260	70	>99.9	>99.9	>99.9	>99.9	>99.9
	V	C752	65	>99.9	>99.9	>99.9	>99.9	>99.9
	VI	C280	60	>99.9	>99.9	>99.9	>99.9	>99.9
Residual Self Sanitizing	I	C110	99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	II	C510	94.8	>99.9	>99.9	>99.9	>99.9	>99.9
	III	C706	88.6	>99.9	>99.9	>99.9	>99.9	>99.9
	IV	C260	70	>99.9	>99.9	>99.9	>99.9	>99.9
	V	C752	65	>99.9	>99.9	>99.9	>99.9	>99.9
	VI	C280	60	>99.9	>99.9	>99.9	>99.9	>99.9
Continuous Reduction	I	C110	99.9	>99.9	>99.9	>99.9	>99.9	>99.9
	II	C510	94.8	>99.9	>99.9	>99.9	>99.9	>99.9
	III	C706	88.6	>99.9	>99.9	99.9	>99.9	>99.9
	IV	C260	70	99.6	>99.9	>99.9	>99.9	>99.9
	V	C752	65	99.7	>99.9	>99.9	>99.9	>99.9
	VI	C280	60	99.8	>99.9	99.9	>99.9	>99.9

Continuous Kill Effect of Copper on Microbes

Continuous Reduction of Bacterial Contaminants-which measures bacteria after inoculating an alloy surface eight times in a 24-hour period without intermediate cleaning or wiping.

For full protocol details:

https://www.antimicrobialcopper.org/sites/default/files/upload/media-library/files/pdfs/us/epa_continuous_reduction_test.pdfepa_continuous_reduction_test.pdf

https://www.antimicrobialcopper.org/us/epa-registration.

**The above links will take you to an external website.*

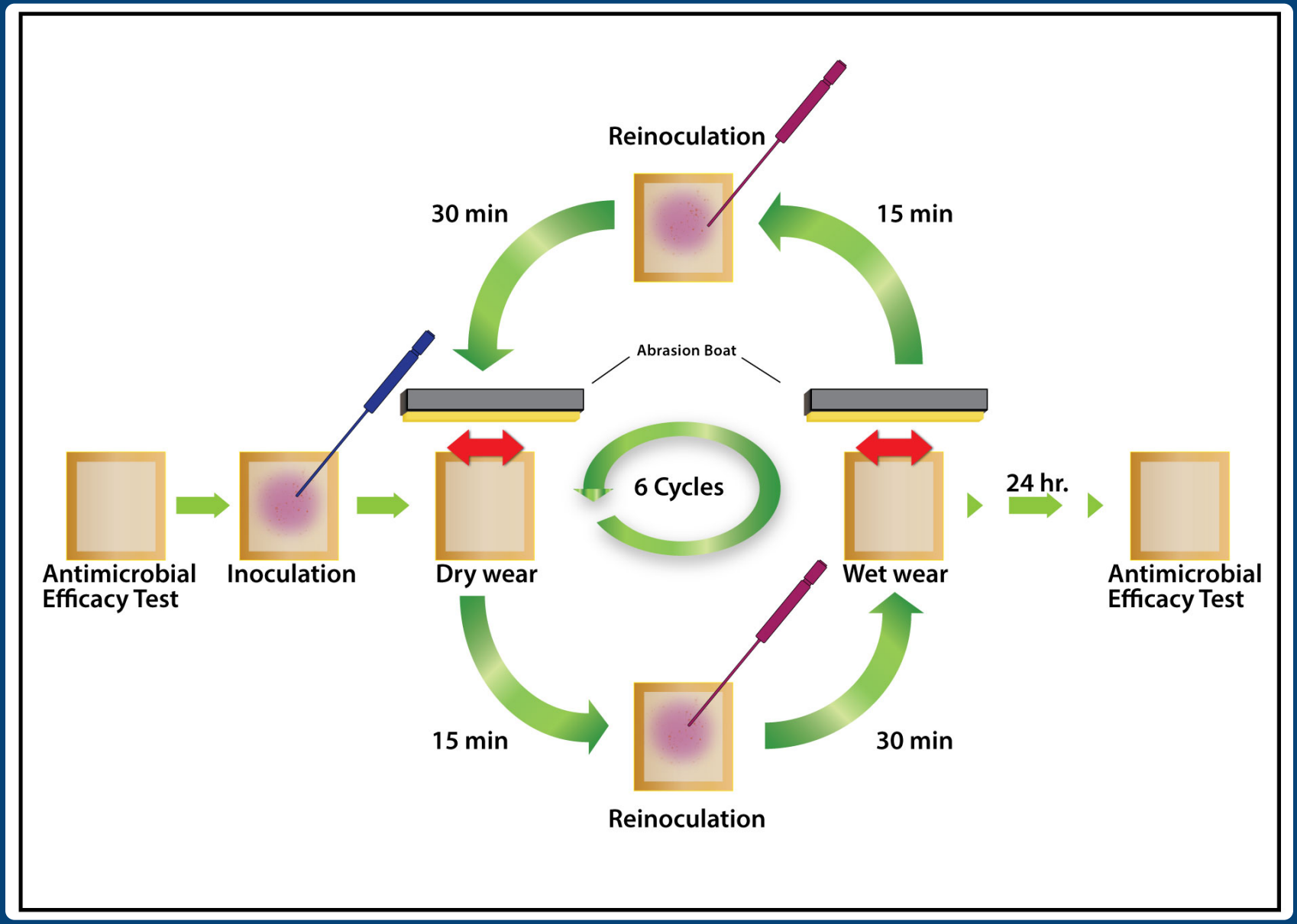
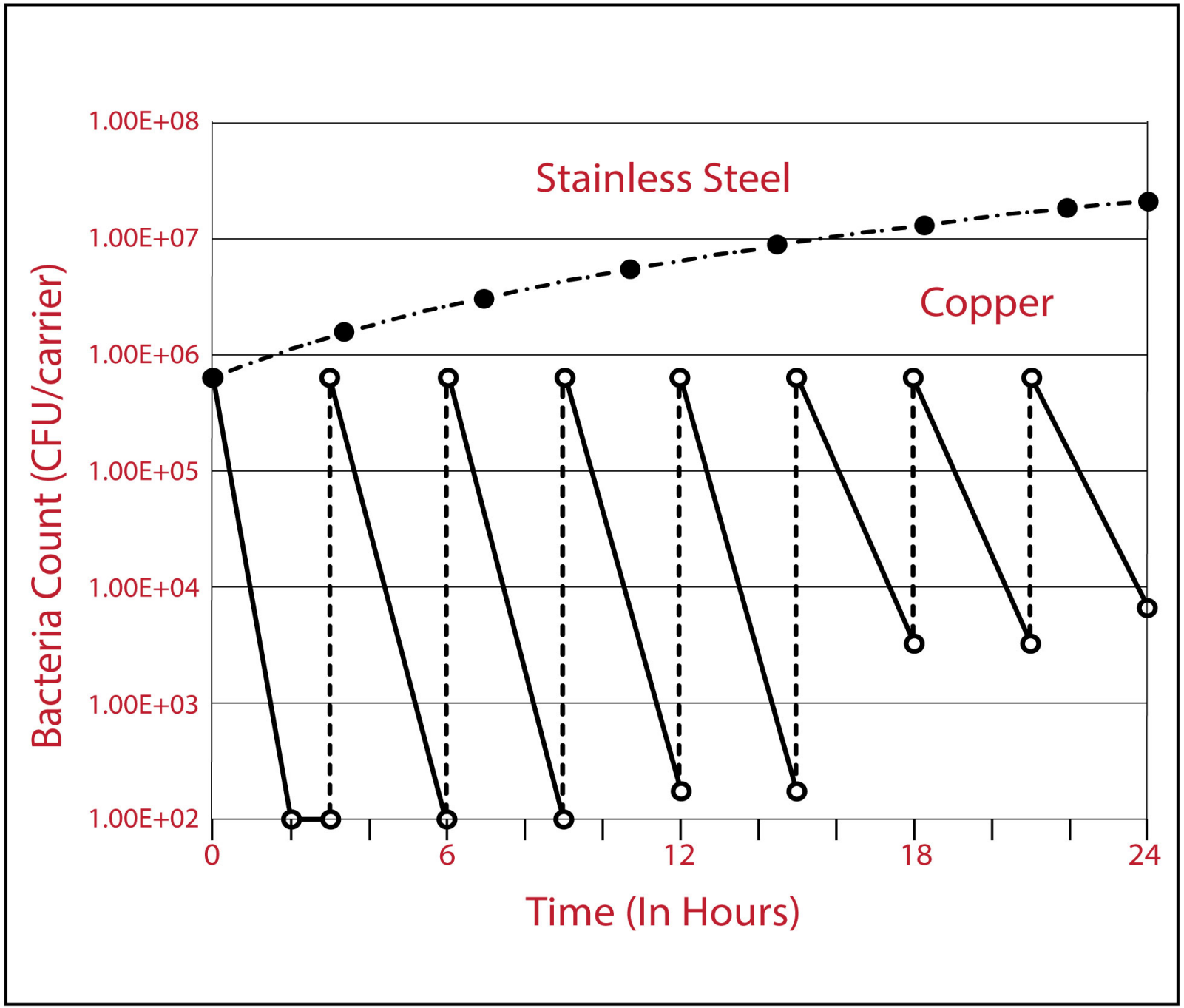


Figure 2: Continuous Reduction test results for MRSA on copper alloy C11000 and stainless steel S30400. Each inoculation adds 650,000 CFUs.



OBSERVATION: This shows the self regenerative antimicrobial power of the copper surface. If someone uses it on their hands, then puts it in their pocket, the surface will be microbe free in a very short time.

Dry Kill of Microbes vs Wet Kill of Microbes on Copper

Recent studies showed that large amounts of copper ions were taken up by *E. coli* over 90 min, when cells were applied to copper coupons in a standing drop. When cells were plated on copper by the dry method, the accumulation of copper ions by cells was even more dramatic, reaching a low molar concentration, or 27-fold the level observed by wet plating, in a fraction of the time. The copper ion level of cells remained high throughout the killing phase, suggesting that cells become overwhelmed by their intracellular copper.

Espírito Santo C, Lam EW, Elowsky CG, Quaranta D, Domaille DW, Chang CJ, Grass GAppl Environ Microbiol. 2011 Feb; 77(3):794-802.

Kill Rate of Microbes Versus Temperature

> NOTE that the kill time decreases by 1/3 going from 4 °C (39 °F) to 20 °C (68 °F). Going to 37 °C (98.6 °F) should decrease by 1/3 again, but a reference to research at body temperature has not been found.

Results of *E. coli* O157:H7 destruction on an alloy containing 99.9% copper (C11000) demonstrate that this pathogen is rapidly and almost completely killed (over 99.9% kill rate) within ninety minutes at room temperature (20 °C). At chill temperatures (4 °C), over 99.9% of E. coli O157:H7 are killed within 270 minutes. *E. coli* O157:H7 destruction on several copper alloys containing 99%–100% copper (including C10200, C11000, C18080, and C19700) at room temperature begins within minutes. At chilled temperatures, the inactivation process takes about

an hour longer. No significant reduction in the amount of viable *E. coli* O157:H7 occurs on stainless steel after 270 minutes.

Wilks, SA; Michels, H; Keevil, CW (2005). “The survival of Escherichia coli O157 on a range of metal surfaces”. *International Journal of Food Microbiology* PMID 16253366
doi10.1016/j.ijfoodmicro.2005.04.021
Michels, H. T.; Wilks, S. A.; Noyce, J. O.; Keevil, C. W. 2005, Copper Alloys for Human Infectious Disease Control, Presented at Materials Science and Technology Conference, September 25–28, 2005, Pittsburgh, PA; Copper for the 21st Century Symposium.

Other Information on the Kill Effects of Solid Copper/Copper Alloys The study of the antimicrobial properties of metallic copper surfaces is a relatively recent development and gained momentum when the Environmental Protection Agency (EPA) registered almost 300 different copper surfaces as antimicrobial in 2008.

(http://www.epa.gov/pesticides/factsheets/copper-alloy-products.htm).
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3067274/)

For the most part, the bacterial kill rate of copper alloys increased with increasing copper content of the alloy. This is further evidence of copper’s intrinsic antibacterial properties.

Michels, H. T.; Wilks, S. A.; Keevil, C. W. 2004, “Effects of Copper Alloy Surfaces on the Viability of Bacterium, *E. coli* 0157:H7″, The Second Global Congress Dedicated to Hygienic Coatings & Surface Conference Papers, Orlando, Florida, US, 26–28 January 2004, Paper 16, Paint Research Association, Middlesex, UK

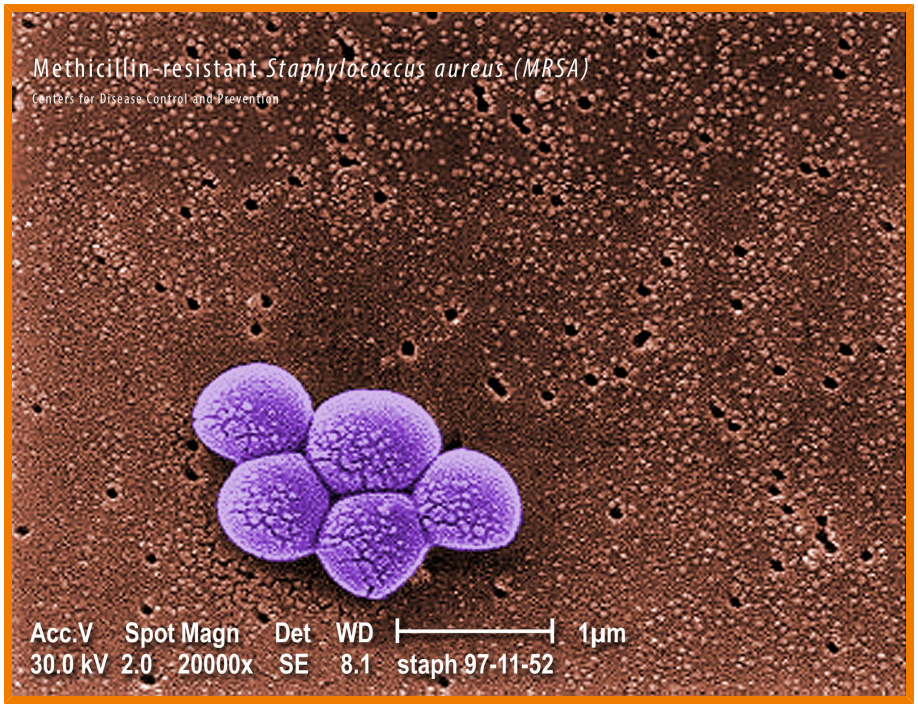
Michels, H. T.; Wilks, S. A.; Keevil, C. W. (2003), The Antimicrobial Effects of Copper Alloy Surfaces on the Bacterium *E. coli* O157:H7, Proceedings of Copper 2003 – Cobre 2003, The 5th International Conference, Santiago, Chile, Vol. 1 – Plenary Lectures, Economics and Applications of Copper, pp. 439–450, The Canadian Institute of Mining, Metallurgy and Petroleum, Montreal, Quebec, Canada, (presented in Santiago, Chile, November 30–December 3, 2003)

Updated Draft Protocol for the Evaluation of Bactericidal Activity of Hard, Non-porous Copper Containing Surface Products issued on 1/29/2016. Amongst the requirements listed is “An effective product is expected to achieve a 3 log10 reduction (LR) in viable bacteria (compared to the stainless steel control) for each microbe within a 1 hr contact period.”

https://www.epa.gov/pesticide-registration/updated-draft-protocol-evaluation-bactericidal-activity-hard-non-porous

It should also be noted that solid copper used in a manner to stimulate rubbing a copper device in one's hands in Vitro-Skin tests on Staphylococcus aureus and Escherichia coli at Accuratus labs confirmed organism kill. In the case of the 3 minute test where the copper was rubbed very lightly on the inoculated Vitro-Skin, the kill was 81 to 86%. For the 1 minute test wherein the rubbing action better replicated the rubbing action of a piece of copper (per agreement of the testing parties after observing hand rubbing) in one's hands, the kill was 94%.

MRSA and VRSA



VRSA (staph) is a strain of Staphylococcus aureus that is resistant to the antibiotic called vancomycin. The acronym, VRSA, stands for vancomycin-resistant Staphylococcus aureus. VRSA can cause an illness from skin infections to severe invasive disease which can result in pneumonia and/or septicemia (bacteria gets in the blood) or even death.

Most susceptible are persons with chronic health conditions and previous methicillin-resistant Staphylococcus aureus (MRSA) infections. In addition, people with open wounds, receive long term treatment and/or improper use of antibiotics, have invasive devices such as catheters or surgical drains, or have had prolonged or repeated hospital stays may also be at increased risk.

The main mode of transmission of VRSA is via hands. Transmission is also by direct contact with a person who has a draining skin lesion or wound.
People can be carriers and infect others without having any symptoms themselves.

Methicillin-resistant Staphylococcus aureus (MRSA) is a bacterium that causes infections in different parts of the body. It's tougher to treat than most strains of staphylococcus aureus — or staph — because it's resistant to some commonly used antibiotics.

The symptoms of MRSA depend on where you're infected. Most often, it causes mild infections on the skin, like sores or boils. But it can also cause more serious skin infections or infect surgical wounds, the bloodstream,
the lungs, or the urinary tract.

Though most MRSA infections aren't serious, some can be life-threatening. Many public health experts are alarmed by the spread of tough strains of MRSA. Because it's hard to treat, MRSA is sometimes called a "super bug."

A large number of independent studies confirm this antimicrobial effect, even against antibiotic-resistant bacteria such as MRSA (Methicillin-resistant Staphylococcus Aureus) and VRSA
(Vancomycin-resistant Staphylococcus Aureus). The mechanisms of antimicrobial action by copperand its alloys, including brass, are a subject of intense and ongoing investigation.

- EPA registers copper-containing alloy products, May 2008
- Michel, James H., Moran, Wilton, R., Michels, Harold T., and Estelle, Adam A. (June 20, 2011). “Antimicrobial copper displaces stainless steel, germs for medical applications: Alloys have natural germ-killing properties”. Tube and Pipe Journal.
- Noyce, J.O.; Michels, H.; and Keevil, C.W. (2006). “Potential use of copper surfaces to reduce survival of epidemic methicillin-resistant Staphylococcus aureus in the healthcare environment” (PDF). Journal of Hospital Infection. 63 (3): 289–297. PMID 16650507. doi:10.1016/j.jhin.2005.12.008. Archived from the original (PDF) on 2012-01-17.

- Schmidt, MG (2011). “Copper surfaces in the ICU reduced the relative risk of acquiring an infection while hospitalized”. BMC Proceedings. 5: O53. PMC 3239467 Freely accessible. doi:10.1186/1753-6561-5-S6-O53.
- “TouchSurfaces Clinical Trials: Home”. coppertouchsurfaces.org.
  “355 Copper Alloys Now Approved by EPA as Antimicrobial”. Appliance Magazine. June 28, 2011.
- Kuhn, Phyllis J. (1983) Doorknobs: A Source of Nosocomial Infection? Archived February 16, 2012, at the Wayback Machine. Diagnostic Medicine
- Espírito Santo, Christopher; Taudte, Nadine; Nies, Dietrich H.; and Grass, Gregor (2007). “Contribution of copper ion resistance to survival of Escherichia coli on metallic copper surfaces”. Applied and Environmental Microbiology. 74 (4): 977–86. PMC 2258564â€¯Freely accessible. PMID 18156321. doi:10.1128/AEM.01938-07.
- Santo, C. E.; Lam, E. W.; Elowsky, C. G.; Quaranta, D.; Domaille, D. W.; Chang, C. J.; Grass, G.(2010). “Bacterial Killing by Dry Metallic Copper Surfaces”. Applied and Environmental Microbiology. 77 (3): 794–802. PMC 3028699 Freely accessible. PMID 21148701. doi:10.1128/AEM.01599-10.