The Basics of Thermal Spray Safety

Working in HVOF or HVAF Mode
HIJET®-9610 is a New Generation High Velocity Combustion Wire Spray System, which provides supersonic spray velocities, combined with improved heating and melting of the wire particles. The HVOF Wire technique has great opportunities where a porous free, very dense, high performance wear resistance coating at most economical cost is the requirement. Unique design of the gun fulfills this gap and opens the scope for the users to use the metallic wires in HVOF rather than using the expensive powders and thus makes it a promising solution to achieve best coating properties for many industrial applications. HVOF Wire is more cost effective than HVOF (Powder).

<table>
<thead>
<tr>
<th>Coating Characteristics</th>
<th>Mo</th>
<th>High Carbon Steel</th>
<th>SS 420</th>
<th>Cu</th>
<th>Al</th>
<th>Al-Bronze</th>
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</thead>
<tbody>
<tr>
<td>Hardness (ASTM-E384)</td>
<td>950 HV</td>
<td>550 HV</td>
<td>519 HV</td>
<td>145 HV</td>
<td>48 HV</td>
<td>236 HV</td>
</tr>
<tr>
<td>Adhesion strength (ASTM-C633)</td>
<td>55 MPa</td>
<td>60 Mpa</td>
<td>45 Mpa</td>
<td>20 Mpa</td>
<td>18 Mpa</td>
<td>19 Mpa</td>
</tr>
<tr>
<td>Porosity (ASTM-2109)</td>
<td>&lt;0.70 %</td>
<td>&lt; 1 %</td>
<td>2-3 %</td>
<td>3-5 %</td>
<td>4-5 %</td>
<td>3-5 %</td>
</tr>
<tr>
<td>Thickness</td>
<td>237 µm</td>
<td>260 µm</td>
<td>250 µm</td>
<td>425 µm</td>
<td>283 µm</td>
<td>400 µm</td>
</tr>
<tr>
<td>As Sprayed Ra (ASTM-D7127)</td>
<td>2.83 µm</td>
<td>11 µm</td>
<td>8 µm</td>
<td>10 µm</td>
<td>6 µm</td>
<td>10 µm</td>
</tr>
<tr>
<td>Deposition Efficiency (DIN EN 17836)</td>
<td>60%</td>
<td>70%</td>
<td>70%</td>
<td>80%</td>
<td>56%</td>
<td>71%</td>
</tr>
<tr>
<td>Wire feed rates</td>
<td>125 cm/min</td>
<td>95 cm/min</td>
<td>95 cm/min</td>
<td>190 cm/min</td>
<td>390 cm/min</td>
<td>170 cm/min</td>
</tr>
<tr>
<td>Coverage</td>
<td>1.95 kg/m²/100µm</td>
<td>0.700 kg/m²/100µm</td>
<td>0.681 kg/m²/100µm</td>
<td>1.41 kg/m²/100µm</td>
<td>0.472 kg/m²/100µm</td>
<td>1.07 kg/m²/100µm</td>
</tr>
</tbody>
</table>

* Tested in MEC Testing Laboratory (ISO 17025:2005 Certified Lab.)

METALLIZING EQUIPMENT CO. PVT. LTD.
sales@mecpl.com, marketing@mecpl.com, trade@mecpl.com
Web: www.mecpl.com
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On the cover: Twin wire arc spraying of steel. (Photo courtesy of Hayden Corp.)
Oerlikon's New Facility to Produce Materials for Thermal Spray Powders

Oerlikon recently held a groundbreaking ceremony for its $50-million manufacturing facility in Plymouth Township, Mich. The 79,000-sq-ft plant will produce advanced materials for additive manufacturing, high-end surface coatings to meet market demand for advanced metal powders, and materials such as titanium alloys and diverse high-end thermal spray powders.

In addition, the center will house a R&D lab for further developments of titanium-related and other alloys for joint R&D projects with users, and make customized powders in small batches. It will be equipped with next-generation VIGA technology, which combines vacuum induction melting with inert gas atomization systems.

The powders produced will serve internal demand from Oerlikon's advanced component manufacturing sites in Charlotte, N.C., Atlanta, Ga., and Magdeburg, Germany, as well as the wider additive manufacturing and thermal spray markets.

Construction is expected to be completed at the end of the first quarter in 2018. The company plans to employ more than 65 highly skilled workers at the site.

Present at the ceremony were state and local government members. Officiating was Mike Tobin, president, Oerlikon Metco US Inc., and other members of the company’s management team.

“This new facility will expand our technology and materials competence and portfolio, and allow us to provide customers cutting-edge technologies in advanced industries such as additive manufacturing. I would like to thank the Michigan Business Development Program for their ongoing support, and we look forward to becoming a part of this community and contributing to it,” said Tobin.

ITSA Scholarships Available to Help Students

Through July 15, ITSA is accepting applications for its scholarship program. Up to two one-year scholarships worth $2000 each may be awarded each year. The winners will be announced in August.

Applications must meet all the following criteria:

- Student must be actively pursuing a postgraduate degree in thermal spray processes (plasma, flame, arc, high velocity oxygen fuel) or materials at an accredited university (U.S. only).
- Student must have at least one more year left in studies (after the current year).
- Student must be recommended by a supervisor of the university the student is attending. Financial need must be verified by a professor.
- Student must be recommended by at least one industrial source.
- Via letter, the student must present his/her interest in pursuing a career in thermal spray (maximum of three typed pages).
- Student must include the completed application form that can be printed at thermalspray.org/scholarship.

All applications must be sent via regular mail to ITSA c/o AWS, 8669 NW 36 Street, Suite 130, Miami, FL 33166. Questions can be sent via email to itsa@thermalspray.org.
Praxair and Flame-Spray Industries Form Global Partnership

Praxair Surface Technologies, TAFA Division has reached an agreement with Flame-Spray Industries Inc., Port Washington, N.Y., an inventor and supplier of plasma transferred wire arc technology, to be a global distributor for this technology in all nonaluminum engine block applications.

Praxair’s global sales and marketing presence will help broaden the plasma transferred wire arc market beyond the aluminum engine block production field and into other traditional thermal spray industries and markets such as material transport, compressors, petrochemical, aerospace, and railroad. Previously, the process was primarily used for new production aluminum engines for automotive, small engine, large diesel remanufacturing, and marine applications.

Guyson Builds Blasting System for Applications Prior to Thermal Spray

Guyson International, North Yorkshire, England, has designed, built, and installed its RB10 PF robotically controlled blasting system into a manufacturer of high-performance coatings. The machine is for the dual application of keying the surface of aerospace seal rings prior to plasma spraying, and the surface preparation of turbine blade tips prior to thermal spraying.

The blast cabinet contains large internal dimensions and doors with viewing windows on two sides, allowing access for loading/unloading and maintenance purposes. Fortress type interlocks prevent robot movement, blasting, or spindle rotation when a door is open. An energy absorbing hanging rubber sheet provides sound absorption and wear resistance.

Additional features include a 5-mm boron carbide blast nozzle robotically manipulated at the fixtured component; a robot that positions the blast nozzle, an ABB foundry plus robot system, located to the rear of the cabinet; and a small 7th axis turntable fitted in the middle of the blast chamber. Blasting is achieved through either of the two Guyson model G55 pressure pots. Blast media quality is maintained with the company’s CY600/12 cyclone reclamator mounted above a sieving system and the twin pressure pots.
Fischer Restructures Its German Salesforce

Helmut Fischer GmbH has reduced the size of each of its sales regions across Germany and expanded its sales team. This move allows responding more quickly to inquiries. From devices for measuring coating thickness, including thermal sprayed aluminum, to x-ray fluorescence instruments for material analysis, on-site consultations at the user’s premises will be more comprehensive. A team of service technicians ensures the continuity of after-sales support.

In addition, two new application laboratories have been opened in Berlin and Düsseldorf. These locations allow users to experience the company’s technology and attend seminars on various metrology topics. They also represent a direct interface to the R&D department.

“With the right measurement technology, it is possible to optimize the thickness of costly coatings and reduce amount of production rejects. This requires lightning-fast service and competent advice onsite, because downtime is very expensive,” said Markus Reichert, head of sales in Germany, about the reasons behind expanding the Fischer team.

Cincinnati Thermal Spray Reveals Applied Innovation Campaign

Cincinnati Thermal Spray, Cincinnati, Ohio, a provider of thermal spray coating systems, has unveiled its Applied Innovation campaign with the launch of a new website at cts-inc.net.

According to President Shane Elbel, the company is excited to “continue exploring new markets with needs for thermal spray applications.” It utilizes five facilities across the United States to serve users around the globe.

“At CTS, we are aggressively working to grow awareness, throughout all industries, of how our coating services can benefit the performance of our customers’ parts and systems. Many industries are unaware of our technologies, but can benefit from thermal spray applications tremendously when combatting wear, erosion, corrosion, and more,” Elbel added.

The company partnered with Wilmington, N.C.-based digital marketing firm Tayloe/Gray for the rebrand strategy, website design, and development.

BECOME A MEMBER

Your company should join the International Thermal Spray Association (ITSA) now! ITSA is a Standing Committee of the American Welding Society expanding the benefits of company membership. As a company-member professional industrial association, our mission is dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.

ITSA members invite your company to join us in this endeavor. (See pages 10–11)

What: Thermal spray coating equipment and consumables from Praxair

Why:

• TAFA-brand coating equipment

• Services: installations and training, calibrations and repairs

• Half a century of leadership

www.praxairsurfacetechologies.com
Heat Exchanger Upgrade for HVOF Processing

The WOKA chiller high-velocity oxygen fuel (HVOF) thermal spray process, employed in many applications to generate high-performance carbide coatings, utilizes liquid fuel to produce velocity and process temperatures for carbide spraying. This new heat exchanger unit is an upgrade that replaces a complex water softening well unit. The equipment requires precision cooling at the gun interface to allow high-quality production over long periods of operation.

ASB Industries Inc.
asbindustries.com / (888) 241-1088

Flexicords Offer Alternative for Producing Coatings

Thermal spray flexicords are an alternative for producing metallic and ceramic coatings using a universal flame spray gun for various markets and applications such as metal casting, glass industry, textile rollers, foundries, and paper. The products are tailored to fit to specific requirements including low porosity (down to 3%), high density, low or high roughness, nano-sized materials, and more. Flexicords offer good performance when coatings are subjected to thermal cycles at high temperatures, and they allow a higher coating thickness of 2 to 3 mm. They are ceramic or metallic wires that are sprayed with a customized flame spray unit (top jet or master jet). The ceramic cords provide coatings with less internal stresses, allowing thermal shock resistance and higher operating temperatures. The guns are lightweight and versatile, useful for on-site jobs to spray chrome carbide, Rocdur 625, and NiCr alloys dedicated to improving oxidation resistance at high temperature for incinerators and W.T.E. boilers.

Saint-Gobain Coating Solutions
saint-gobain-northamerica.com / (844) 243-0028
Global Thermal Spray Market Anticipated to Increase

The Global Thermal Spray Market 2017–2021 report assesses key opportunities in the thermal spray market and outlines the factors that are and will be driving growth of the industry. The market is anticipated to increase at a significant CAGR of 8.28% during the years 2017–2021.

The report covers emerging market trends, market dynamics, industry structure and developments, market share assessments for the regional and country level segments, as well as key market players and strategies in the market, detailed value chain analysis and review of growth factors essential for the existing market players, and new entrants. It also delivers detailed study on the major drivers and challenges with respect to regions, key players, and their impact. The report offers an analysis of the market potential for each geographical region based on the growth rate, macroeconomic parameters, consumer buying patterns, demand, and present scenarios in the thermal spray industry.

360 Market Updates
360marketupdates.com / (408) 520-9750

Global Thermal Spray Coating Market will Reach $13.61 Billion by 2022

Thermal Spray Coating Market (Polymer, Ceramic, Metal and Others) for Automotive, Aerospace, Industrial Gas Turbine and Other Applications: Global Market Perspective, Comprehensive Analysis, and Forecast, 2016–2022 reports the global thermal spray coating market was valued at $8.53 billion in 2016 and is expected to reach $13.61 billion in 2022, growing at a CAGR of 8.1% between 2017 and 2022. Growing demand for thermal spray coatings in industries such as automotive and aerospace across the globe is a major driving force of the global thermal spray coating market. Rising demand for thermal spray coatings from the medical sector is also expected to boom the market size in the coming years.

Ceramic was the leading product of the global thermal spray coating market in 2016. It accounted for more than 25% of the total market and is estimated to grow at a significant CAGR within the forecast period. Aerospace was one of the foremost applications, and it accounted for more than 32% of the entire market in 2016. New developments and increasing investments for aerospace, especially in North America and Asia Pacific, are predicted to witness the lucrative growth of the thermal spray coating market during the next few years.

Zion Market Research
zionmarketresearch.com / +49-322 210 92714
CALL FOR SPEAKERS FOR ITSA 2017 ANNUAL MEETING

- Are you responsible for quality evaluation of spray coatings?
- Are you developing the next big advancement in spray coating evaluation?

The International Thermal Spray Association (ITSA) is working on the program for the 2017 Annual Meeting “Evaluation of Thermal Spray Coatings” and invites you to consider speaking during this prestigious event. The ITSA Annual Meeting will be held October 11–13 in Albuquerque, N.M., and draws the industry elite in thermal spray coatings to a forum for networking and idea exchange.

Potential speaker candidates include:
- Quality coating evaluation representatives of equipment manufacturers, commercial laboratories, spray shops, and end users working in the aerospace, IGT, oil and gas, and commercial industries
- Researchers, engineers, or subject-matter experts who are using or developing advancements in coating evaluation

If you’re interested in sharing your knowledge and expertise in this rapidly advancing field, email itsa@thermalspray.org.
## ITSA Membership

**ITSA Mission Statement**

The International Thermal Spray Association, a Standing Committee of the American Welding Society, is a professional-industrial organization dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.

### JOB SHOP MEMBER COMPANIES

<table>
<thead>
<tr>
<th>Company Name</th>
<th>City, State</th>
<th>Contact Person</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCUWRIGHT INDUSTRIES INC.</td>
<td>Gilbert, AZ</td>
<td>Mr. David Wright</td>
<td><a href="mailto:dave@accuwright.com">dave@accuwright.com</a></td>
<td>480.892.9595</td>
</tr>
<tr>
<td>ATLAS MACHINE &amp; SUPPLY INC.</td>
<td>Louisville, KY</td>
<td>Mr. Rich Gimmel</td>
<td><a href="mailto:richie@atlasmachine.com">richie@atlasmachine.com</a></td>
<td>502.584.7262</td>
</tr>
<tr>
<td>BENDER CCP INC.</td>
<td>Vernon, CA</td>
<td>Mr. Doug Martin</td>
<td><a href="mailto:dmartin@benderus.com">dmartin@benderus.com</a></td>
<td>323.232.2371</td>
</tr>
<tr>
<td>CASTOLIN EUTECTIC</td>
<td>Lasanne, Switzerland</td>
<td>Ms. Patricia Frund</td>
<td><a href="mailto:pfund@castolin.com">pfund@castolin.com</a></td>
<td>0041.21.694.1132</td>
</tr>
<tr>
<td>CINCINNATI THERMAL SPRAY INC.</td>
<td>Cincinnati, OH</td>
<td>Mr. Bill Menth</td>
<td><a href="mailto:bmenth@cts-inc.net">bmenth@cts-inc.net</a></td>
<td>513.770.4928</td>
</tr>
<tr>
<td>CURTISS-WRIGHT SURFACE TECHNOLOGIES</td>
<td>Windsor, CT</td>
<td>Mr. Peter Ruggiero</td>
<td><a href="mailto:peter.ruggiero@cwst.com">peter.ruggiero@cwst.com</a></td>
<td>860.623.9901</td>
</tr>
<tr>
<td>ELLISON SURFACE TECHNOLOGIES INC.</td>
<td>Mason, OH</td>
<td>Mr. Eric Dolby</td>
<td><a href="mailto:info@ellisonsurfacotech.com">info@ellisonsurfacotech.com</a></td>
<td>513.770.4928</td>
</tr>
<tr>
<td>EXLINE INC.</td>
<td>Salina, KS</td>
<td>Mr. Brent Hilbig</td>
<td><a href="mailto:b.hilbig@exline-inc.com">b.hilbig@exline-inc.com</a></td>
<td>785.825.4683</td>
</tr>
<tr>
<td>F.W. GARTNER THERMAL SPRAYING</td>
<td>Houston, TX</td>
<td>Mr. Richard McCullough</td>
<td><a href="mailto:rmccullough@fwgts.com">rmccullough@fwgts.com</a></td>
<td>713.225.0010</td>
</tr>
<tr>
<td>FUSION INC.</td>
<td>Houston, TX</td>
<td>Mr. Jeff Fenner</td>
<td><a href="mailto:jfenner@fusionhouston.com">jfenner@fusionhouston.com</a></td>
<td>713.691.6547</td>
</tr>
<tr>
<td>HAYDEN CORP.</td>
<td>West Springfield, MA</td>
<td>Mr. Dan Hayden</td>
<td><a href="mailto:daniel.hayden@haydencorp.com">daniel.hayden@haydencorp.com</a></td>
<td>413.734.4981</td>
</tr>
<tr>
<td>HFW INDUSTRIES INC.</td>
<td>Buffalo, NY</td>
<td>Mr. Matt Watson</td>
<td><a href="mailto:mwatson@hfwindustries.com">mwatson@hfwindustries.com</a></td>
<td>716.875.3380</td>
</tr>
<tr>
<td>KERMETICO INC.</td>
<td>Benicia, CA</td>
<td>Mr. Andrew Verstak</td>
<td><a href="mailto:averstak@kermetico.com">averstak@kermetico.com</a></td>
<td>707.745.3862</td>
</tr>
<tr>
<td>NATION COATING SYSTEMS</td>
<td>Franklin, OH</td>
<td>Mr. Larry Grimenstein</td>
<td><a href="mailto:ncsgrimen@aol.com">ncsgrimen@aol.com</a></td>
<td>937.746.7632</td>
</tr>
<tr>
<td>SPRAYMETAL INC.</td>
<td>Houston, TX</td>
<td>Mr. Andrew Schumacher</td>
<td><a href="mailto:ars@schumachercoid.com">ars@schumachercoid.com</a></td>
<td>713.924.4200</td>
</tr>
<tr>
<td>SUPERIOR SHOT PEENING INC.</td>
<td>Houston, TX</td>
<td>Ms. Mollie Blasingame</td>
<td><a href="mailto:mmb@superiorshotpeening.com">mmb@superiorshotpeening.com</a></td>
<td>281.449.6559</td>
</tr>
<tr>
<td>TACOLO CO. LTD.</td>
<td>Japan</td>
<td>Mr. Daisuke Inoue</td>
<td><a href="mailto:inouedaisuke@tocalo.co.jp">inouedaisuke@tocalo.co.jp</a></td>
<td>81781207646</td>
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### SUPPLIER MEMBER COMPANIES

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<th>Contact Person</th>
<th>Email</th>
<th>Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALLOY COATING SUPPLY</td>
<td>Spring, TX</td>
<td>Mr. Jeffrey Noto</td>
<td><a href="mailto:jnoto@alloycoatingsupply.com">jnoto@alloycoatingsupply.com</a></td>
<td>281.528.0980</td>
</tr>
<tr>
<td>AMETEK INC.</td>
<td>Eighty-Four, PA</td>
<td>Ms. Cindy Freeby</td>
<td><a href="mailto:cindy.freeby@ametek.com">cindy.freeby@ametek.com</a></td>
<td>724.225.8400</td>
</tr>
<tr>
<td>CAMFIL APC</td>
<td>Jonesboro, AR</td>
<td>Mr. Matt Caulfield</td>
<td><a href="mailto:mcaulfield@camfil.com">mcaulfield@camfil.com</a></td>
<td>800.479.6801</td>
</tr>
<tr>
<td>CARPENTER POWDER PRODUCTS</td>
<td>Pittsburgh, PA</td>
<td>Mr. Chip Arata</td>
<td><a href="mailto:warata@cartech.com">warata@cartech.com</a></td>
<td>412.257.5102</td>
</tr>
<tr>
<td>CENTERLINE WINDSOR LTD.</td>
<td>Windsor, ON, Canada</td>
<td>Mr. Julio Villafuerte</td>
<td><a href="mailto:julio.villafuerte@cntrline.com">julio.villafuerte@cntrline.com</a></td>
<td>519.734.8464</td>
</tr>
<tr>
<td>DEWAL INDUSTRIES INC.</td>
<td>Narragansett, RI</td>
<td>Ms. Susan Dunn</td>
<td><a href="mailto:sdunn@dewal.com">sdunn@dewal.com</a></td>
<td>401.789.9736</td>
</tr>
<tr>
<td>DONALDSON TORIT</td>
<td>Minneapolis, MN</td>
<td>Mr. Jeff Abelson</td>
<td><a href="mailto:jeff.abelson@mail.donaldson.com">jeff.abelson@mail.donaldson.com</a></td>
<td>800.365.1331</td>
</tr>
<tr>
<td>FUJIMI INC.</td>
<td>Tualatin, OR</td>
<td>Mr. Peter Eckert</td>
<td><a href="mailto:petere@fujimico.com">petere@fujimico.com</a></td>
<td>503.830.2265</td>
</tr>
</tbody>
</table>

---

**TUNGCO POWDER PROCUREMENT**

Madisonville, KY
Mr. Ryan Sizemore
rsizemore@tungco.com / 270.825.0000
tungco.com

**WHITE ENGINEERING SURFACE CORP.**

Newtown, PA
Mr. Deanne Nanni
info@whiteengineering.com / 215.968.5021
whiteengineering.com
GLOBAL TUNGSTEN AND POWDERS CORP.  
Towanda, PA  
Ms. Laura Morelli  
Laura.morelli@globaltungsten.com  
570.268.5182 / globaltungsten.com

GLOBE METAL INC.  
Sainte-Catherine, QC, Canada  
Mr. Josh Lifshitz  
josh@globemetals.com / 450.635.9397

GREEN BELTING INDUSTRIES LTD  
Mississauga, ON, Canada  
Mr. Tim Connelly  
tconnelly@greenbelting.com / 905.564.6712

H.C. STARCH NORTH AMERICAN TRADING LLC  
Newton, MA  
Ms. Ana Duminie  
a.duminie@hschark.com / 617.407.9960

HAI ADVANCED MATERIAL SPECIALIST INC.  
Placentia, CA  
Mr. Daren Gansert  
dgansert@haiinc.com / 877.411.8971

HAYNES INTERNATIONAL  
Mountain Home, NC  
Mr. Brandon Furr  
bfurr@haynesintl.com / 713.937.7597

IMERYS FUSED MINERALS  
Greeneville, TN  
Mr. Mitch Krieg  
mitch.krieg@imerys.com

IMPERIAL SYSTEMS  
Jackson Center, PA  
Mr. Jeremiah Wann  
wann@isystemsweb.com / 724.992.1721

KENNAMETAL STELLITE COMPANY INC.  
Gothenburg, NE  
Mr. David A. Lee  
david.a.lee@kennametal.com  
574.534.8631 / stellite.com

LINCOLN ELECTRIC  
Cleveland, OH  
Mr. Thomas Brown  
thomas.brown@lincolnelectric.com  
216.383.2951 / lincolnelectric.com

LINEAGE ALLOYS  
Baytown, TX  
Mr. Adel Djam  
adjam@lineagealloysllc.com  
281.426.5535 / lineagealloys.com

METALLISATION LTD.  
Dudley West Midlands, United Kingdom  
Mr. Stuart Milton  
sales@metallisation.com  
+44.1384.252464 / metallisation.com

METALLIZING EQUIPMENT CO. PVT.  
Jodhpur, India  
Mr. SC Modi  
scmodi@mecpl.com / 91.291.2747601

NORTH AMERICAN HÓGANÁS  
Hollosopple, PA  
Mr. Andy Hoffman  
andy.hoffman@nah.com / 814.361.6875

OERLIKON METCO (US) INC.  
Westbury, NY  
Ms. Karen Sender  
karen.sender@oerlikon.com / 516.334.1300

POLYMET CORP.  
Cincinnati, OH  
Mr. Bob Unger  
runger@polymet.us / 513.874.3586

PRAXAIR SURFACE TECHNOLOGIES  
Concord, NH  
Mr. Richard Thorpe  
richard.thorpe@praxair.com / 603.224.9585

PROGRESSIVE SURFACE  
Grand Rapids, MI  
Mr. Bill Barker  
wmb@progressivesurface.com  
800.968.0871 / progressivesurface.com

SAINT-GOBAIN CERAMIC MATERIALS  
Worcester, MA  
Mr. Howard Wallar  
howard.wallar@saint-gobain.com  
508.795.2351

THERMACH INC.  
Appleton, WI  
Mr. David Lewisen  
davelewisen@thermach.com / 920.779.4299

THERMION  
Silverdale, WA  
Mr. Dean Hooks  
dhooks@thermioninc.com / 360.692.6469

STATE UNIVERSITY OF NEW YORK AT STONY BROOK  
Stony Brook, NY  
Prof. Sanjay Sampath  
ssampath@ms.cc.sunysb.edu  
631.632.8480 / ctsr-sunysb.org

DVS, THE GERMAN WELDING SOCIETY  
Mr. Jens Jerzembeck  
jens.jerzembeck@dvs-hg.de  
die-verbindungs-spezialisten.de

GTS E.V., THE ASSOCIATION OF THERMAL SPRAYERS  
Mr. Werner Kroemmer  
werner.kroemmer@gts-ev.de  
+49.89.31001.5203 / gts-ev.de

IMM, INSTITUTE OF MATERIALS MALAYSIA  
Mr. Johar Juhari  
johar.juhari@petronas.com.my  
603.5882.3584 / iomm.org.my

JTSS, JAPAN THERMAL SPRAY SOCIETY  
Mr. Nick Yumiba  
jtss@mb8.seikyou.ne.jp / +81.6.6722.0096

MPIF, METAL POWDER INDUSTRIES FEDERATION  
Mr. James R. Dale  
jdale@mpif.org / 609.452.7700

TSCC – THERMAL SPRAYING COMMITTEE OF CHINA SURFACE ENGINEERING ASSOCIATION  
Prof. Huang Xiao  
xiaoo@chinathermalspray.org  
+86.10.64882554 / chinathermalspray.org

Become a member  
Your company should join the International Thermal Spray Association (ITSA) now! ITSA is a Standing Committee of the American Welding Society expanding the benefits of company membership. As a company-member professional industrial association, our mission is dedicated to expanding the use of thermal spray technologies for the benefit of industry and society.

ITSA members invite your company to join us in this endeavor.

thermalspray.org
The International Thermal Spray Association is closely interwoven with the history of thermal spray development in this hemisphere. Founded in 1948, and once known as Metallizing Service Contractors, the association has been closely tied to most major advances in thermal spray technology, equipment and materials, industry events, education, standards, and market development.

A company-member association, ITSA invites all interested companies to talk with our officers, and company representatives to better understand member benefits. A complete list of ITSA member companies and their representatives can be found at their website thermalspray.org

**ITSA MISSION STATEMENT**

The International Thermal Spray Association, a Standing Committee of The American Welding Society, is a professional industrial organization dedicated to expanding the use of thermal spray technologies for the benefit of industry and society. ITSA invites all interested companies to talk with our officers, and company representatives to better understand member benefits.

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**ITSA MEMBER NEWS**

**Tradeshow Assessment for ITSA Member Eliminated**

Earlier this year, ITSA Members were invited to participate in an ITSA Member Satisfaction Survey, in which they were asked to rate the value of various member benefits. Based on feedback received on the value of ITSA Booth participation at industry tradeshows, at its April 20, 2016, meeting, the ITSA Executive Committee unanimously decided to discontinue ITSA booth activity at tradeshows effective July 2016. As ITSA Members subsidized the cost of ITSA booth activity via annual assessments, this move will result in the elimination of these costly annual ITSA Member assessments going forward.

In lieu of booth representation at tradeshows, ITSA will proactively participate in alternative ways at key industry events. For example, a series of educational presentations promoting thermal spray are being scheduled as free, half-day sessions at tradeshows like FABTECH, POWER-GEN International, and CORROSION.

**ITSA SCHOLARSHIP OPPORTUNITIES**

The International Thermal Spray Association offers annual Graduate Scholarships. Since 1992, the ITSA scholarship program has contributed to the growth of the thermal spray community, especially in the development of new technologists and engineers. ITSA is very proud of this education partnership and encourages all eligible participants to apply. Please visit thermalspray.org for criteria information and a printable application form.

**ITSA THERMAL SPRAY HISTORICAL COLLECTION**

In April 2000, the International Thermal Spray Association announced the establishment of a Thermal Spray Historical Collection that is now on display at the State University of New York at Stony Brook in the Thermal Spray Research Center, USA.

Growing in size and value, there are now over 30 different spray guns and miscellaneous equipment, a variety of spray gun manuals, hundreds of photographs, and several historic thermal spray publications and reference books.

Future plans include a virtual tour of the collection on the ITSA website for the entire global community to visit. This is a worldwide industry collection and we welcome donations from the entire thermal spray community.

**ITSA SPRAYTIME**

Since 1992, the International Thermal Spray Association has been publishing SPRAYTIME for the thermal spray industry. The mission is to be the flagship thermal spray industry publication providing company, event, people, product, research, and membership news of interest to the thermal spray community.

**JOIN THE INTERNATIONAL THERMAL SPRAY ASSOCIATION**

ITSA is a professional, industrial association dedicated to expanding the use of thermal spray technologies for the benefit of industry and society. ITSA Membership is open to companies involved in all facets of the industry – equipment and materials suppliers, job shops, in-house facilities, educational institutions, industry consultants, and others.

Engage with dozens of like-minded industry professionals at the Annual ITSA Membership Meeting, where there’s ample time for business and personal discussions. Learn about industry advancements through the one-day technical program, participate in the half-day business meeting, and enjoy your peers in a relaxed atmosphere complete with fun social events.

Build awareness of your company and its products and services through valuable promotional opportunities – a centerfold listing in the SPRAYTIME Newsletter, exposure on the ITSA Website, and recognition at industry trade shows.

PLUS, ITSA Membership comes with an American Welding Society (AWS) Supporting Company Membership and up to five AWS Individual Memberships to give to your best employees, colleagues or customers. Visit aws.org/membership/supportingcompany for a complete listing of additional AWS benefits.

For more information, contact Alfred Nieves at 800.443.9353 Ext. 467, or itsa@thermalspray.org. For an ITSA Membership Application, visit the membership section at thermalspray.org.
ITSA Welcomes New Members

**HFW INDUSTRIES** *(hfwindustries.com)*, Buffalo, N.Y., combines thermal spray coating, hardfacing, and high-precision machining/grinding all under one roof. The company was founded in 1947 and has reinstated its ITSA membership after a brief absence.

The company manufactures and reconditions precision-machined components for a variety of industries including chemical, power generation, oil and gas, paper and pulp, and printing. Its success is rooted in its ability to solve problems by integrating high-performance coatings and weld overlays with state-of-the-art manufacturing. Thermal spray capabilities include HVOF, plasma spray, twin wire arc, and the spray and fuse process.

HFW Industries is a pioneer in the thermal spray industry and has established a lead position by excelling in meeting customer requirements. The company’s many Fortune 500 customers rely on its ability to perform as an outsourced engineering department, metallurgy expert, and world-class manufacturing arm.

196 Philadelphia Street
Buffalo, New York 14207
716.875.3380 / sales@hfwindustries.com

**TOCALO CO. LTD.** *(tocalo.co.jp/english)*, Kobe, Japan, is a leading thermal spray and surface engineering company with more than 66 years of experience in the industry. The company specializes in thermal spray coatings, which can provide wear resistance, corrosion resistance, electrical insulation, thermal barrier, and other properties the customer’s components may need for optimizing performance and prolonging service life. Its applications are in various industrial fields including electronics, steel, paper, plastic, industrial machinery, power generations, aerospace, and biomedical. TOCALO USA Inc., La Palma, Calif., is a subsidiary of TOCALO and will begin coating services focused on electronics application in Fall 2017.

Kobe, Japan
inouedaisuke@tocalo.co.jp

**IMERYS FUSED MINERALS** *(imerys.com)* is a leader in fused and crushed zirconia and other advanced ceramic compositions for a variety of applications, including standard & SPS coatings for aerospace and gas turbines.

The company’s manufacturing facility in Laufenburg, Germany offers multiple fusion and processing technologies, and a wide product range to address stringent chemical, physical, and sizing properties demanded in both specialized and standard applications. Imery’s ability to do customized R&D work in its CARRD research center, and small scale plant trials before promptly moving to larger production lots, makes them an ideal partner for the development of new materials.

109 Coile Street
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428.787.0333 / ifm-mu@imerys.com

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Workplace safety is not a subject that typically captivates an audience, but in the thermal spray trade, we face a broad array of conditions to pay close attention to throughout the shop. There are some compelling reasons to face the topic head on and ensure your facility, and your people, are taking all of the necessary precautions.

Operating Safely

First and foremost, maintaining a safe workplace is the law. Title 29 Part 1900 of the Code of Federal Regulations outlines the mandate, reach, and policies of the Occupational Safety and Health Administration (OSHA). Although there may be misconceptions of OSHA’s jurisdiction not applying to shops below a certain size, there is not likely to be a thermal spray or welding shop that isn’t subject to OSHA’s regulations. Facilities operating in states that have their own occupational safety divisions may report to state officials rather than OSHA alone. However, in such cases, state safety guidelines must meet or exceed OSHA’s (29 CFR Part 1902.1[b]). Discussions like this one can help make smaller facilities aware...
of operating requirements they may be unfamiliar with.

Second, it is important for frontline employees to be aware of the potential hazards they face every day so that they are motivated to take the appropriate precautions voluntarily.

Finally, when the topic can be discussed clearly and concisely, it is easier to ensure requirements are met. Involving people at every level of operation in the development of plant policies ensures that keeping employees safe and getting the job done go together.

Another reason discussing safety is especially important in the thermal spray workplace is that hazards appear throughout the coating operation, practically from incoming inspection to finalization. Dust and fume hazards are an excellent example. Dust and/or fume exposures occur during degreasing, blasting, powder handling, spraying, sealing, and even during maintenance and cleaning. Technically speaking, dusts are airborne fine solid particles such as fractured grit blasting media or thermal spray powders, which can irritate lungs and mucous membranes. Fumes are finer suspended particles released when materials are heated or burned, which happens when thermal spray feedstock enters the combustion zone or plasma plume of a spray gun. Some thermal spray fumes, such as hexavalent chromium, are known to cause cancer. Vapors are emitted by liquids that evaporate at room temperature like solvents more commonly used for cleaning and degreasing parts i.e., acetone and trichloroethane. Inhalation of vapors such as these can damage the lungs and internal organs.

Most dusts and fumes common in the spray shop are irritating to the lungs, but some have more reactive effects. For example, nickel, cobalt, and chromium can cause eczema or contact dermatitis (Ref. 1). Fumes released during twin arc wire spraying of zinc can cause nausea, fever, and other flu-like symptoms, a phenomenon referred to as zinc fever (Ref. 2). The hazard of the airborne carcinogen hexavalent chromium is so acute that the code places specific requirements on employers who are known generators. Part 1910.1026 requires regular physical testing of employees who may be exposed, and makes the provision and handling of specialized protective clothing, among other things, the responsibility of the employer.

**Eliminating and Substituting**

There are several methods for eliminating or remediating the hazards caused by dust and fume. The first and most effective option is eliminating it altogether, though this is a difficult option. The next best alternative is substitution of a less hazardous material or process than the existing one. Depending on the application, this may not be a viable option. Since these alternatives may be difficult to perform, engineering controls may be the better option.

**Different Types of Controls**

Engineering controls are those methods by which equipment can be added or a process design can be modified to reduce or eliminate the hazard to employees. In the case of dust and fume, the use of sufficient air filtration is an engineering control that can ensure contaminated air is drawn away from the operator, removing the hazard, and that the air is effectively cleaned before being reintroduced into the environment.

Administrative controls are the next layer of hazard mitigation available to the employer. These consist of policies and procedures that mandate specific safe working practices for each workplace hazard. Training, signage, procedures, and employee exposure time management are all administrative controls that might aid in the mitigation of dust and fume hazards.

Finally, personal protective equipment (PPE), such as dust masks and gloves (Fig. 1), may be used to protect employees. Though it is perhaps the most common workplace safety measure, PPE is dependent upon employee participation and supervision.

**Hearing Importance**

Noise is another pervasive workplace hazard common to thermal spraying operations. Excessive exposure to noise not only damages hearing, potentially leading to hearing loss, but can also cause tinnitus (ringing in the ears), stress, hypertension, and sleep disturbance (Ref. 3). Given the nature of most thermal spray processes,
excessive noise is common at the point of application, and, as with dust and fume, there are a range of methods by which an employer may ensure the safety and health of technicians who work with spray equipment throughout their shift.

Because most thermal spray guns emit noise in excess of 95 dBA continually (high-velocity oxyfuel systems regularly exceed the 115–dBA limit), several layers of employee protection are usually required. The most effective administrative control is the use of a hearing conservation program whereby employees’ hearing is tested annually by a hearing professional in a controlled environment. Regular testing allows employers to detect a change in an employee’s hearing ability long before significant damage can become permanent. Environmental controls, such as sound-deadening enclosures and isolated control rooms, can shield technicians from the source of the noise and substantially lower their exposure. Of course, the use of earplugs and muffs when in close proximity to the process is required.

Robot Considerations

Though less obvious than noise and dust, mechanical hazards are also common in thermal spray. The modern industrial robot is one of the best engineering controls available to limit operator exposure to both dust and noise. Impervious to the hazards that affect most frontline personnel, robots allow us to get the job done safely and efficiently, while keeping their human operators out of harm’s way. However, robots are capable of moving at speeds far faster than a human, and with much greater force and agility.

Even when running a known program, a robot’s motion can be unpredictable. It is essential, therefore, to remain aware of a robot operating in automatic mode and stay well outside its range of motion. Most robotic systems incorporate either mechanical or electronic means for restricting the arm’s movement about its base axis. Doing so can create a “safe” zone into which the robot is unable to reach. Whether restricted or not, it is advisable to mark a robot’s range of motion on the floor around it. Door interlocks and an external enabling device are added engineering controls often used in thermal spray installations. These are designed to ensure that the safety enclosure is fully closed, and the operator is outside before the automatic robot program is initiated.

Additional Aspects

To a lesser extent, though no less important, other hazards such as electrical (both high voltage and high current), compressed gas, and material handling are also part of the thermal spray workplace. Plasma and twin arc spray systems both employ high-current, low-voltage power supplies, similar to many commercial welding power supplies, and, like their welding and plasma cutting counterparts, these systems are nearly always designed for safe industrial use. However, it is the nature of spray operations that the business end of nearly every electrical gun can present a significant electrical shock hazard, particularly since conductive metal dust and water from cooling lines are often present, as is abrasive grit, which can deteriorate electrical insulation.

Compressed gases, whether in the form of cylindered oxygen, fuel, or shielding gas, bulk liquid or gaseous storage, or even compressed shop air, are also often present throughout the production facility. From the point of origin to the point of use, there is always a potential for an unexpected release of stored energy in the form of a gas leak. Safe handling practices, such as ensuring all gas cylinders are secured from tipping, and venting all equipment at the end of a shift can minimize the risk of an accident.

Conclusion

This article covers the basic kinds of hazards around the spray shop. As far as compliance, in addition to following workplace safety regulations, OSHA typically requires completion of three basic forms. The Log of Work-Related Injuries and Illnesses (Form 300) records basic information about each occurrence of a recordable injury or illness. The Injury or Illness Incident Report (Form 301) is completed for each recordable incident of work-related injury or illness, and includes details about the individual case, including any treatment given, and the likely cause. Form 300A is a summary of all incidences recorded for the calendar year on Form 300, and, for most businesses, it is the only form that must be submitted to OSHA annually (even if no recordable events occurred during the year).

In the event of an audit, however, evidence of an organized safety program, including documentation of regular training, demonstrates an active interest in maintaining a safe workplace.

The topics discussed here constitute opportunities for training. There are plenty of opportunities to make safety a regular part of the workplace conversation. Just bringing visibility to the subject can make the job safer.

Acknowledgments

This paper is based on a presentation delivered at the International Thermal Spray Association meeting on April 24–26, 2014, in Savannah, Ga. Much of the material was researched by the ASM International Thermal Spray Society Safety Committee, chaired by Gregory West of Sulzer Metco. Members are Aaron Hall, Sandia National Labs; Tony Supine, Camfil Farr APC; Robert Miller, Kennametal; Marty Hillbrands, Progressive Surface Technologies; Mike Walters, Camfil Farr APC; Deidre Hirschfeld, Sandia National Labs; Jesse Beske, Thermal Spray Technologies; Jon Head, Praxair; Daniel Hayden, Hayden Corp.; and Armelle Vardelle, Université de Limoges.

References


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Daniel Hayden (daniel.hayden@haydencorp.com) is president of Hayden Corp., West Springfield, Mass.
SAVE THE DATESAVE THE DATE
2017 ITSA ANNUAL MEMBERSHIP MEETING
October 11–13, 2017 / Albuquerque, NM

Mark your calendars to attend the 2017 ITSA Annual Membership Meeting in Albuquerque where the thermal spray community will join to network, learn, and share the latest in technological advancements. The theme for this year’s event will be “Evaluation of Thermal Spray Coatings.” Development of the technical program is under way.

PLUS, a tour of the Thermal Spray Research Lab at Sandia National Laboratories will be held on Oct. 12 for ITSA Members (restrictions apply).

In addition, ITSA Members and guests will get to participate in the 46th Annual International Balloon Fiesta.

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New high-velocity oxygen fuel coating (HVOF) equipment is infrequently introduced. However, Kermetico Inc., a company known for its high-velocity air fuel coating (HVAF), has recently introduced a new system that can work in HVOF or HVAF mode. Andrew Verstak, Kermetico’s founder and director, explained that for more than 20 years he has been attracted by the potential of the HVAF process. "Knowing something about the science of a thermal spray coating formation, it’s difficult to overestimate the fact that air-fuel combustion temperatures are ideally suited for spraying the Fe-, Ni-, and Co-based alloys and cemented carbides. Simply because it is relatively easy to avoid these materials overheating in the HVAF process. It is a huge potential for improving the coating quality. Then, thanks to this very factor — relatively low air-fuel combustion temperature — one has the luxury to run the spray particles through the combustion chamber without their thermal deterioration and oxidation. You can drop gas velocity in the combustion chamber to 40 m/s or even 20 m/s, providing a long time for spray particles heating, as long of a time as needed to utilize the gas thermal energy fully. Thus, HVAF is more energy efficient than conventional HVOF. It means higher spray rates, better cost, and greater flexibility," he said.

**HVAF and HVOF Processes**

Gas composition and combustion temperature are technological factors in the HVAF and HVOF process developed by the company. Both systems let you tweak these factors to achieve needed coating quality. The new HVAF/HVOF system is named “Convertible.” An operator can quickly convert it to HVOF or HVAF as needed. And a shop can spray HVOF-spec powders with the same spray rate as HVAF practically using the same equipment.

HVAF sprays faster than an HVOF system of similar power. The Convertible system sprays with the same rate as HVAF. Temperature and gas composition are technological factors in the company’s HVAF and HVOF processes. The acceleration process in the nozzle works independently from the heating process in the chamber. Spray particles are preheated to the "needed" temperature in the combustion chamber, and accelerated to the "needed" velocity in the nozzle of the chosen length and configuration. "Needed" regarding deposit efficiency and coating quality. Furthermore, "needed" particle temperature and "needed" particle velocity are never “maximal” when we consider spraying alloys or carbides. The Convertible guns provide wider windows of available spray parameters than used in industry.

![Fig. 1 — A comparison of popular HVOF and HVAF guns aligned by the powder injection point.](https://thermalspray.org/)

**JP 5000**

1.03 (MPa)
Barred
Radial Powder Injection
3100 °C
Liquid Fuel Oxygen

**Jet Kote**

2982 °C
Jet Fuel Oxygen

**DJ 2600**

2982 °C
Jet Fuel Oxygen

**Kermetico C6, C7**

1700-2100 °C
The first HVAF gun, J. Browning’s Aerospray, had an essential weakness: the spray particles were injected into the nozzle at the point of its expansion—a design similar to liquid-fueled HVOF (J. Browning’s JP 5000). The loss of 500°–800°C due to gas expansion in the nozzle was acceptable for high-temperature HVOF, but completely detrimental to low-temperature HVAF. Radial injection of the powder into the cylindrical or substantially underexpanded nozzle (where the gas temperatures were sufficient for the powder heating) resulted in fast clogging of the nozzle. This was a major reason for early HVAF losing the competition to HVOF. The situation changed with the introduction of the microflame combustion process by setting permeable ceramic block in the HVAF combustion chamber. Now the combustion process could be localized at the back wall of the combustion chamber, the chamber length reduced to the point where the spray particles could be injected axially into the combustion chamber, and then through the nozzle. This became the basis for the creation of the family of Kermetico HVAF guns — including AK7, AK6, AK5, AK4-ID, and AK5-ID — specialized guns and convertible guns. The idea behind each gun is precise control of spray particle temperature and optimal heating of the spray part. The rule of thumb is to minimize temperature and use particle velocity to do the rest of the job.

Temperature as a Technological Factor

Usually, we control the combustion temperature in the range of 1700° to 2100°C to heat a metal alloy or cemented carbide not far from the metal melting temperature. And we can increase or decrease the temperature in the combustion chamber beyond these limits if necessary.

In Fig. 1, we aligned different high-velocity combustion guns by the powder entrance point. Why do the HVAF guns have such a short path for the powder? They are too hot. Having 3000°C in a chamber full of oxygen, it is too easy to melt the powder and oxidize it. Our guns combust most of the oxygen near the ceramic insert, while the powder is still shrouded by the transport gas. Then we have enough time to preheat the powder and accelerate it to the needed velocity because the nozzles are wide enough to prevent clogging, so they can be as long as necessary to reach the target velocity.

Coating Quality and Cost

With Convertible HVAF/HVOF guns, we have the ability to control particle temperature from 1300° to more than 1800°C and independently control particle velocity from 600 to more than 1000 m/s with minimal, if any, material oxidation and thermal deterioration. When spraying cemented carbides and hard metals, the increase of particle velocity results in the formation of harder and denser coatings, but deposition efficiency (DE) decreases, resulting in higher coating costs. Dependent on the coating quality requirements, the user can spray the same WC-10Co-4Cr powder depositing a coating as hard as 1500–1600 HV300 at 38–40% DE or 1100–1200 HV300 hardness coating at 60–65% DE. Due to precise temperature control, even the hardest coatings are not brittle, showing fracture toughness values higher than traditional HVOF-sprayed counterparts of lower hardness.

Abrasive wear and erosion resistance of such carbide coatings is improved 3–5 fold, and cavitation resistance more than 10 fold. Because the coatings are extremely dense, they provide reliable protection against corrosion at a thickness of 50 microns or less. The most substantial cost benefits come from the application of very thin layers of high-quality coatings even if their DE is not very high.

Spray Gun Sizes

Large HVAF guns resulted in improvements for roll manufacturers in paper machines and steel mills. Furthermore, our customers needed to spray smaller parts, so we designed lower throughput guns. Our first and largest AK7 sprays 550 g/min using 200 kW of power; our AK6 sprays 460 g/min using 130 kW of power; and our AK5 sprays 250 g/min using 80 kW. We have developed a 30 kW AK-ID for coating internal diameters as small as 80 mm with a spray rate of 80 g/min, or about the same as any traditional HVOF system for external diameters. It is important to emphasize that high spray rates are utilized not only for large rollers but for small parts spraying while using lower power guns. For instance, the typical spray rate of the WC coating with a AK6 gun onto the 25–30 mm diameter shaft is 400–450 g/min, routinely depositing a thickness of 50 microns per pass.

![Image](image.png)

**Fig. 2** — A 200x microscope of WC-10Co-4Cr coating sprayed by the HVAF AK7 in ultra-mode.

**Conclusion**

The essential advantage of the Convertible HVAF/HVOF process is the ability to deposit low-cost coatings meeting existing HVOF specifications or to deposit extremely dense, hard and tough coatings exceeding typical industry requirements. The use of different power guns for different parts is an important part of this technology. An operator can change a gun in a matter of minutes to switch from spraying an internal diameter to an external surface and back again.

**Vitaly Geraskin** (v@kermetico.com) is the general manager of the equipment division at Kermetico Inc., Benicia, Calif.
A New Revision of AWS C2.16/C2.16M Is Coming Your Way

By Karen Sender, chair, AWS C2 Committee on Thermal Spraying

The AWS C2 Committee on Thermal Spraying is pleased to announce that a new edition of the AWS C2.16/C2.16M standard will soon be published and available for purchase.

This standard, previously titled Guide for Thermal-Spray Operator Qualification, will be retitled Guide for Thermal Spray Operator Qualification Programs, to reflect the very important changes that we believe much of our thermal spray community will welcome. Previous editions of the standard gave guidelines to actually qualify a thermal spray operator within some fairly rigid requirements. These requirements included specific testing standards for a variety of thermal spray processes and applications. The newly revised standard no longer adheres to these rigid requirements. Instead, the document has been refocused as a guide for a thermal spray shop or organization to create its own thermal spray operator qualification program.

The revised standard should better resonate with many of today’s modern thermal spray facilities. Whereas the older version of the standard required testing for a limited number of materials and processes, the new standard certainly widens the possibilities. For example, if your facility requires thermal spray operators to be qualified for specific coatings that the facility applies, the new standard gives program guidelines so you can do exactly that — qualify your operators for the work product of your facility. In addition, the new version of the standard has removed much of the redundant information found in previous versions. It is now easier to follow and correctly interpret.

In the past, it was correct to say that a thermal spray operator was qualified in accordance with the requirements of AWS C2.16/C2.16M. This is no longer a valid statement. Instead, one can say that the thermal spray operator is qualified in accordance with a qualification program developed in accordance with the requirements of AWS C2.16/C2.16M. This is an important distinction. Therefore, if you currently qualify your operators to older versions of the standard, the new standard requires that you create a qualification program and qualify operators to that program. It is no longer correct to say that operators are qualified in accordance with AWS C2.16/C2.16M.

Look for the new version of the AWS C2.16/C2.16M standard within the next couple of months on the AWS website. The C2 Committee on Thermal Spraying is always interested in your feedback. Should you purchase the new standard, and we hope that you do, let us know what you think.

AWS Welding Handbook — Your chance to contribute!

AWS is reviewing its thermal spray and cold spray information in the AWS Welding Handbook. We have already received quite a number of volunteers from the C2 Committee to work on these chapters. However, ITSA members should also have a say as to our content in this prestigious publication. If you are aware of changes you would like to see to these chapters in the Welding Handbook, please forward them to C2 Committee Secretary Jennifer Rosario, jrosario@aws.org, or email me directly at karen.sender@oerlikon.com.
Determining the Thickness of Thermal Spray Aluminum Coatings on Stainless Steel

Ensuring the long-term protection of parts exposed to the extremely harsh conditions found in offshore environments requires specialized anti-corrosion coatings. For example, thermal spray aluminum (TSA) — used to protect stainless steel against corrosion even at high temperatures — can withstand marine influences for decades. However, to achieve such longevity, the TSA must have a certain coating thickness, making quality inspections mandatory. The thickness of thermal spray aluminum (TSA) coatings on stainless steel and steel constructions can be measured easily and effectively using Fischer’s PHASCOPE® PMP10 with the ESD20-TSA probe. Visit protective-coating-inspection.com.

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Calendar

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■ ITSC 2017 International Thermal Spray Conference and Exposition
  June 7–9 / Düsseldorf, Germany
dvs-ev.de/itsc2017/

■ Additive Manufacturing with Powder Metallurgy Conference
  June 13–15 / Las Vegas, NV
mpif.org

■ Powdernet 2017
  June 13–16 / Las Vegas, NV
mpif.org

AUGUST 2017

■ NACE Egypt Corrosion Conference
  August 2, 3 / Cairo, Egypt
egyptcorrosion.nace.org

SEPTEMBER 2017

■ Eurocorr 2017 and 20th International Corrosion Congress
  September 3–7 / Czech Republic
eurocorr2017.org

■ International Porous Powder Materials Symposium & Exhibition
  September 12–15 / Izmir-Kusadasi, Turkey
ppm2017.org

■ Thermal Spray of Suspensions & Solutions Symposium
  September 13, 14 / Niskayuna, N.Y.
asminational.org

■ Power-Gen Asia
  September 19–21 / Bangkok, Thailand
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OCTOBER 2017

■ Powder Coating (PC) Summit
  October 3, 4 / Columbus, Ohio
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■ ITSA Annual Meeting and Technical Program
  October 11–13 / Albuquerque, N.M.
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