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Kermetico High Velocity Air-Fuel Thermal Spray

March 2017

Superior hard & tough coatings for new markets

- Gas-tight
- WC-based 1350-1600+ HV_{300}
- Cr_3C_2-based 1050-1100 HV_{300}, service up to 900^oC
- MoB-based 1200 HV_{300}, service up to 1100^oC
- Thin coatings (40-70 micron) for:

  High and alternating stress, impact, etc.

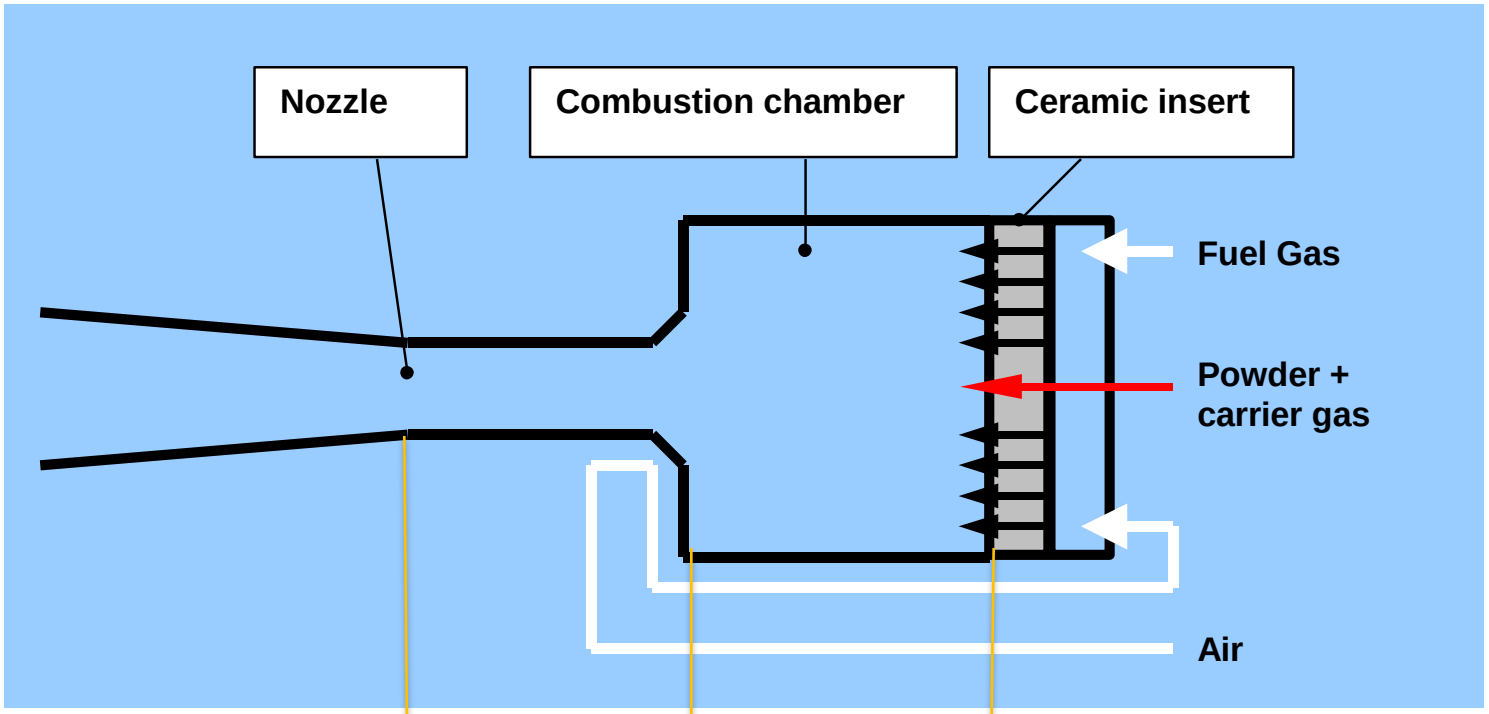
  Economy grades for “flash chrome” replacement

HVAF Application Development

2. Economical “currently specified quality” coatings for existing and new markets

1200 HV_{300} /<0.8% porosity WC-coatings,
sprayed at 65-70% DE with
spray rates 33+ kg/hour (73 lbs./hr.)

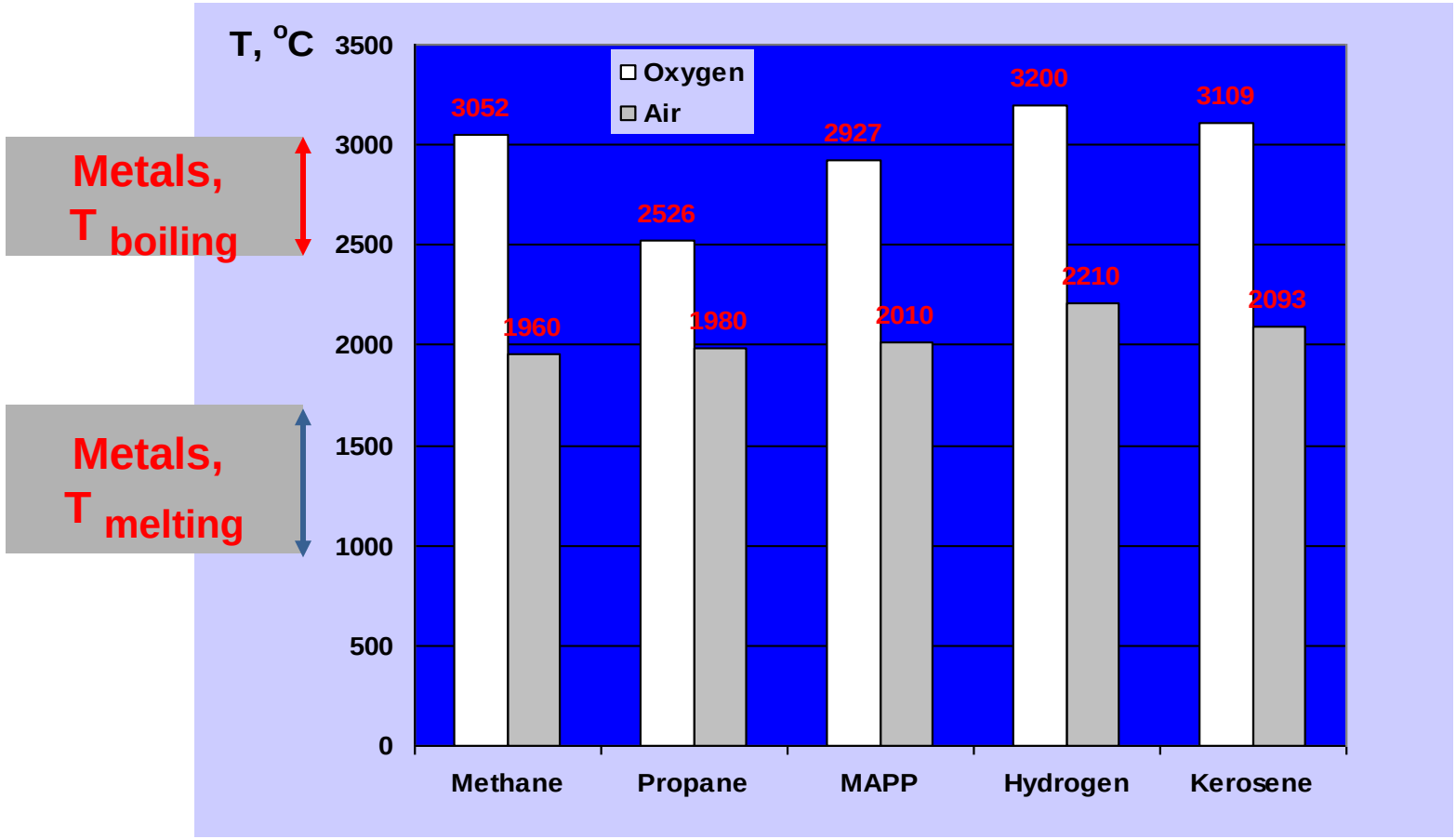
Kermetico HVAF Gun Design



1100-1500 m/s	850 m/s	40-50 m/s	Gas velocity
<1500°C	~1600°C	1900°C	Gas temperature
Acceleration		Heating	Spray particle

Combustion Temperature: HVAF vs. HVOF

Adiabatic combustion temperature of fuels in oxygen and air (α=1, 20°C, 1 Bar)



Lower Gas Temperature in HVAF

HVOF:

Combustion temperature is higher by more than 1000°C than melting temperature of metals;

Combustion temperature may exceed metal boiling temperature.

HVAF:

Combustion temperature only slightly higher than metal melting temperature.

Lower Gas Temperature in HVAF

- **Affects Coating Properties**

Prevention of oxidation of metals and oxidation/ thermal deterioration of carbides

Note: oxygen activity is 5-times lower in HVAF

- **Influences Gun Design**

HVAF ability to use heating in long/ slow-gas combustion chambers = long time for "soft" heating

High pressure in the chamber = better heat transfer

Combustion Temperature: AF vs OF Design

Ability to use heating in long/ slow-gas combustion chambers =>

long time for “soft” heating

High pressure in the chamber =>

better heat transfer

Result:

High energy efficiency of HVAF

(same or lower power while higher spray rates than HVOF)

Energy Efficiency = COST

State-of-the-art HVOF:

JP 5000	**270 kW**	**spray rate 5 kg/hour**
DJ 2600	**115 kW**	**spray rate 4 kg/hour**

Kermetico HVAF:

AK6	**130 kW**	**spray rate 28 kg/ hour**
AK5	**80 kW**	**spray rate 15 kg/hour**
AK-ID	**30 kW**	**spray rate 5 kg/hour**

Acceleration of spray particles in the nozzle:

- **Gas velocity & density**
- **Time (nozzle length)**
- **Particle size**

Smaller particles are accelerated to higher velocities.

HVAF uses smaller particle size without material oxidation/ thermal deterioration

Note on nozzle wall influence on particle velocity:

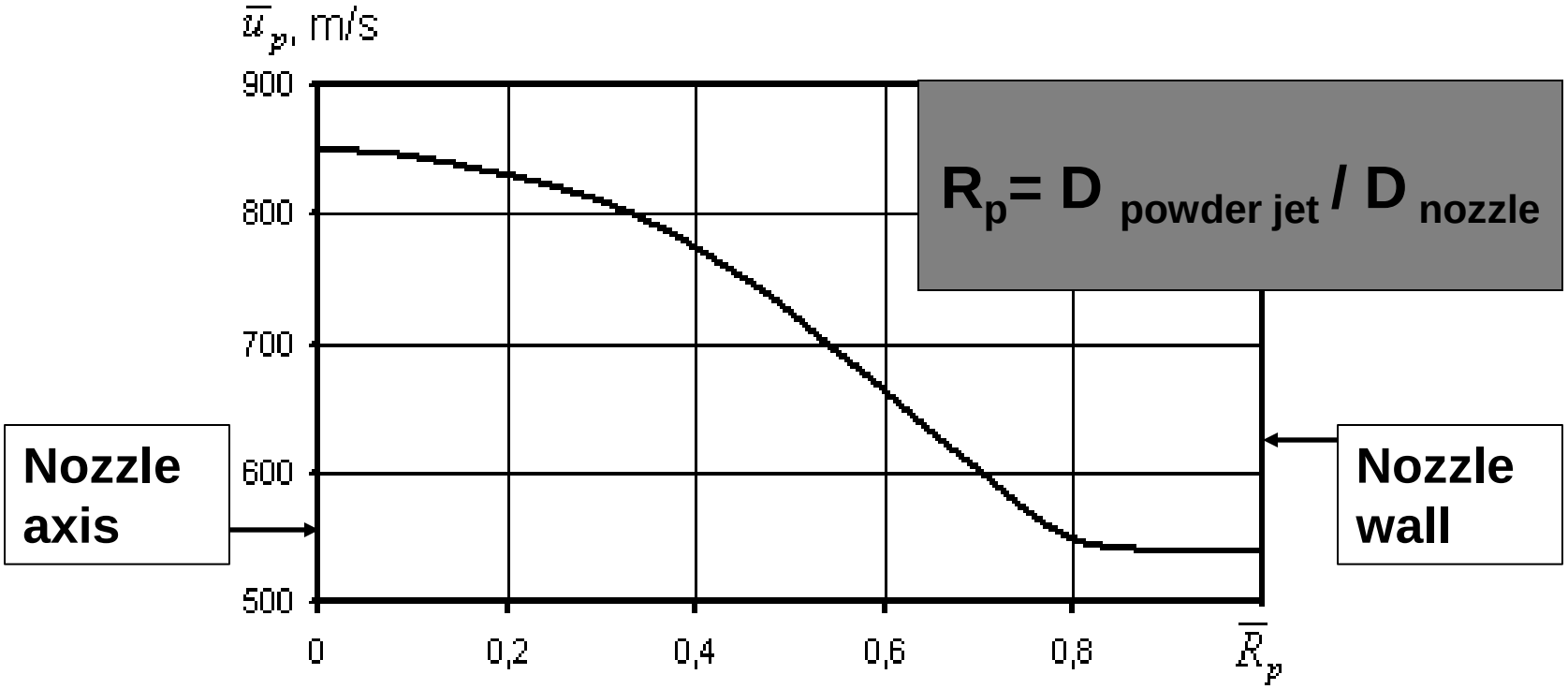
HVOF – dramatic

(more so – in radial injection)

HVAF – no influence

Particles Acceleration: Influence of the Nozzle Walls

HVOF (kerosene) per A. Voronetsky et. all, ITSC2004



Influence of R_p on the mean particles velocity at L_S=250 mm. (p_{cc} =0.9 MPa, d_p=30 μm, L_b=100 mm)

Particle Acceleration in the Nozzle

Kermetico HVAF:

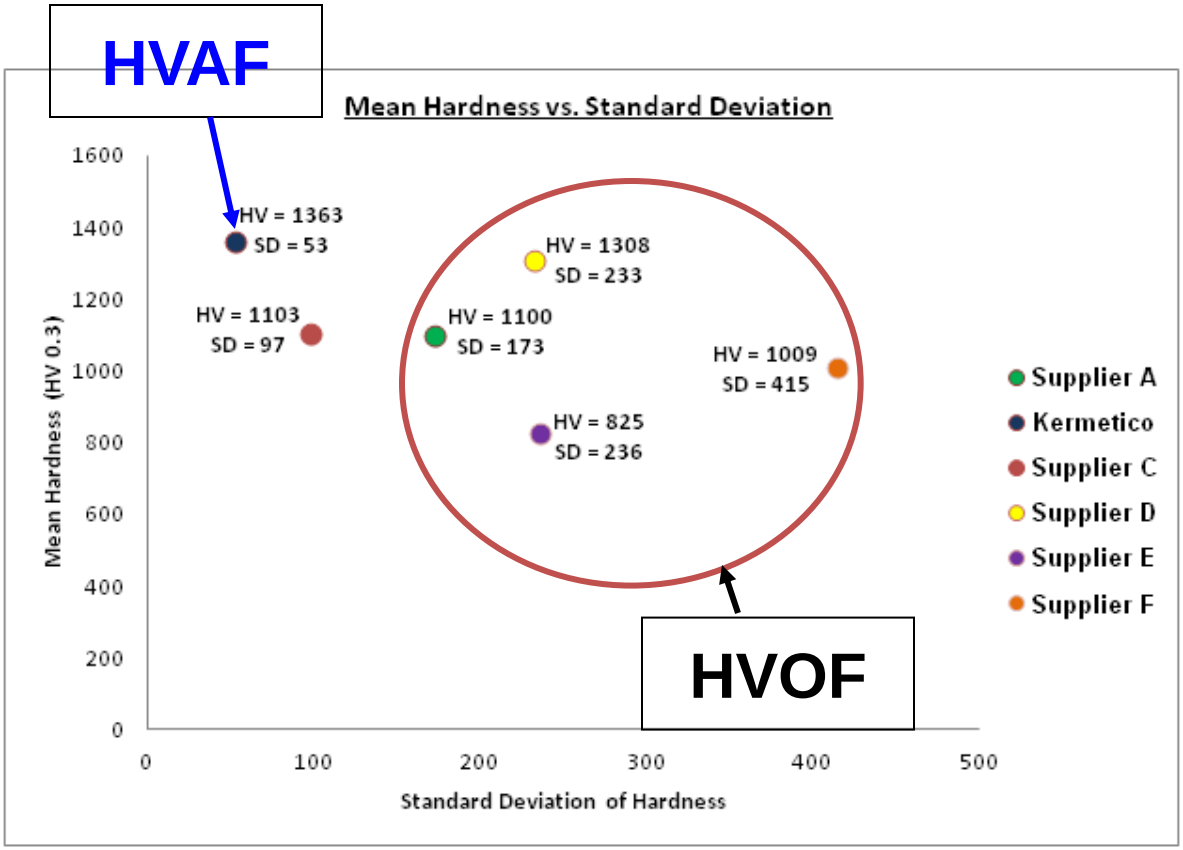
$$D_{powder\ jet} / D_{nozzle} = 0.1\text{-}0.2$$

I. **There is practically no restriction on the nozzle length to reach necessary acceleration of spray particles**

II. **Uniform acceleration = uniform coating structure and properties**

Uniformity of HVAF Coating Properties:

Hardness of HVOF and Kermetico HVAF WC-10Co-4Cr coatings (Schlumberger, UK)



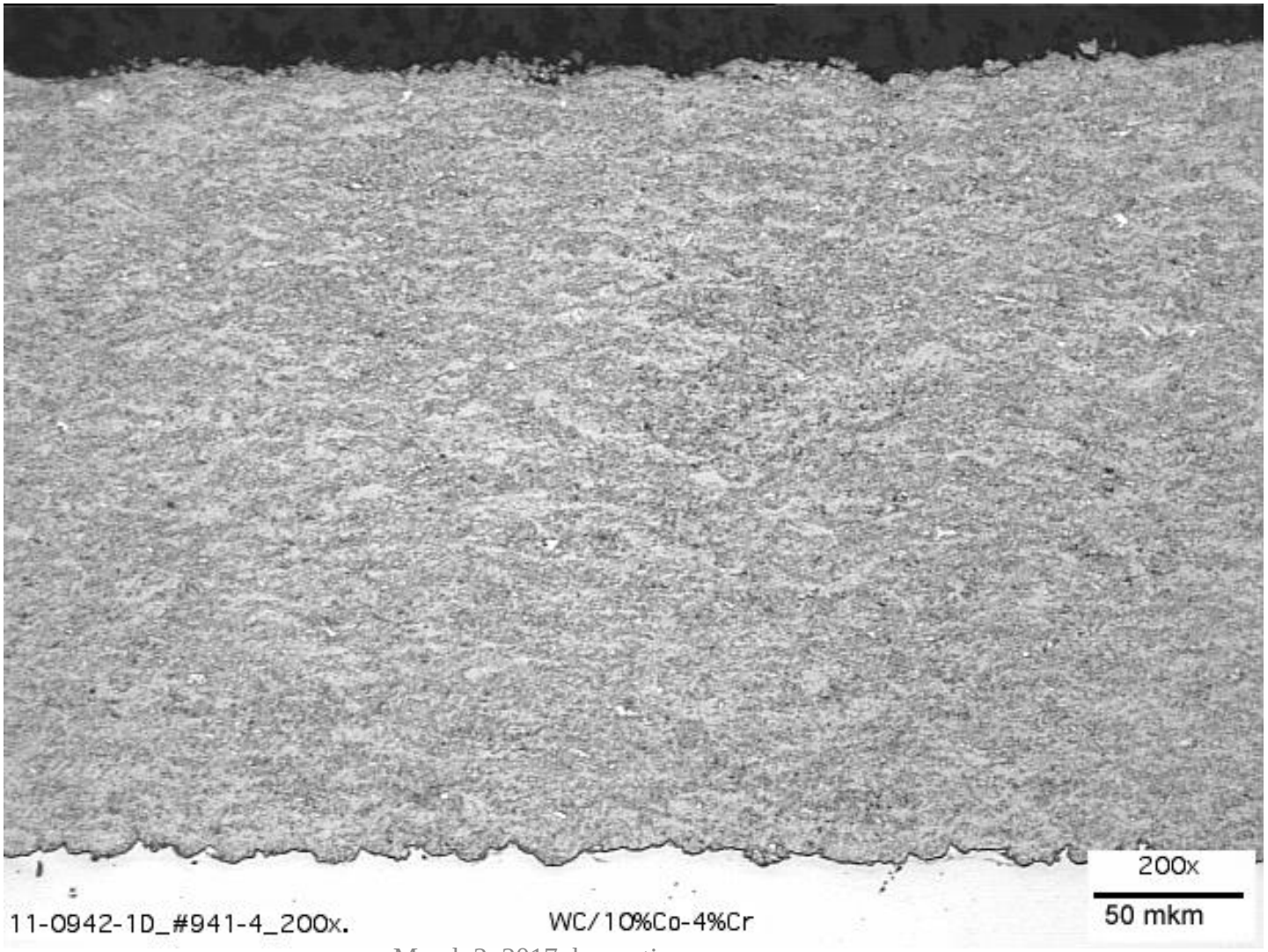
Relative standard deviation, %

HVAF: 3.9 %

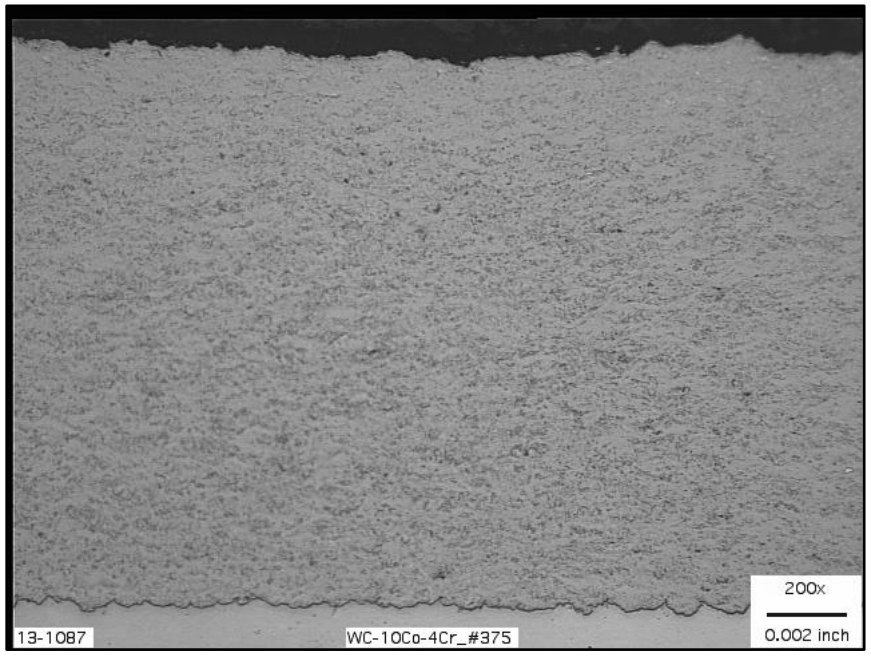
HVOF: 15.7-17.8%

WC-10Co-4Cr Coating Characterization

Propane
1470 HV_{300}



WC-10Co-4Cr Coating Characterization

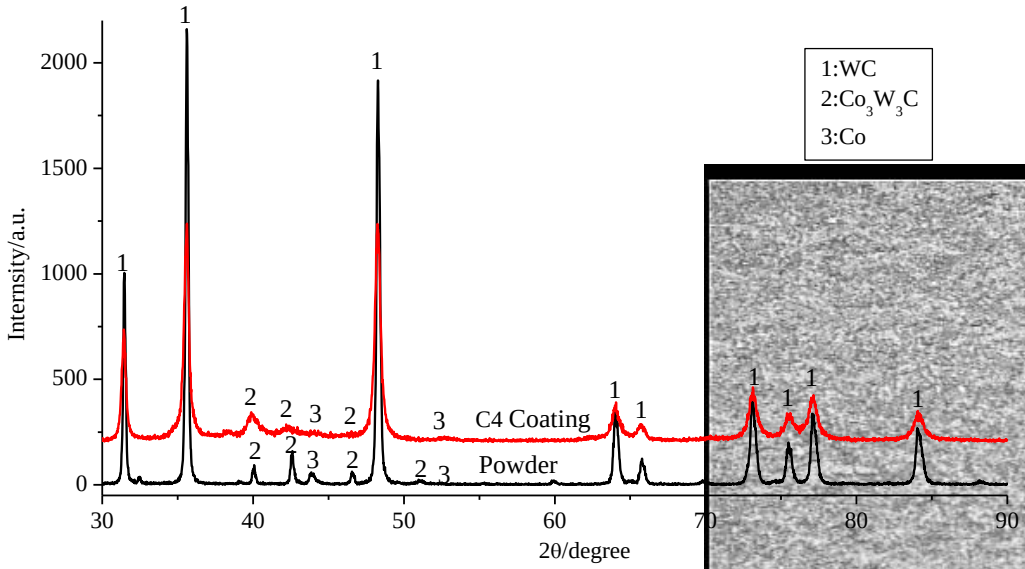


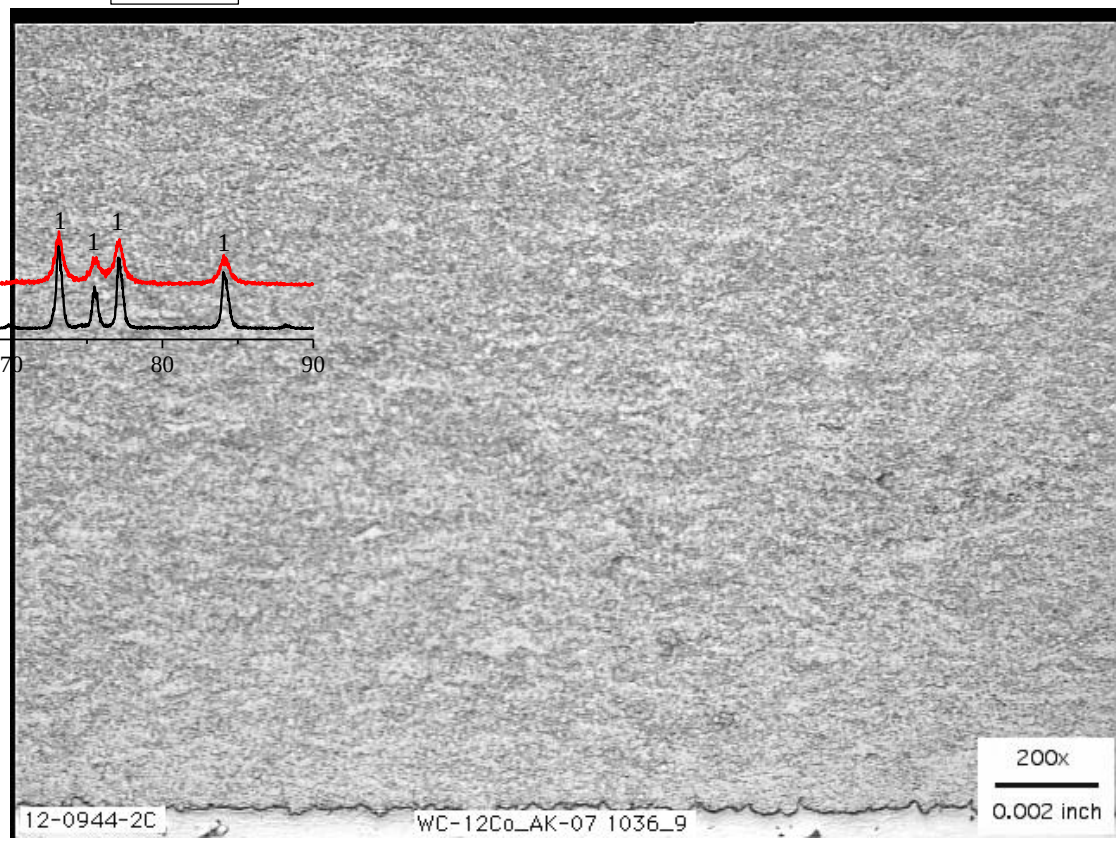
Propane- 60% Butane
1,500 HV300

Propylene
1,650 HV300

Kermetico HVAF:

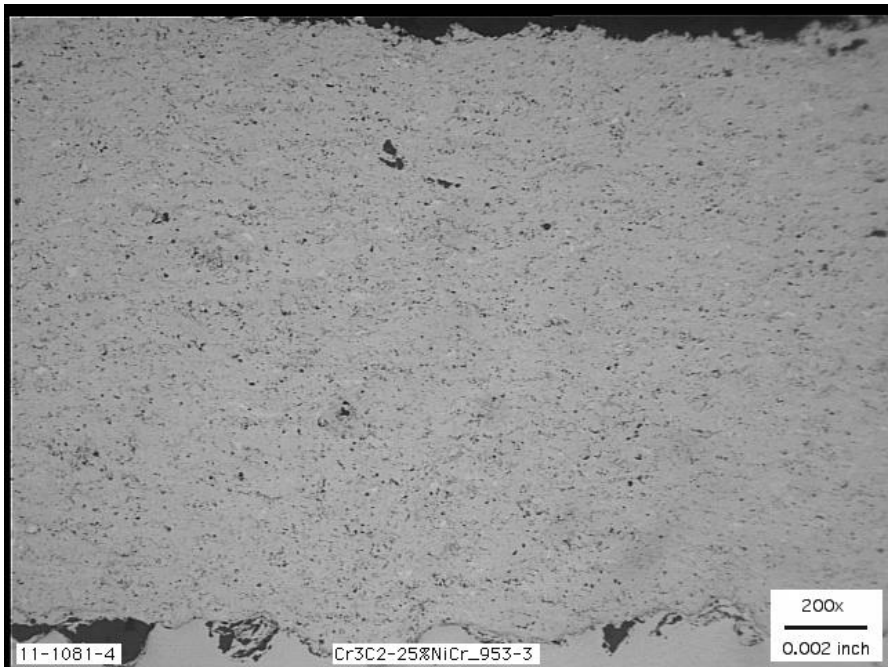
Carbides are hard, but… ductile

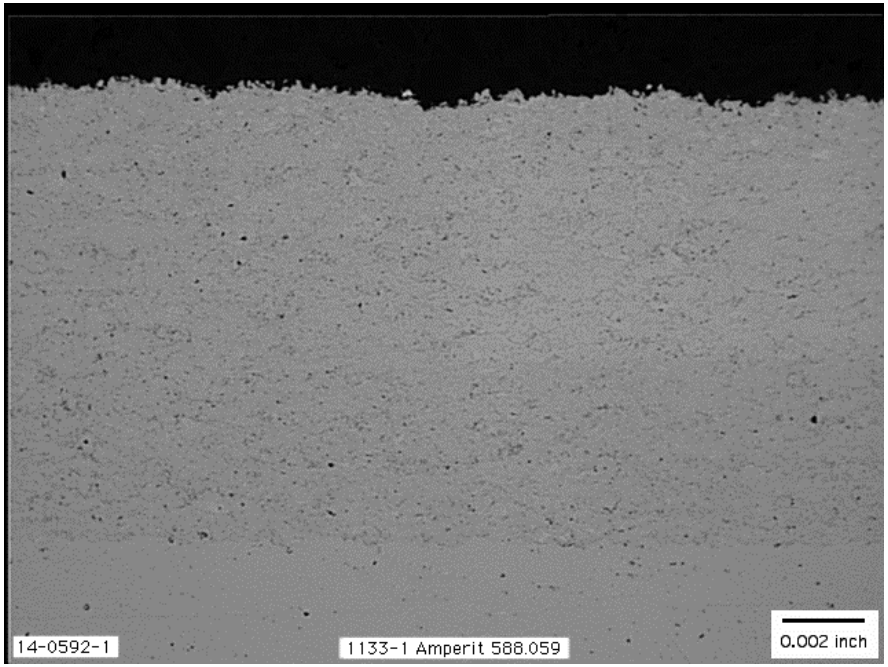




WC-12Co
Propane
1,540 HV300

Cr_3C_2-25NiCr Coating Characterization





AK7, Propane
WOKA 7210 (25/5 μm)
1082 HV300

AK6, Propane
Amperit 588.059 (30/5 μm)
1068 HV300

Data of Central Power Research Institute Bangalore, India

Comparison of WC-10Co-4Cr coatings, deposited with HVOF (JP5000) and Kermetico HVAF (AK06)

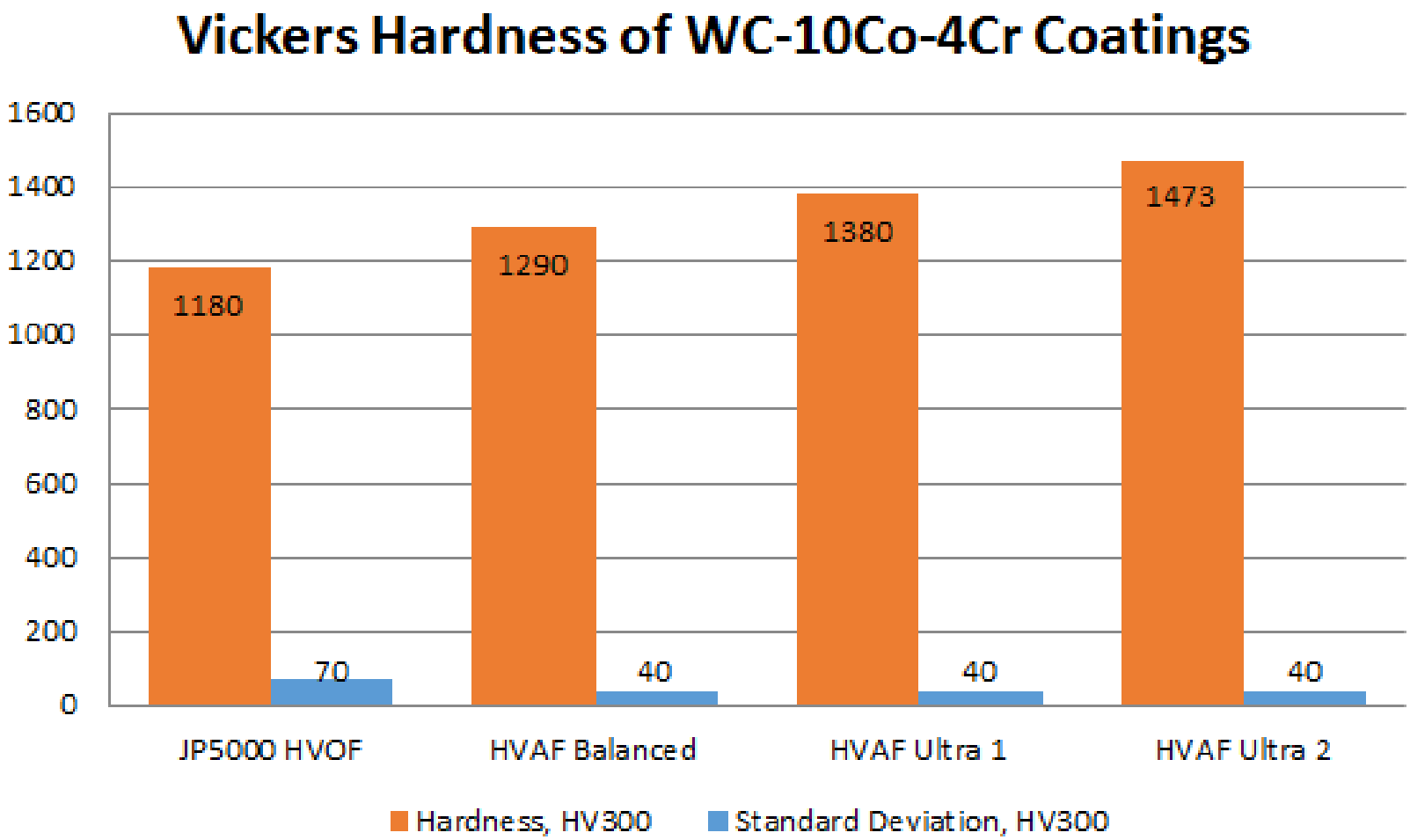
Notes:
HVOF optimized for the best cavitation resistance

HVAF applied in different modes, targeting different particle velocity (coating hardness)

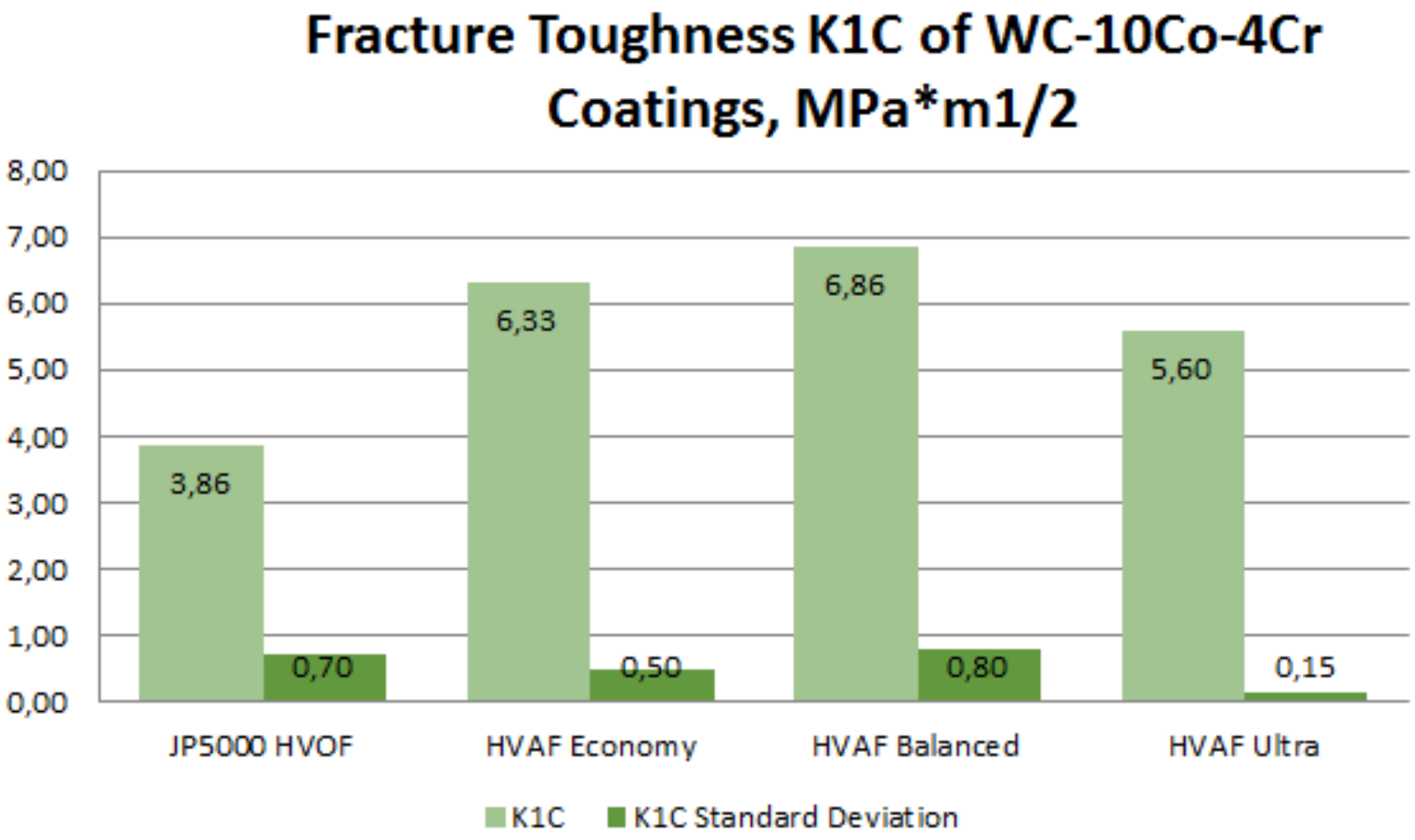
Spray Parameters: Normalized

	JP5000 HVOF	Kermetico AK6 HVAF		
		Balanced	Ultra 1	Ultra 2
Oxidizer flow, SLPM	O2: 873.1	Air: 2,104 (O2: 421.0)		
Fuel, g/sec	5.01	2.65		
O_2/Fuel Ratio vs. Stoichiometric	1.16 (Oxidizing)	1.03 (~Neutral)		
Carrier Nitrogen, SLPM	10.85	21		
Combustion pressure, Bar	7.56	5.25		
Powder feed rate, g/sec	1.50	2.22		
Particle average size, micron	27	18		
Particle velocity, m/s	740	895 +/-2	960 +/-3	1010+/-4
Particle temperature, ^{o}C	1790-1840	1470 +/-10	1460 +/-10	1470 +/-10
Particle kinetic energy, μJ	29.4	12.7	14.7	16.2
Energy density, GJ/m^3 = = Contact pressure, GPa	**3.8**	**5.6**	**6.4**	**7.1**

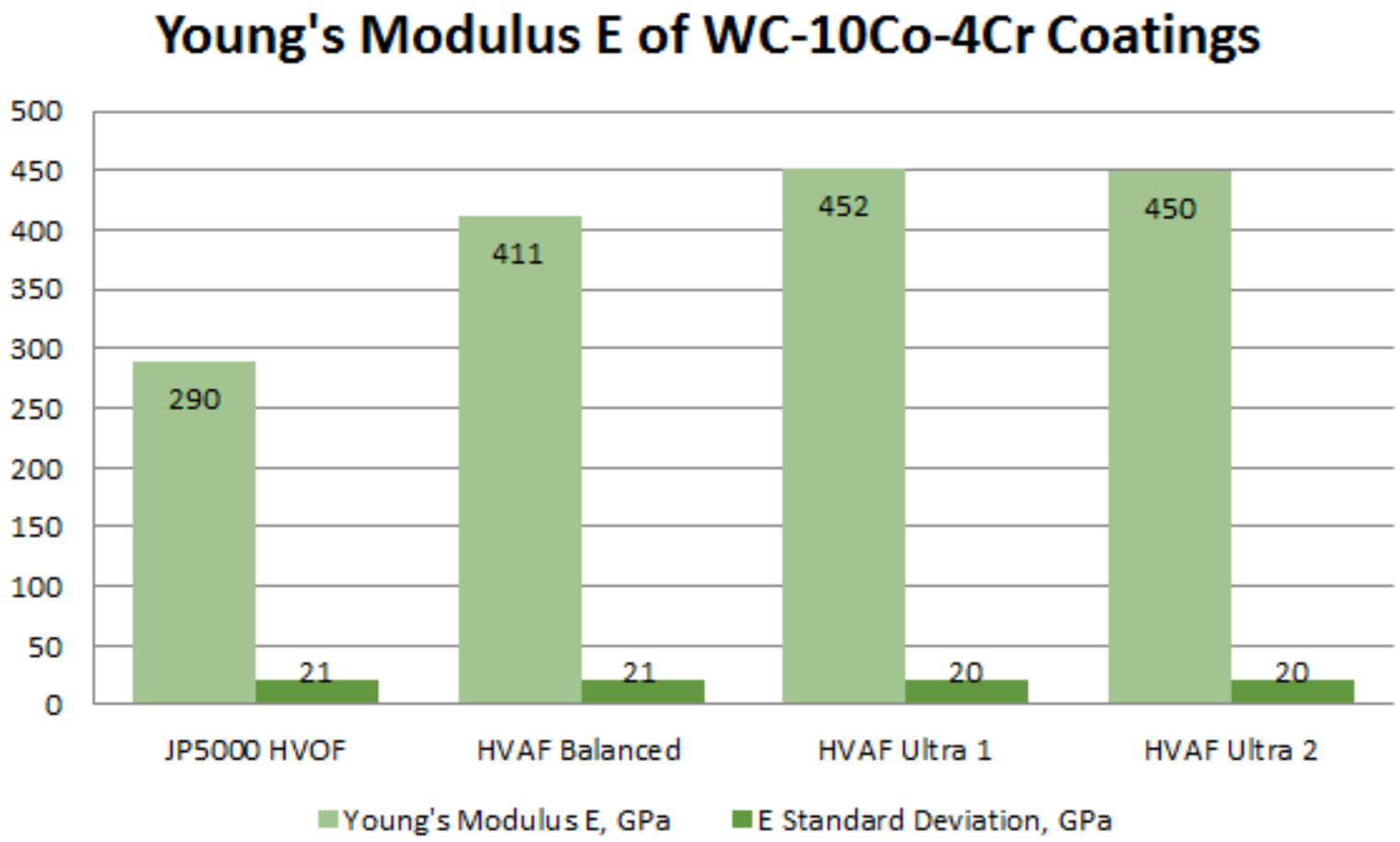
Mechanical Properties 1/3



Mechanical Properties 2/3



Mechanical Properties 3/3



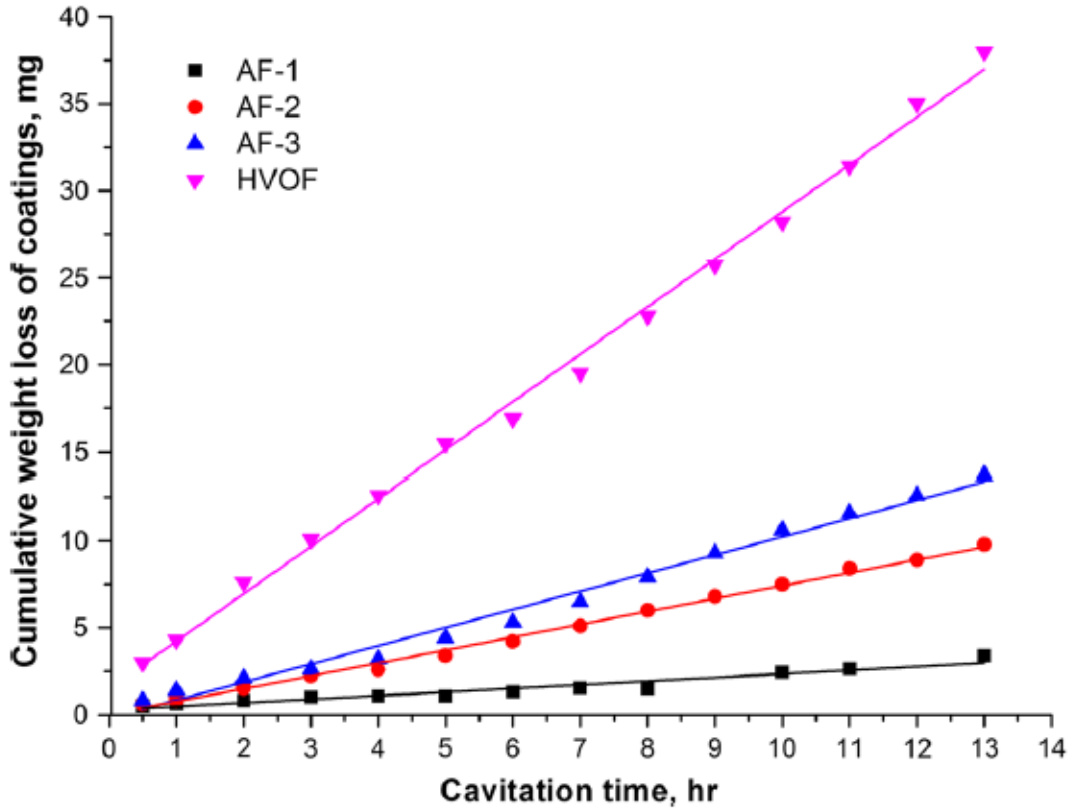
Cavitation Resistance

of WC-10Co-4Cr HVOF and HVAF coatings

(dw/dt) AF1 (U2) = 0.23 mg/h
(dw/dt) AF3 (U1) = 0.71 mg/h
(dw/dt) AF2 (B) = 0.96 mg/h

(dw/dt) HVOF = > 3.26 mg/h

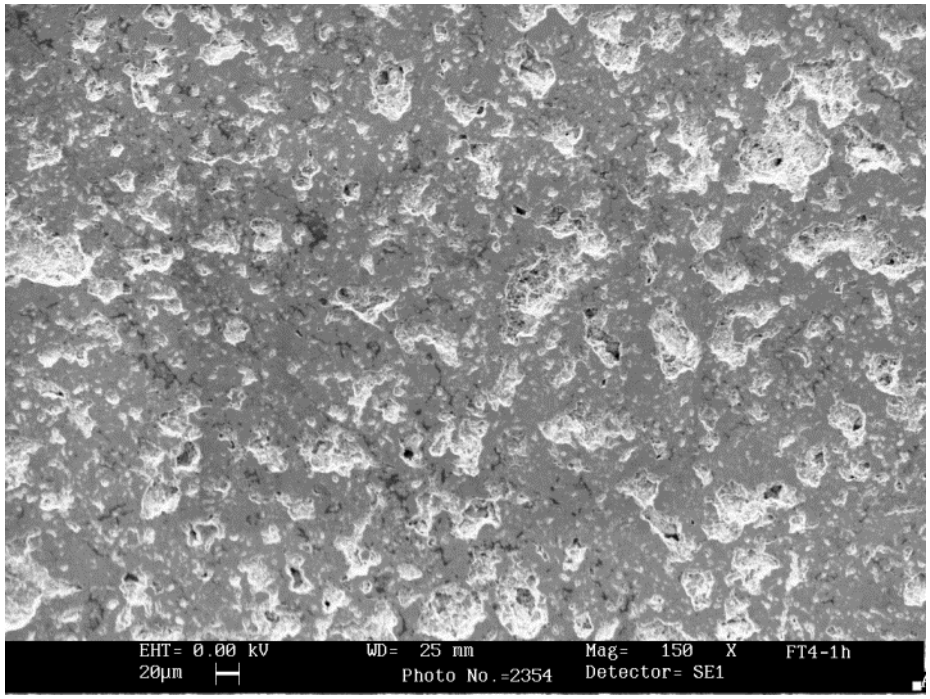
(dw/dt) 16Cr-5Ni steel = 2.0 - 2.5 mg/h



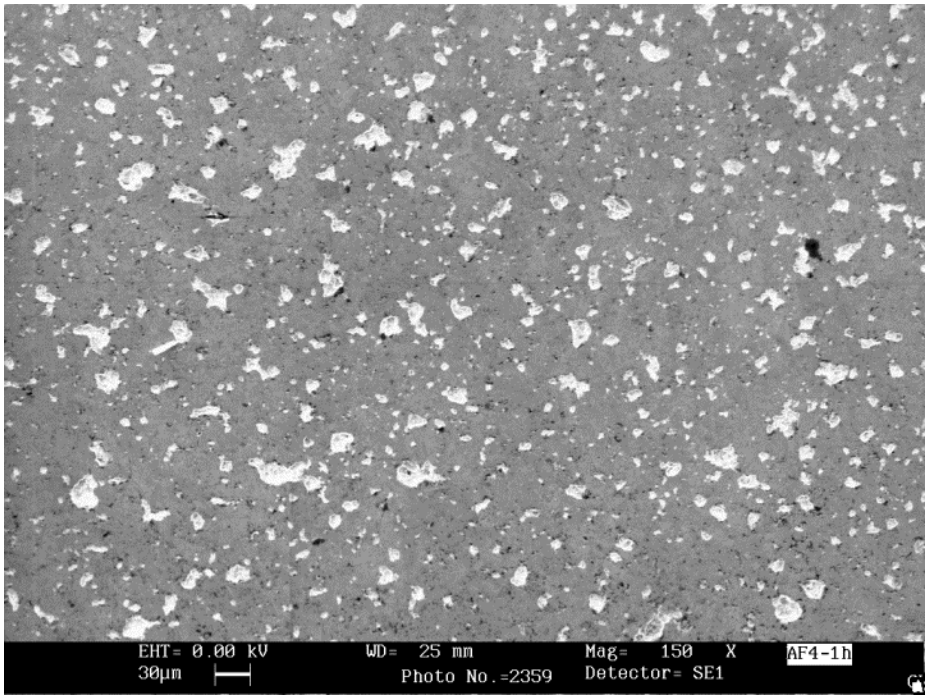
Surface SEM Micrographs of WC-10Co-4Cr Coatings after Cavitation Testing

Test duration: 1 hour

JP5000 HVOF



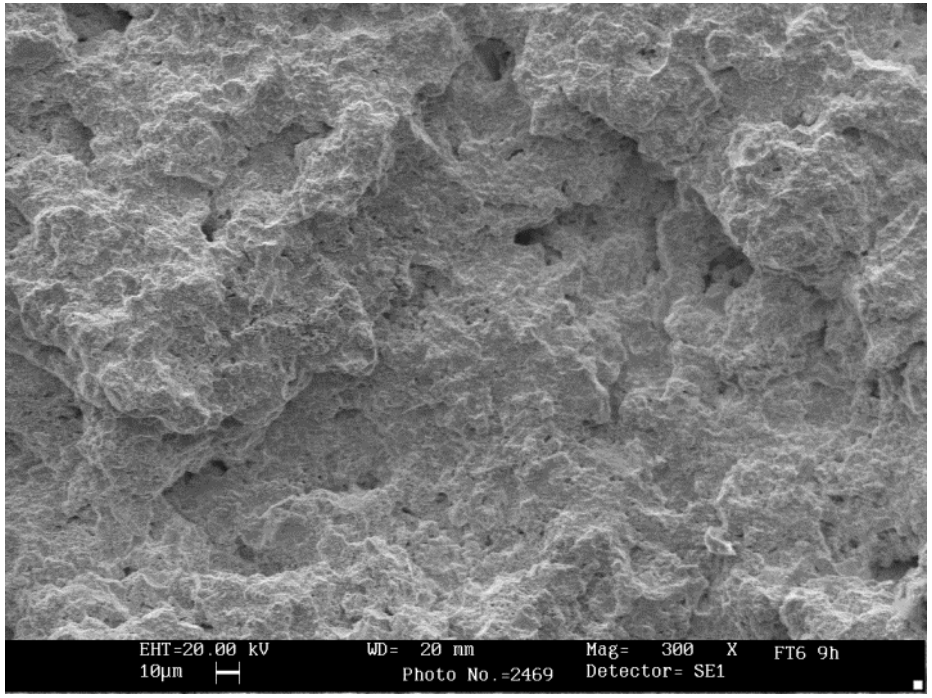
AK6 HVAF



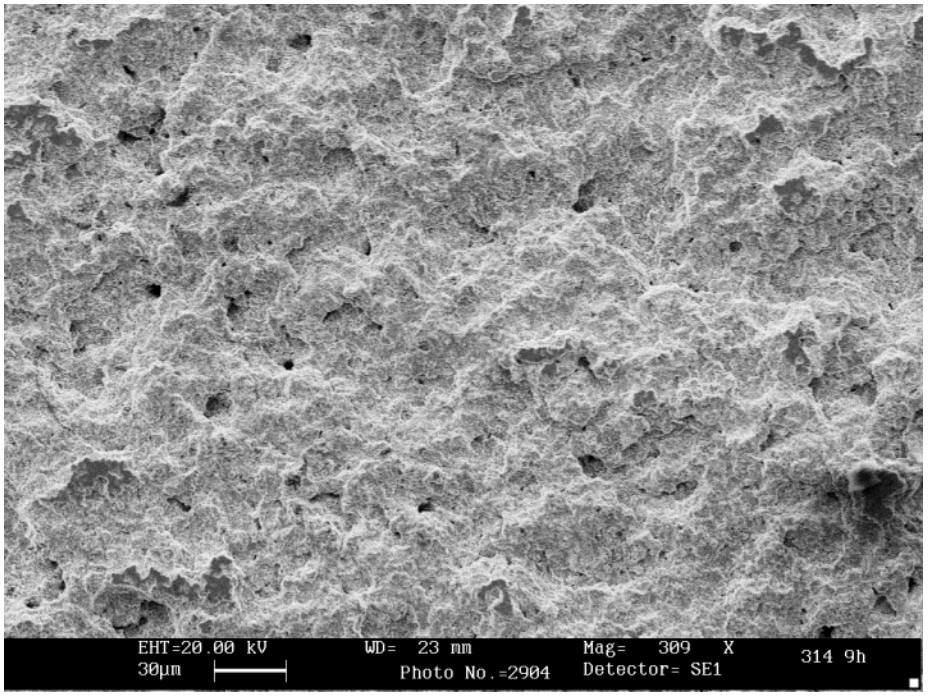
Surface SEM Micrographs of WC-10Co-4Cr Coatings after Cavitation Testing

Test duration: 9 hours

JP5000 HVOF

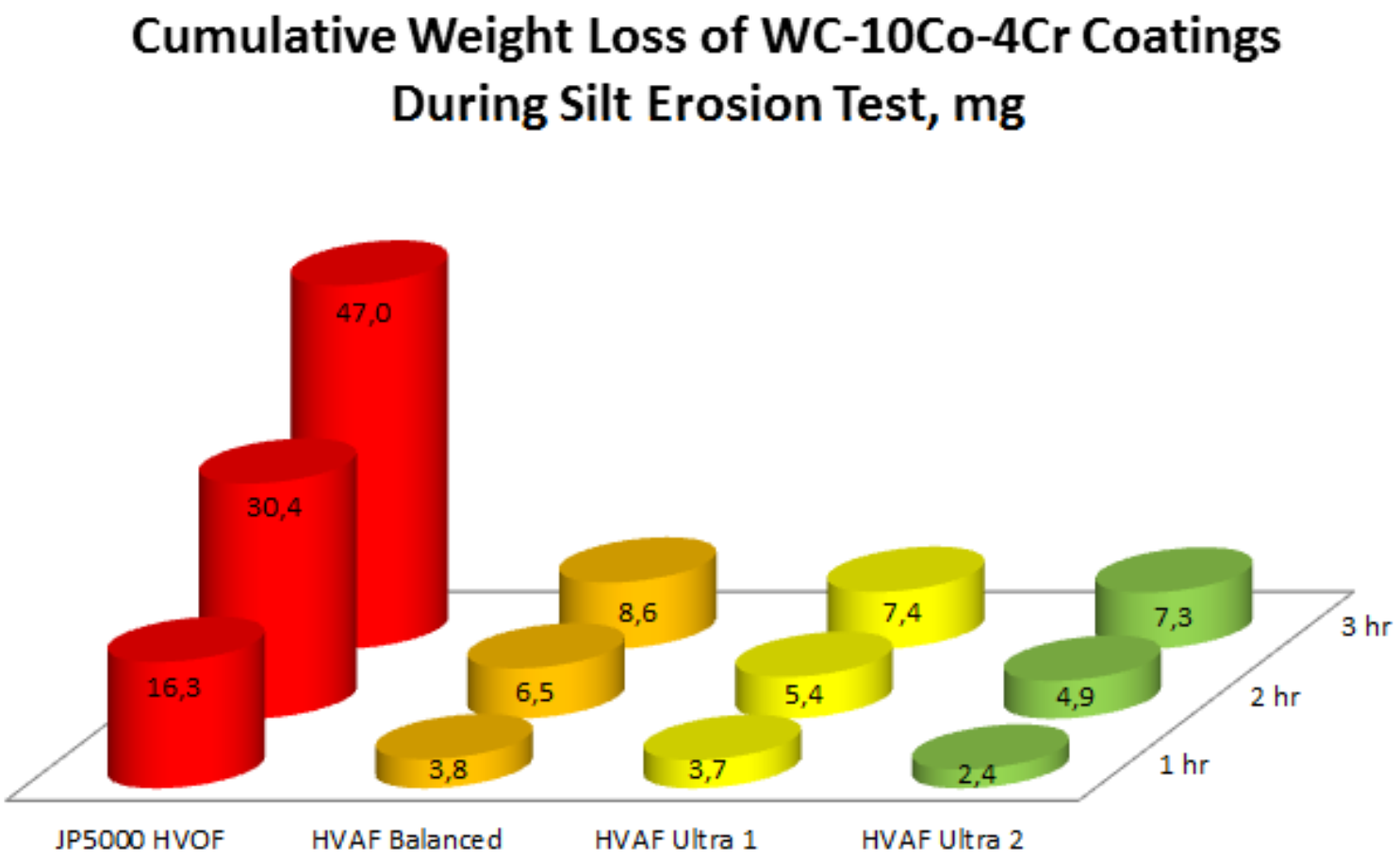


AK6 HVAF



Resistance to Silt Erosion

WC-10Co-4Cr HVOF and HVAF Coatings



Other Third-Party Data, Comparing Kermetico HVAF WC-10Co-4Cr Coatings to the Best HVOF and Detonation Systems

Test Results

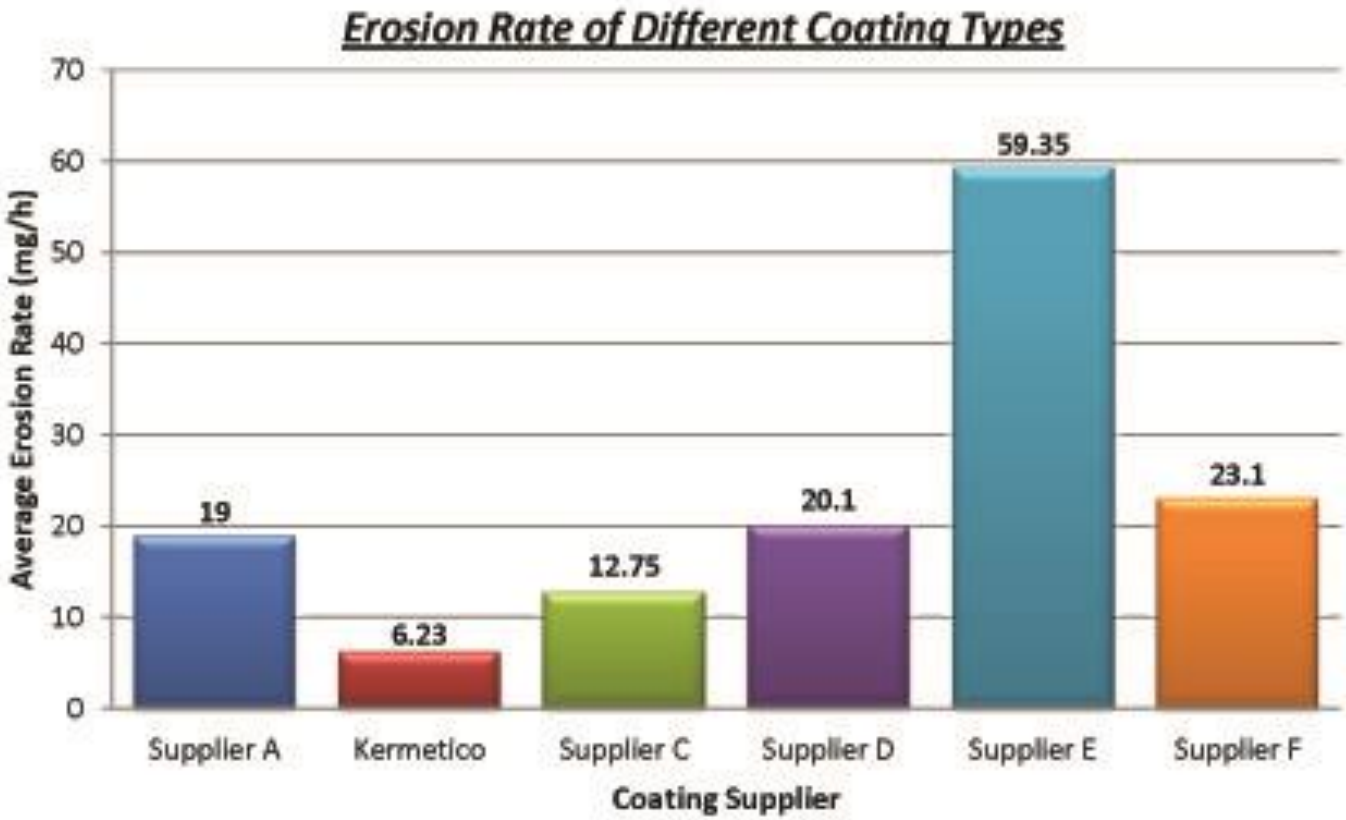
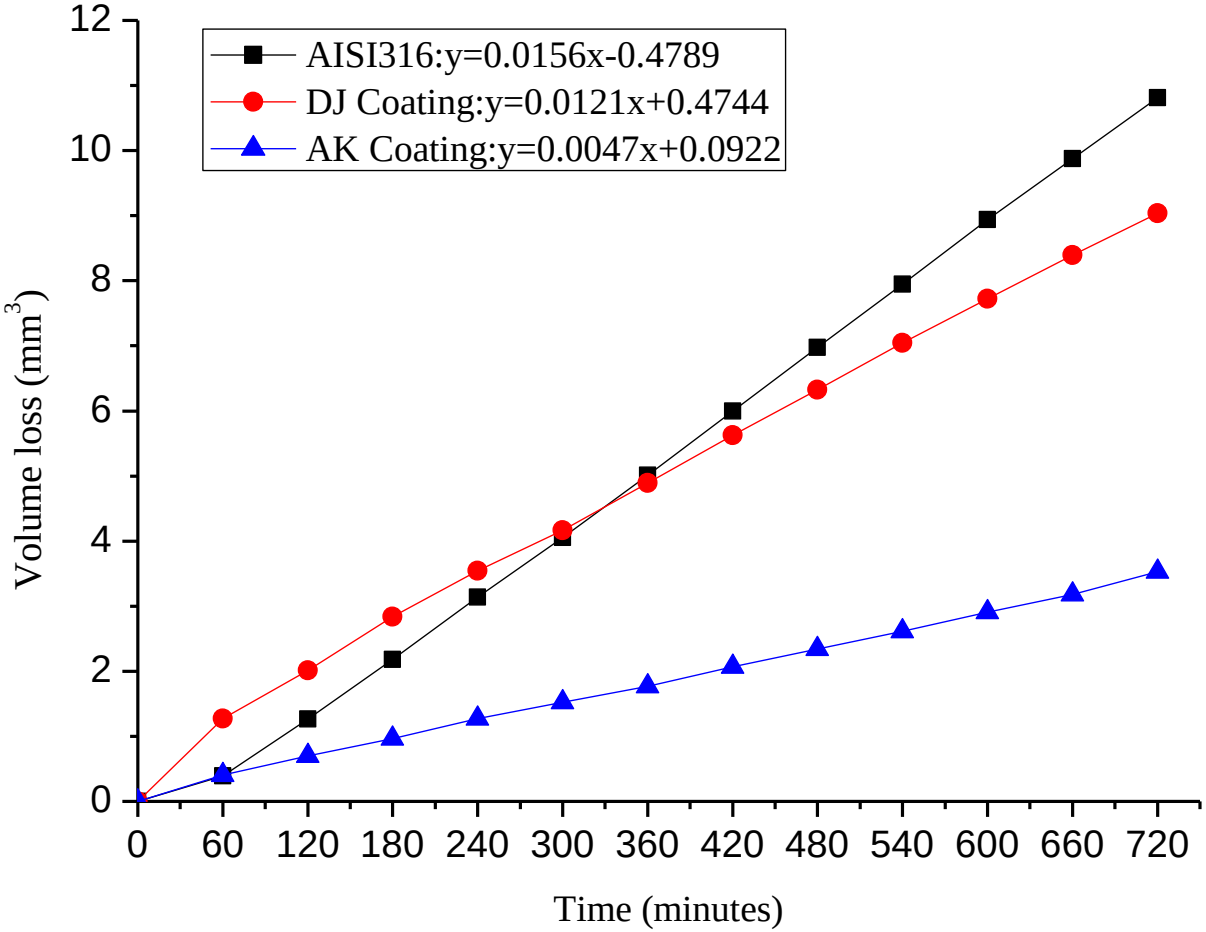


FIGURE 5 - EROSION RATE OF DIFFERENT SUPPLIER COATINGS

Hunan University
Changsha, Hunan, China:
WC-10Co-4Cr HVOF & HVAF coatings. Cavitation test



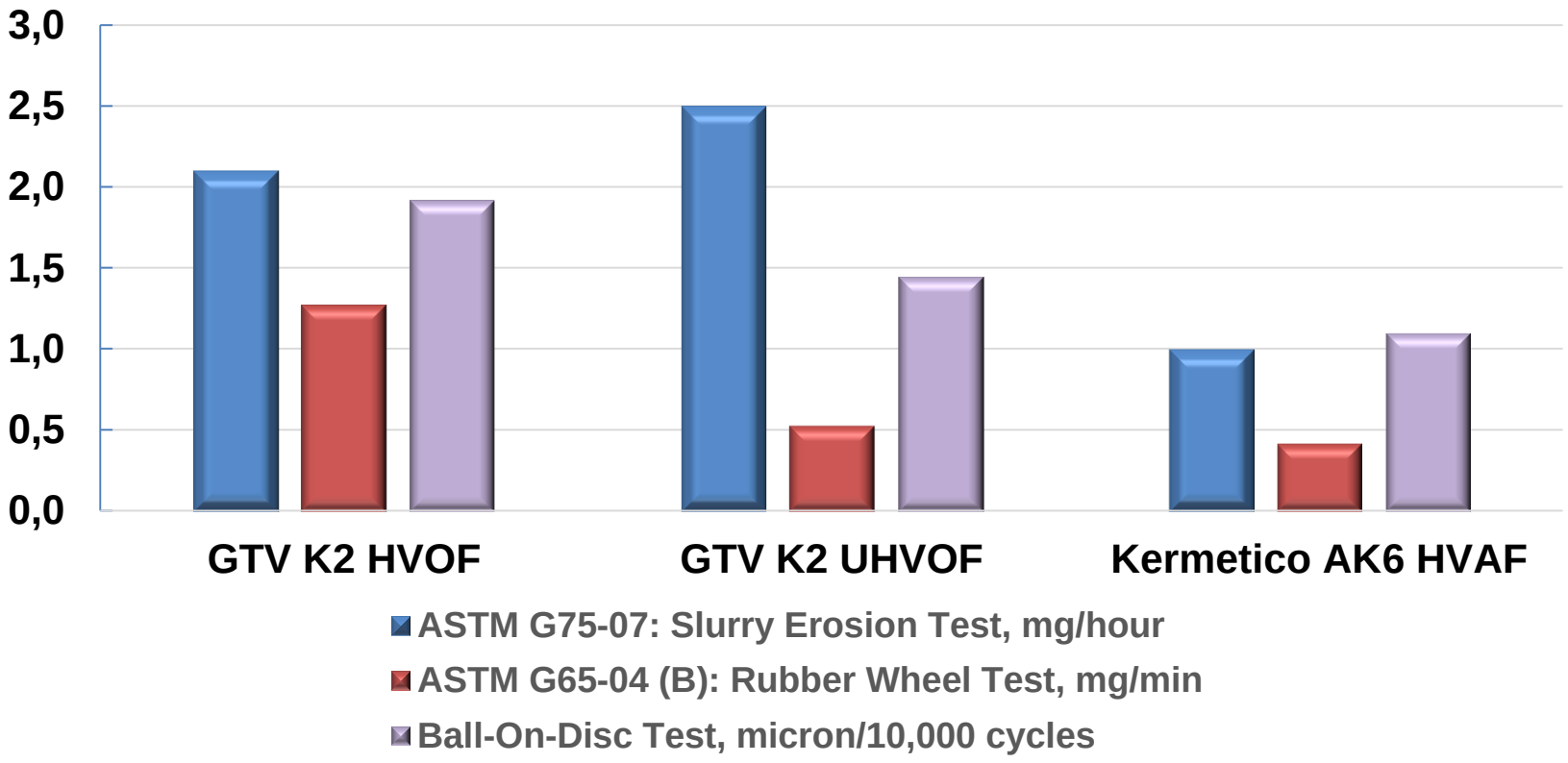
InnoMat GmbH

KERMETICO

Gesellschaft für innovative Materialtechnik
InnoMat GmbH
Annaberger Str. 240, 09125 Chemnitz

Stellba AG
Wohlerstrasse 51
CH - 5605 Dottikon

InnoMat GmbH Report on WCCoCr coatings for Stellba AG (2016)

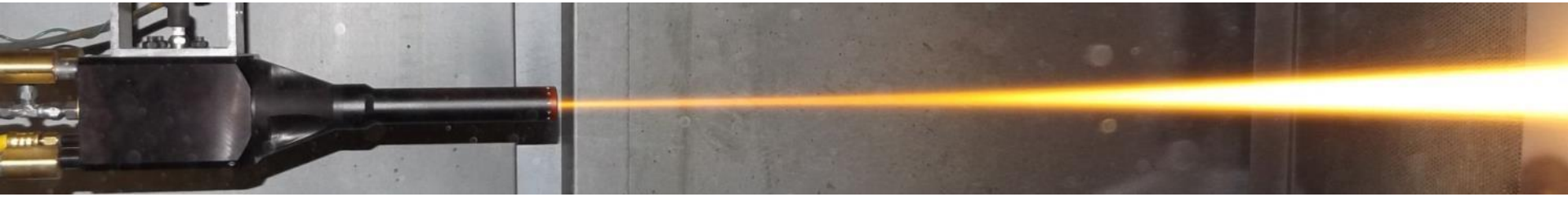


Slat Spray: All WCCoCr Samples Passed 312-Hour Test

	K2 HVOF	K2 UHVOF	AK6 HVAF
Before testing			
After 312-hours testing			

Note: HVAF samples were tested after Pin-On-Disc Wear Test

Economic Aspects of Kermetico HVAF Spraying:
Your Choice of Cost and Quality



HVAF-E (Economy) – meets HVOF specs

HVAF-B (Balanced) – exceeds HVOF specs

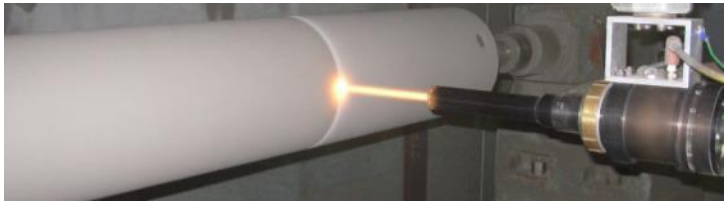
HVAF-U (Ultra) – substantially exceeds HVOF specs

Economic Aspects of Kermetico HVAF

Gun Setup	Coating Hardness , HV_{300}	Coating Porosity, %	Deposition Efficiency, %
Economy (E)	1050-1250	<0.8	65+
Balanced (B)	1250-1350	<0.5	48 - 58
Ultra (U)	1350-1600+	<0.3	36 - 42

High spray rates are applicable for large and small parts

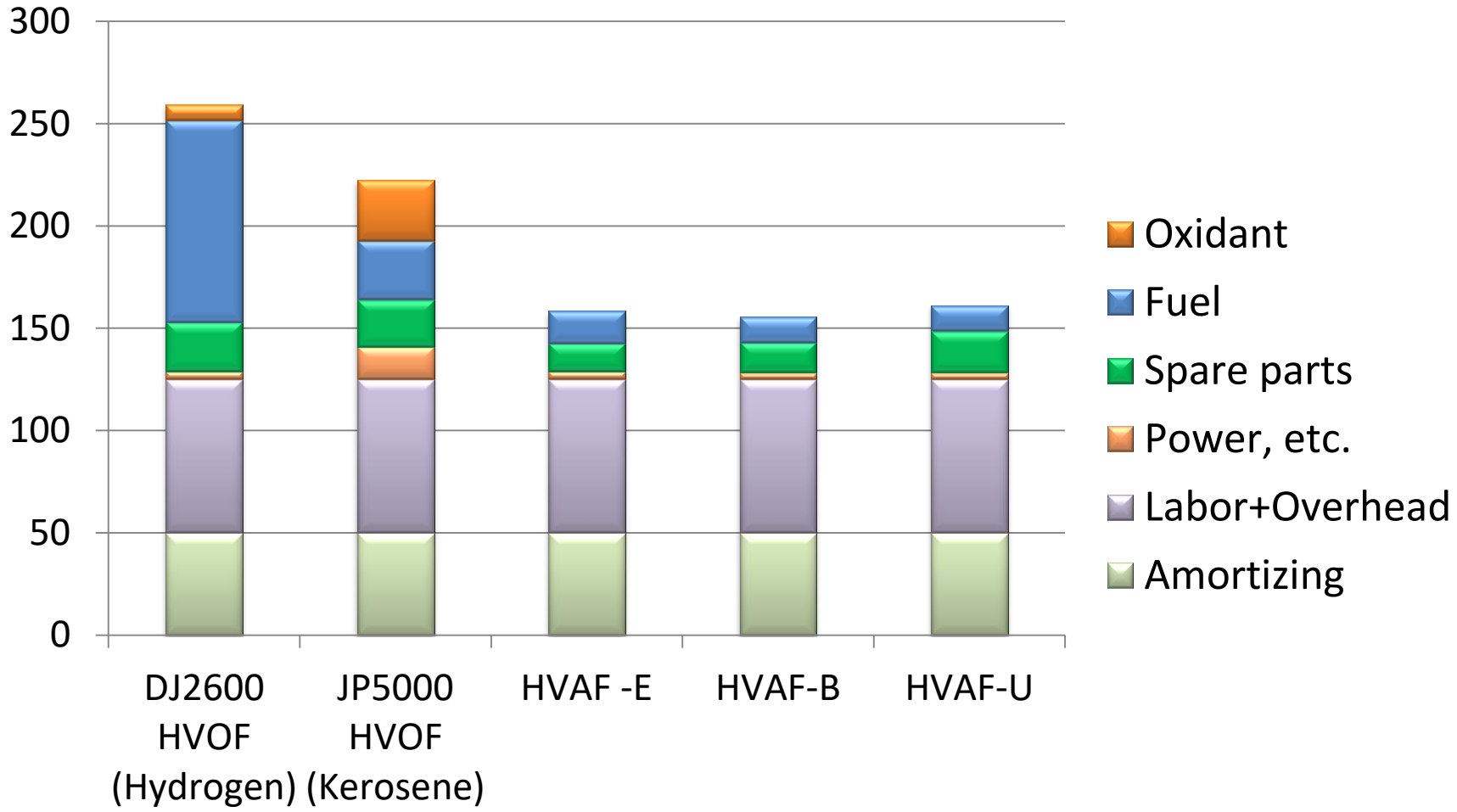
O.D. 38 mm: Rate 25 kg/hour



O.D. 330 mm: Rate 32 kg/hour

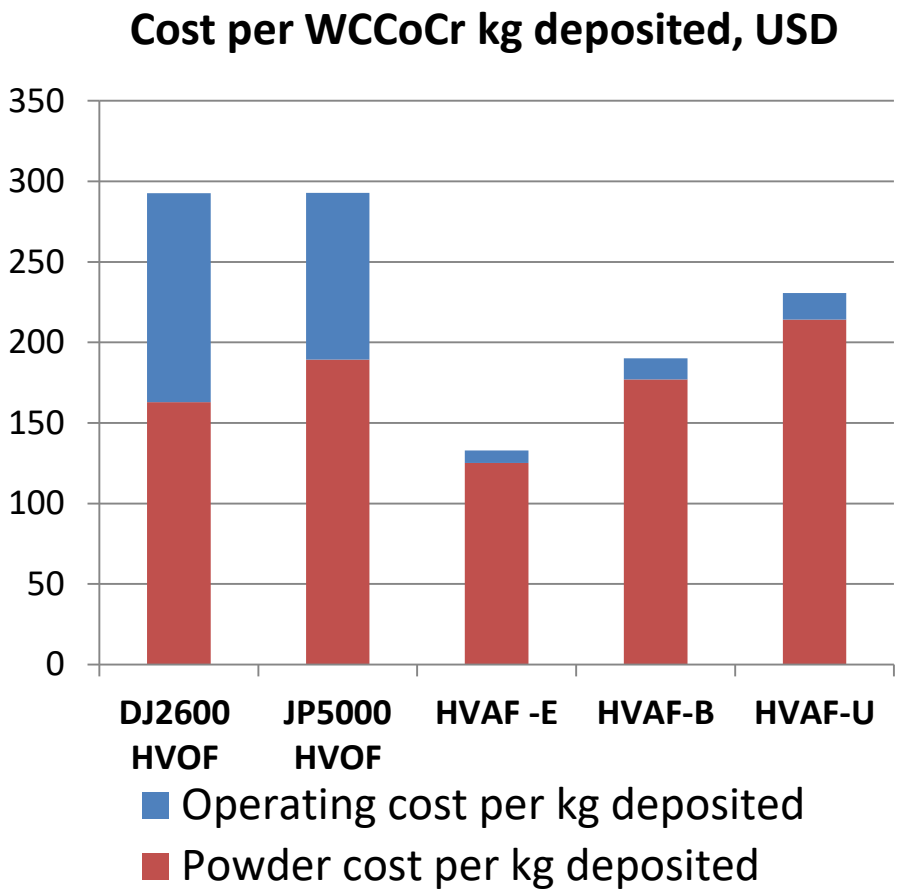
Data for WC-10Co-4Cr, agglomerated & sintered powder

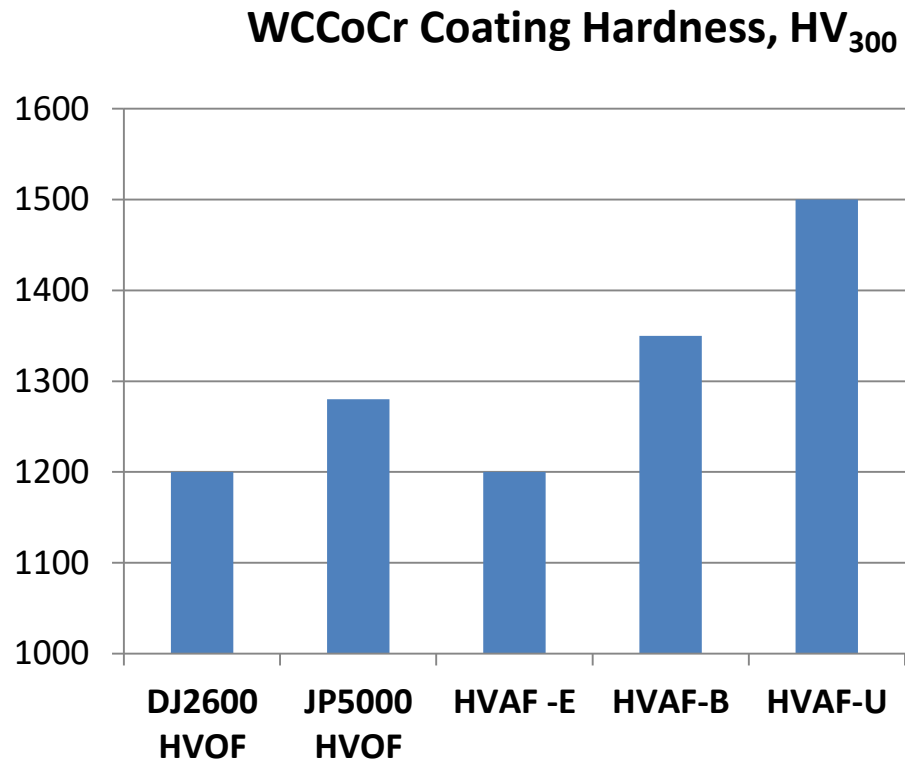
HVOF vs HVAF WC-10Co-4Cr Costs



Comparison of HVAF and HVOF operating costs, USD per hour (prices in Texas, USA)

Comparison of HVAF and HVOF Cost
(prices in Texas, USA)





Note: Cost of WC-Co-Cr powder: $81.4 per kg

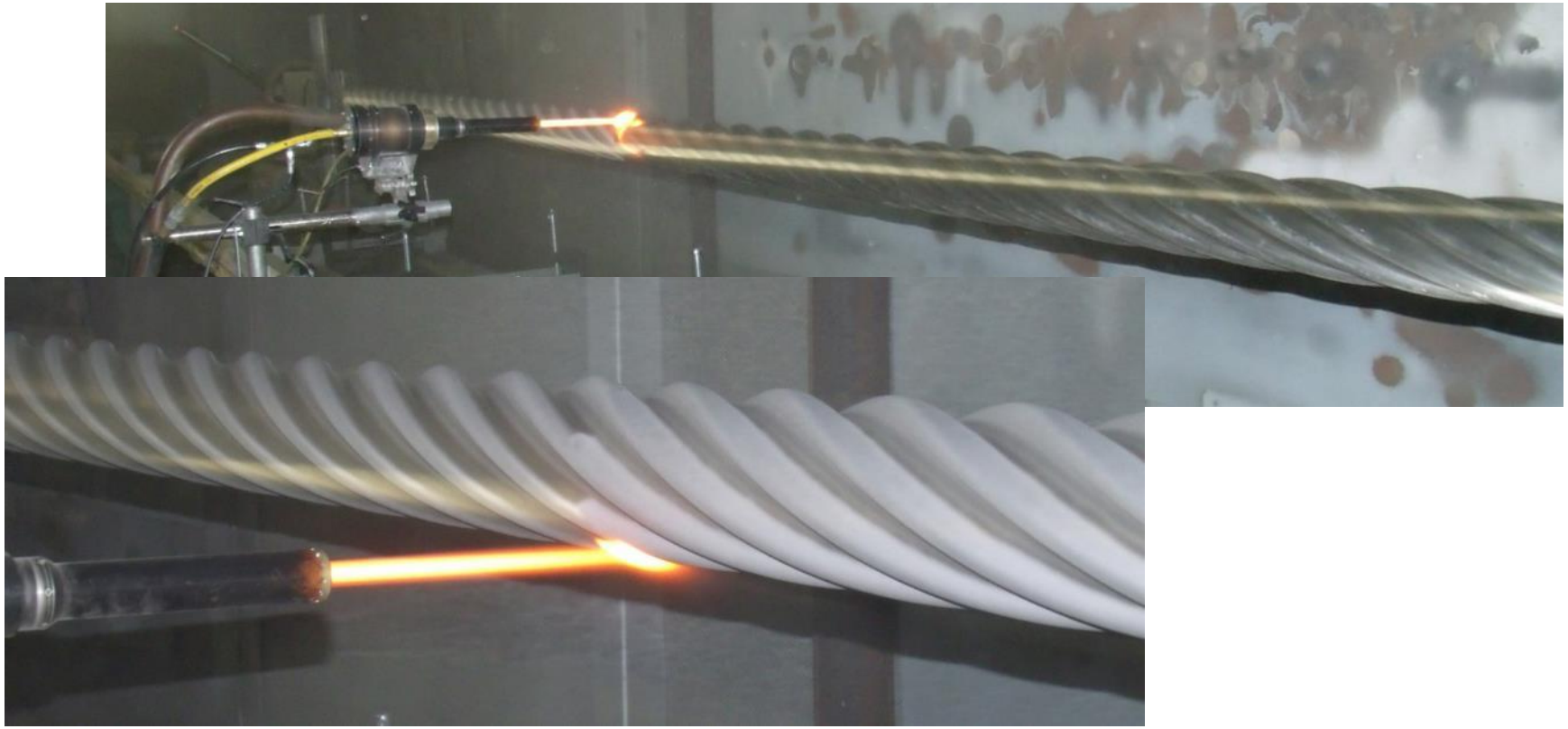
	DJ2600 HVOF	JP5000 HVOF	HVAF-E	HVAF-B	HVAF-U
Spray Rate, kg/hour	4	5	32	26	26
Deposition Efficiency	50%	43%	65%	46%	38%

HVOF vs HVAF WC-10Co-4Cr Costs

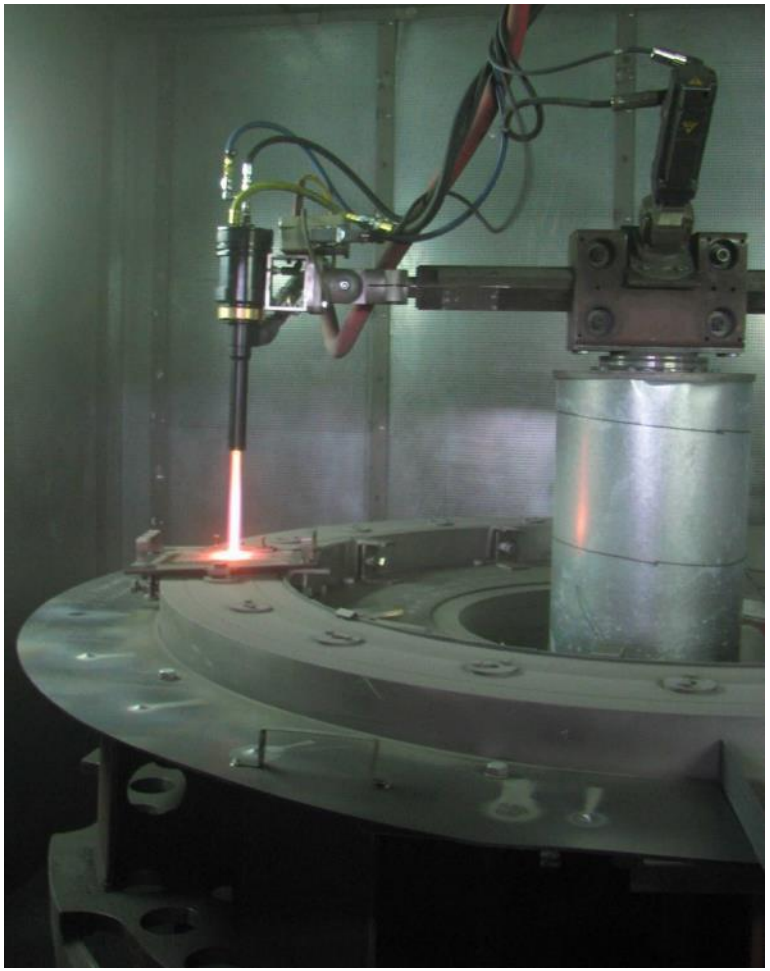
WC-Co-Cr powder cost: 81.4 USD/kg	DJ2600 HVOF	JP5000 HVOF	AK7 HVAF (E)
Total operating cost, USD/hour	260	223	160
Spray rate, kg/hour	4	5	32
Deposition efficiency, %	50	43	65
Deposition rate, kg/hour	2.2	2.2	20.8
Cost per KG of sprayed coating, USD	293	293	133
AK7 savings per KG of deposited coating, USD	160	160	

Examples of Kermetico HVAF Applications

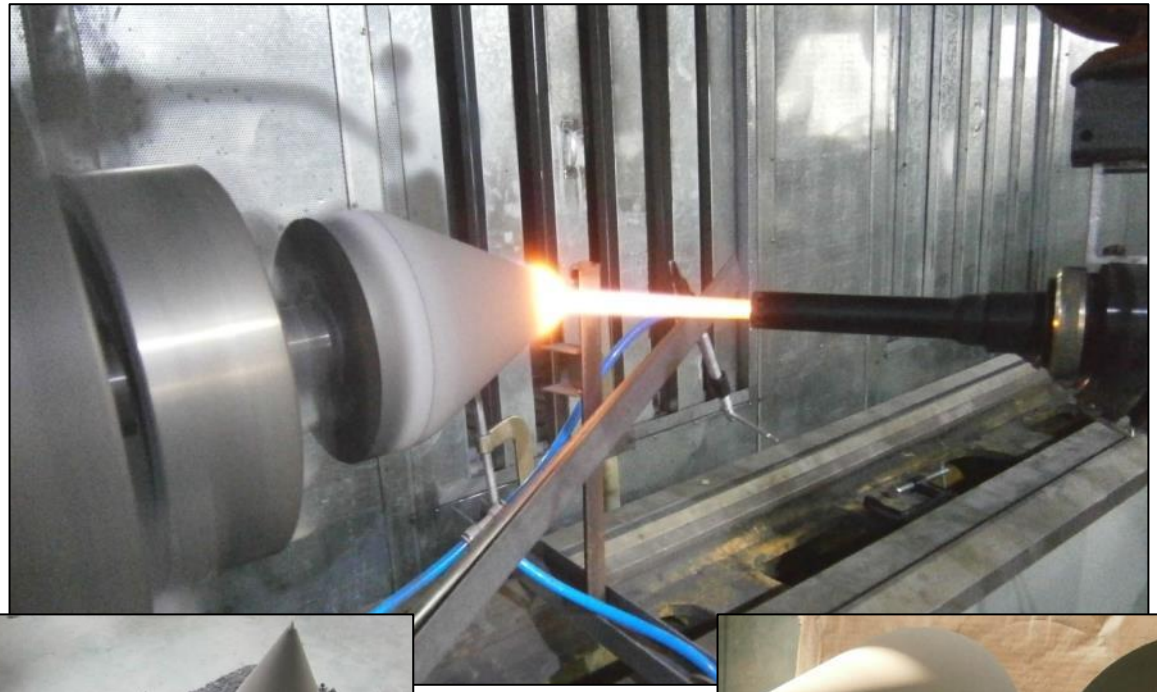
Mud Rotors, Oil Drilling: WC-20Cr7Ni, WC-10Co-4Cr



Hydro-Power:
Francis Turbine Runner and Head Cover
WCCoCr Application by Plackart CJSC, Russia



Hydro-Power:
Metering Needle Valve and Seat
Application by RenCoat Ltd., China



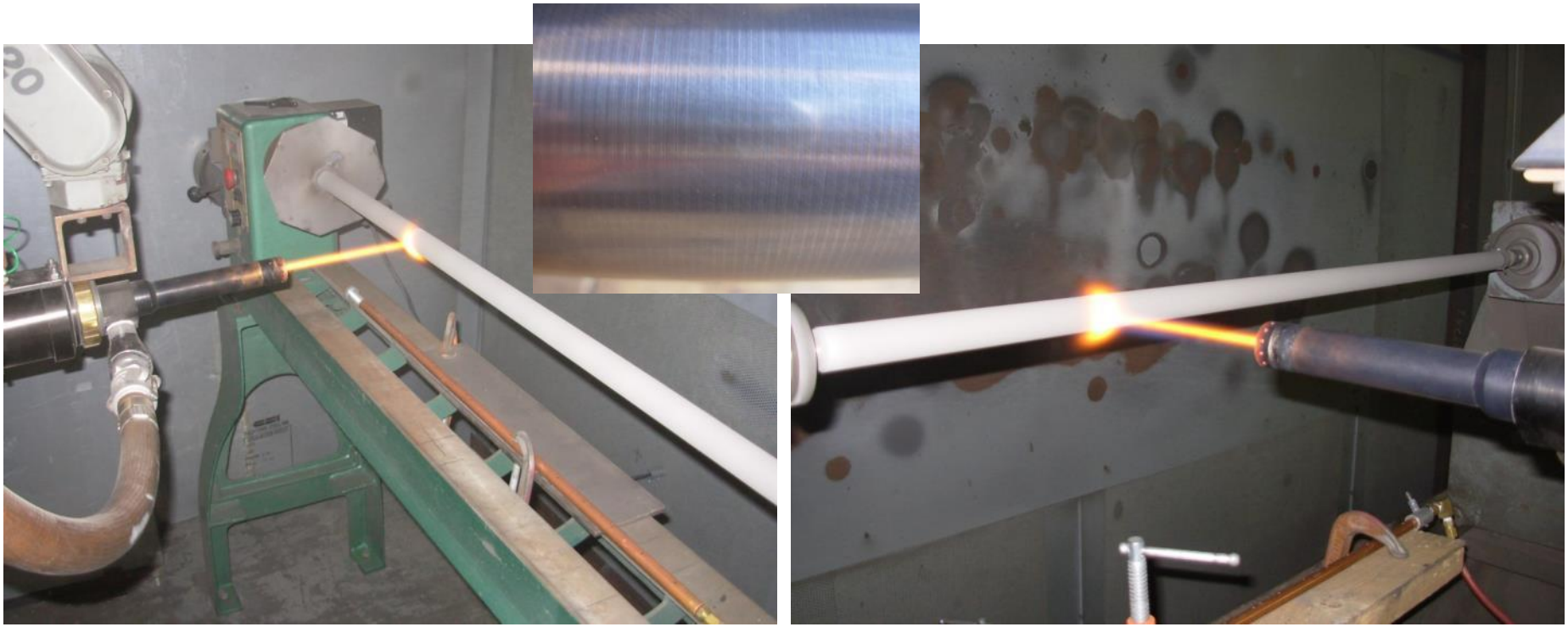
Sliding Gate of Catalyst Tower

Spraying Upper Sliding Gate

Hydraulic Rods of Dock Cranes

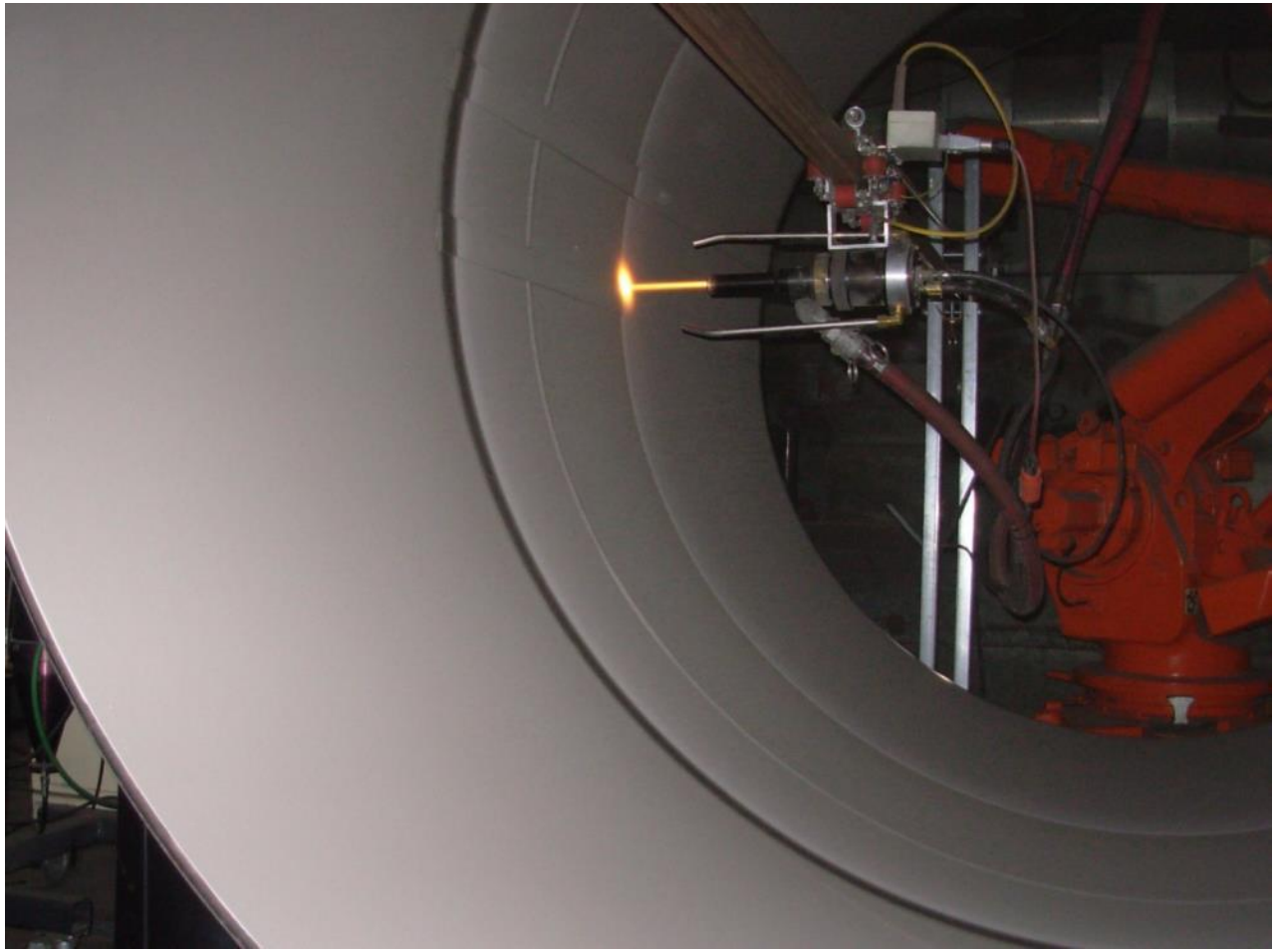
Hard chrome performance: 0.5 year max (pitting)

HVAF WC-Co-Cr coating performance: 5+ years



A Refinery Sulfur Condenser Vessel

Application of Hastelloy C HVAF coating
DIA 1.8 m x L 2.4 m

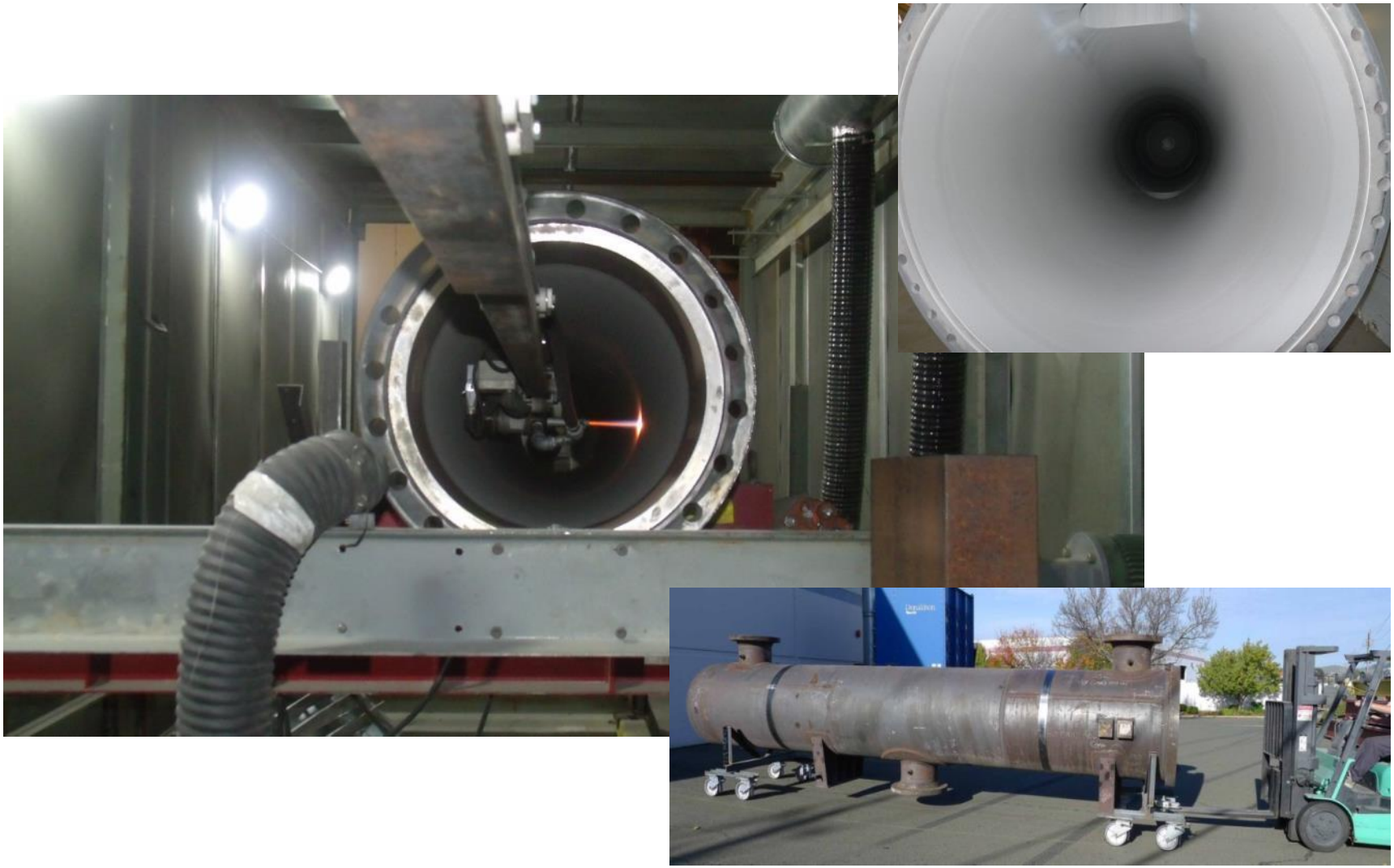


Refinery: Automated Coating with the Rotating AK5 Gun Inside the Processing Vessel

Diameter: 1.8 m

Length: 11.8 m

Refinery: Heat Exchanger Vessels



Double-Elbow, Coke Transport Line

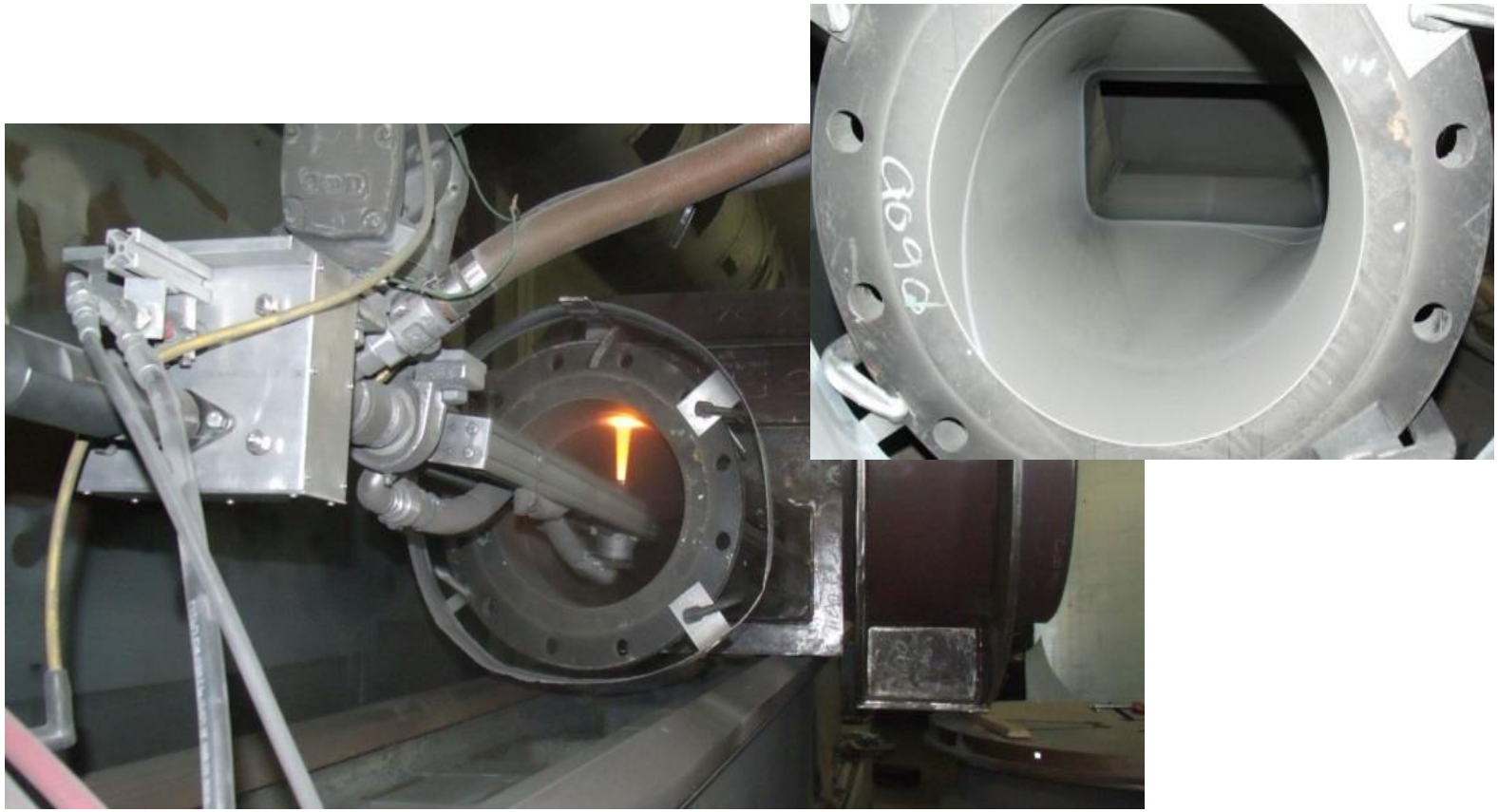
12-inch ID,

6-feet long

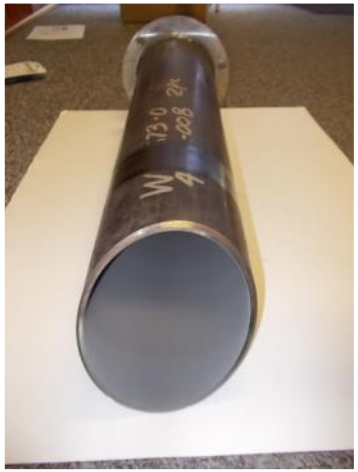
Double-Elbow, Spraying with Rotating AK5 Gun

Coke Line Cyclone: Application of WC-10Co-4Cr Coating with the Rotating AK5 Gun

Coke Line Cyclone: Application of WC-10Co-4Cr Coating with the Rotating AK5 Gun

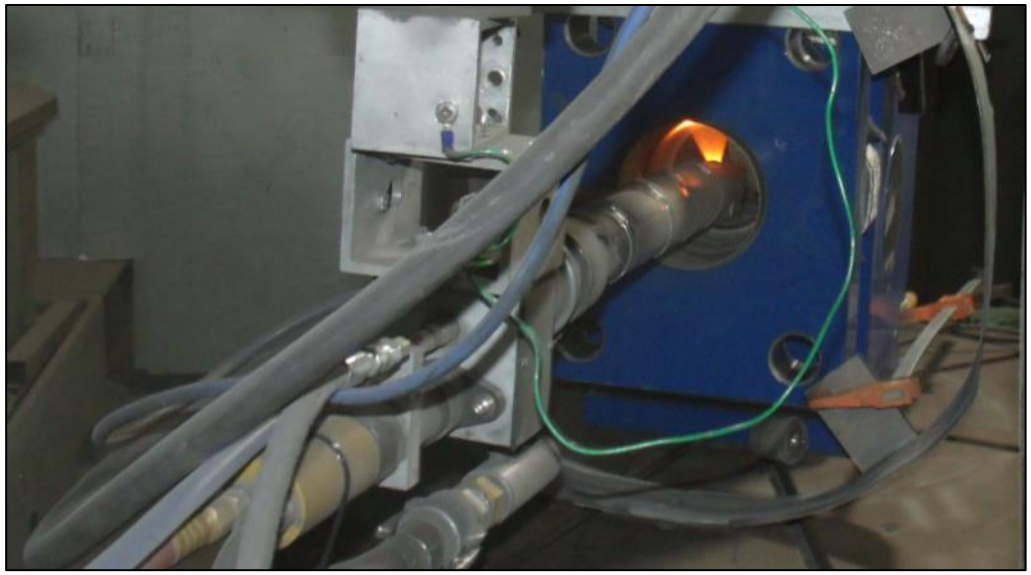


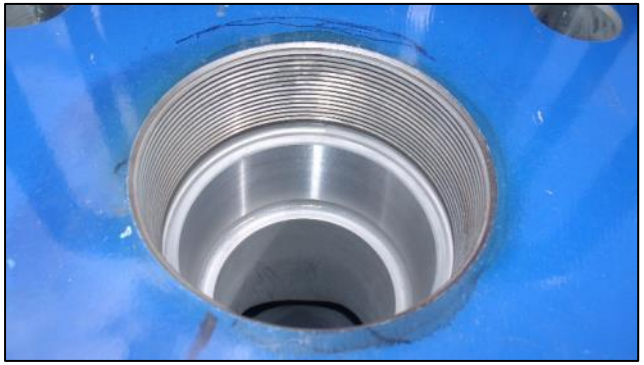
Small ID Transport Pipe Line Components: Application of WC-10Co-4Cr Coating with the Rotating AK-IDR Gun



Oil Refinery:
ID Spraying Pump Casing

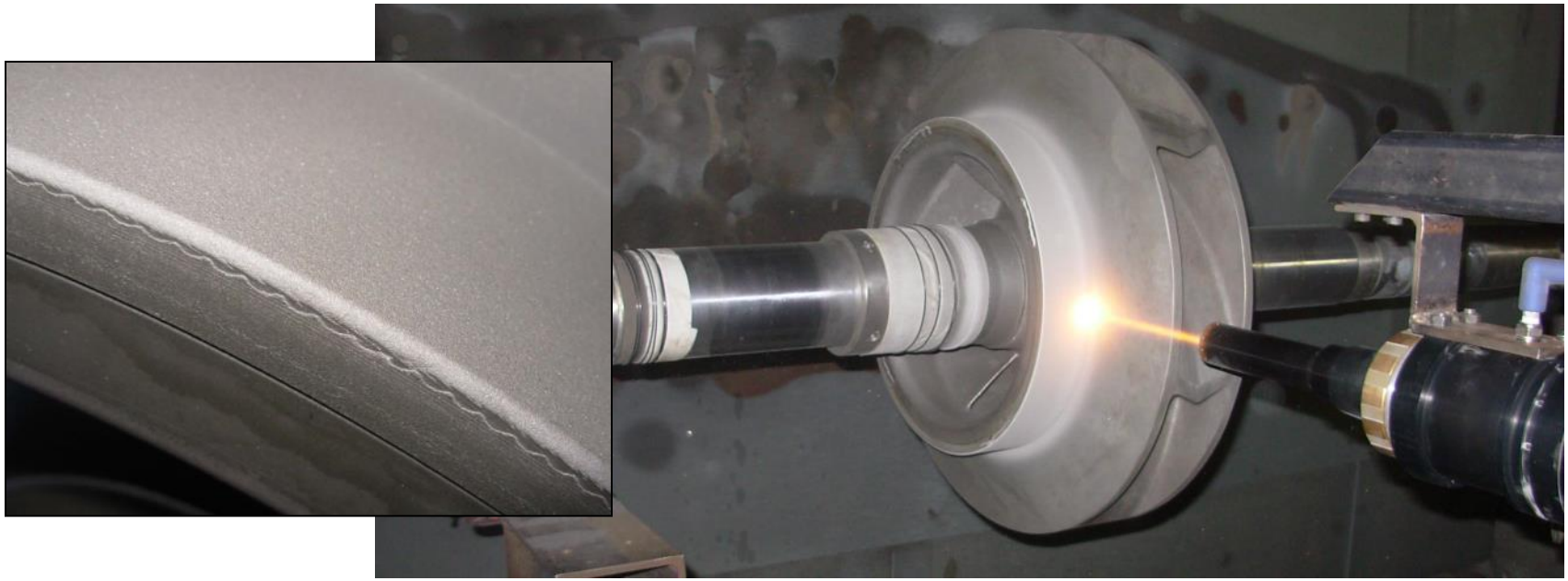
Oil Drilling:
Fluid-End Pump Casing, 5-inch (125 mm) ID
Application of coating with AK-IDR rotating gun





Wear Rings on HT Pump Housings and Impeller Hubs

AK7 Stellite 6 coating over Stellite weld overlay



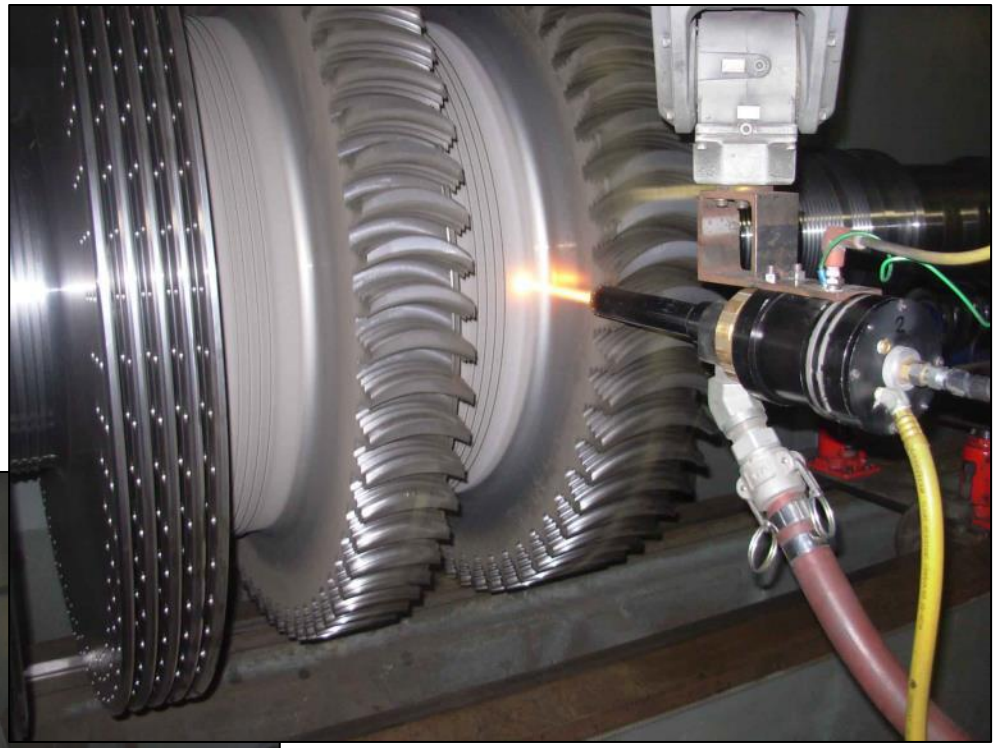
HT (400°C) Pump coating solutions:

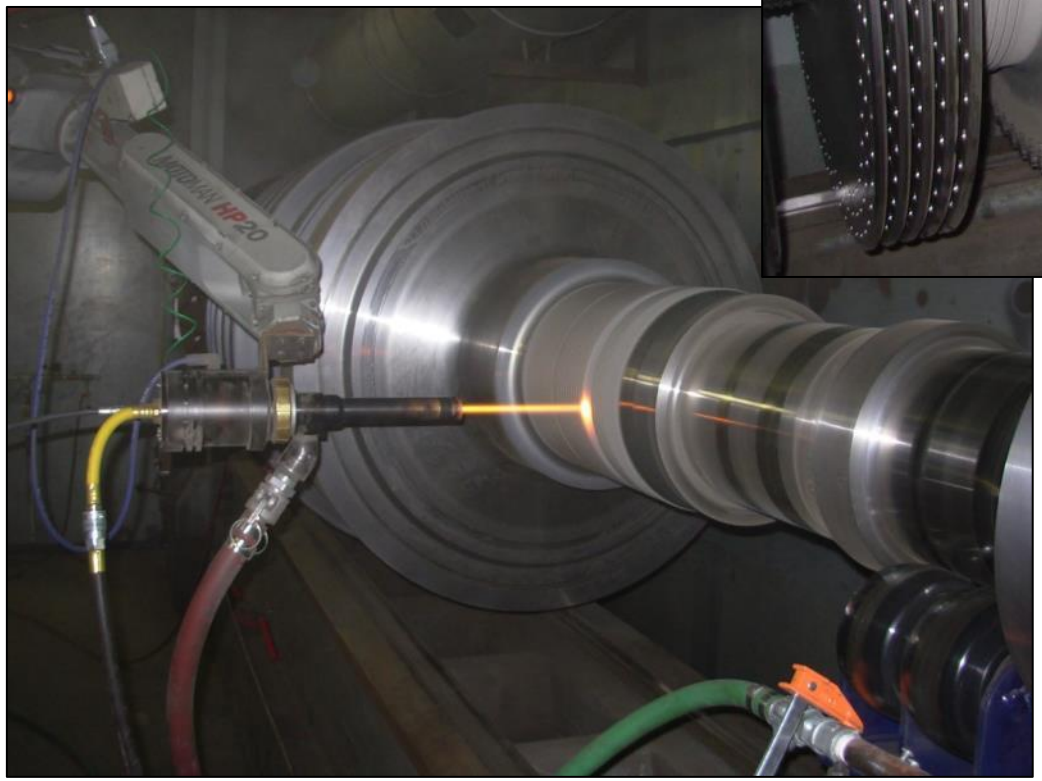
Housing ring: Stellite 6
Impeller ring: Stellite 1

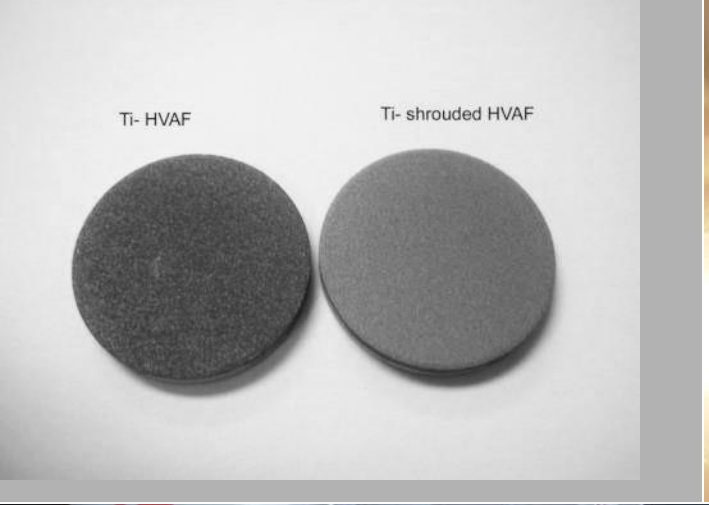
⇨

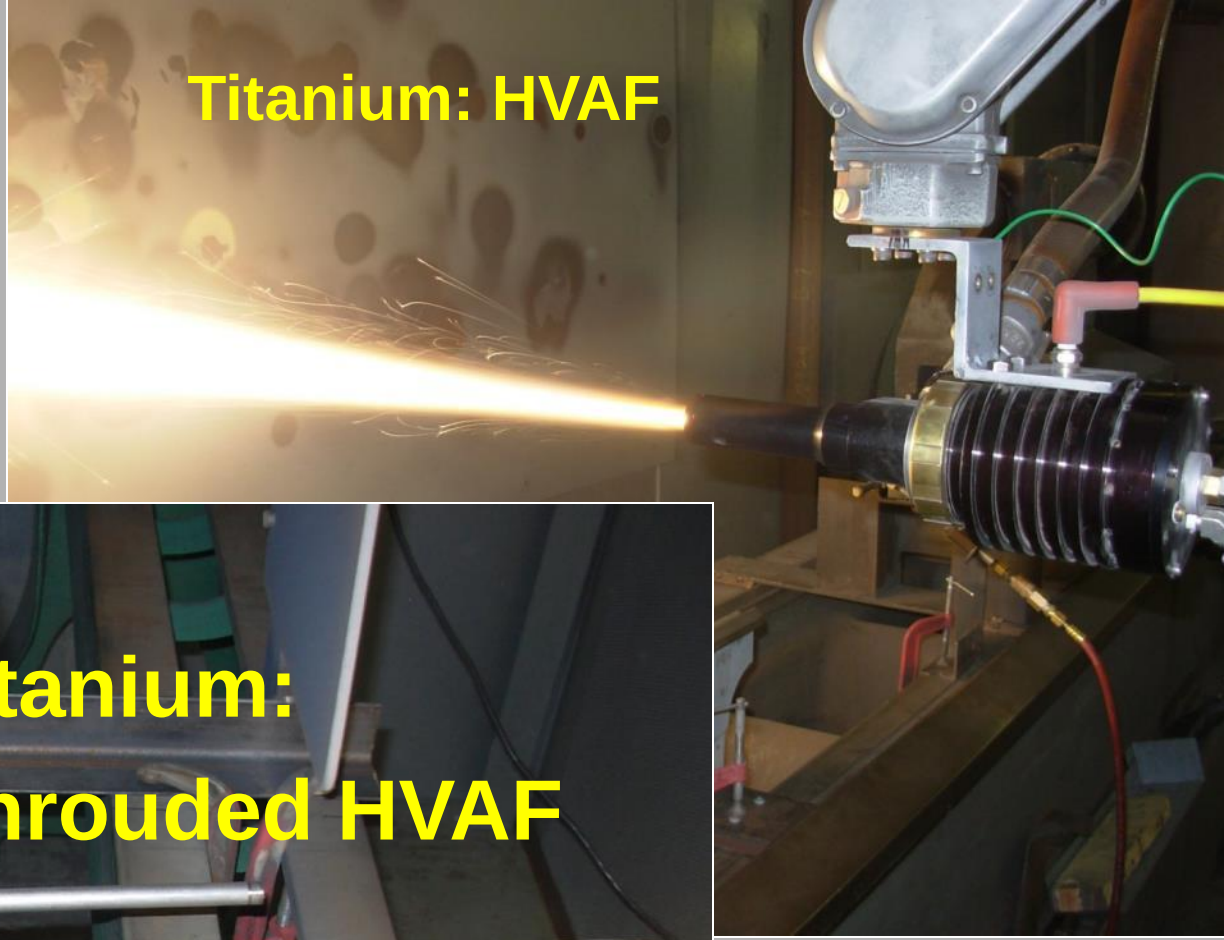
Housing ring: Stellite 6
Impeller ring: WCCoCr

Geothermal Power: Turbine Rotor WC-10Co-4Cr



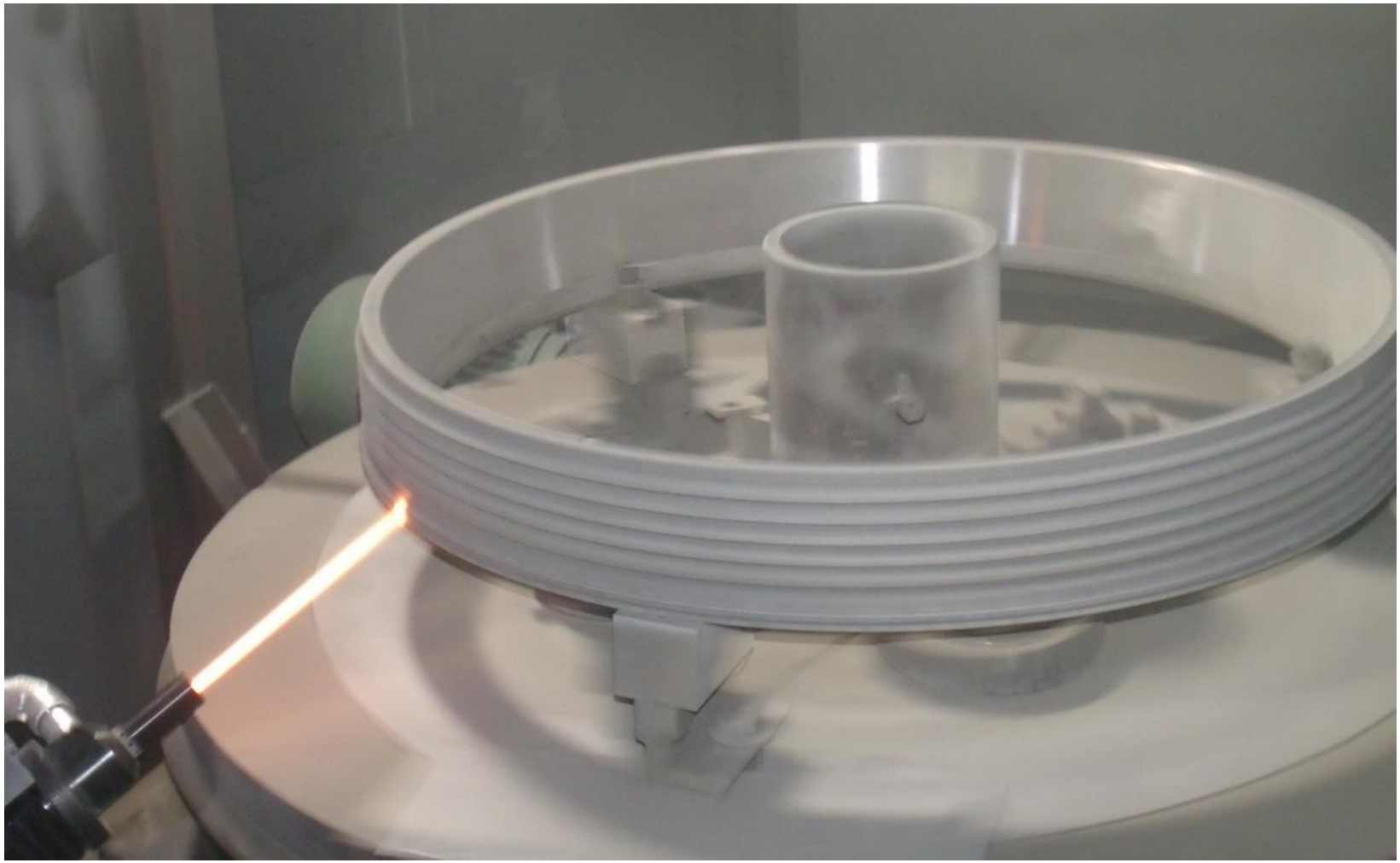



Ti- HVAF
Ti- shrouded HVAF

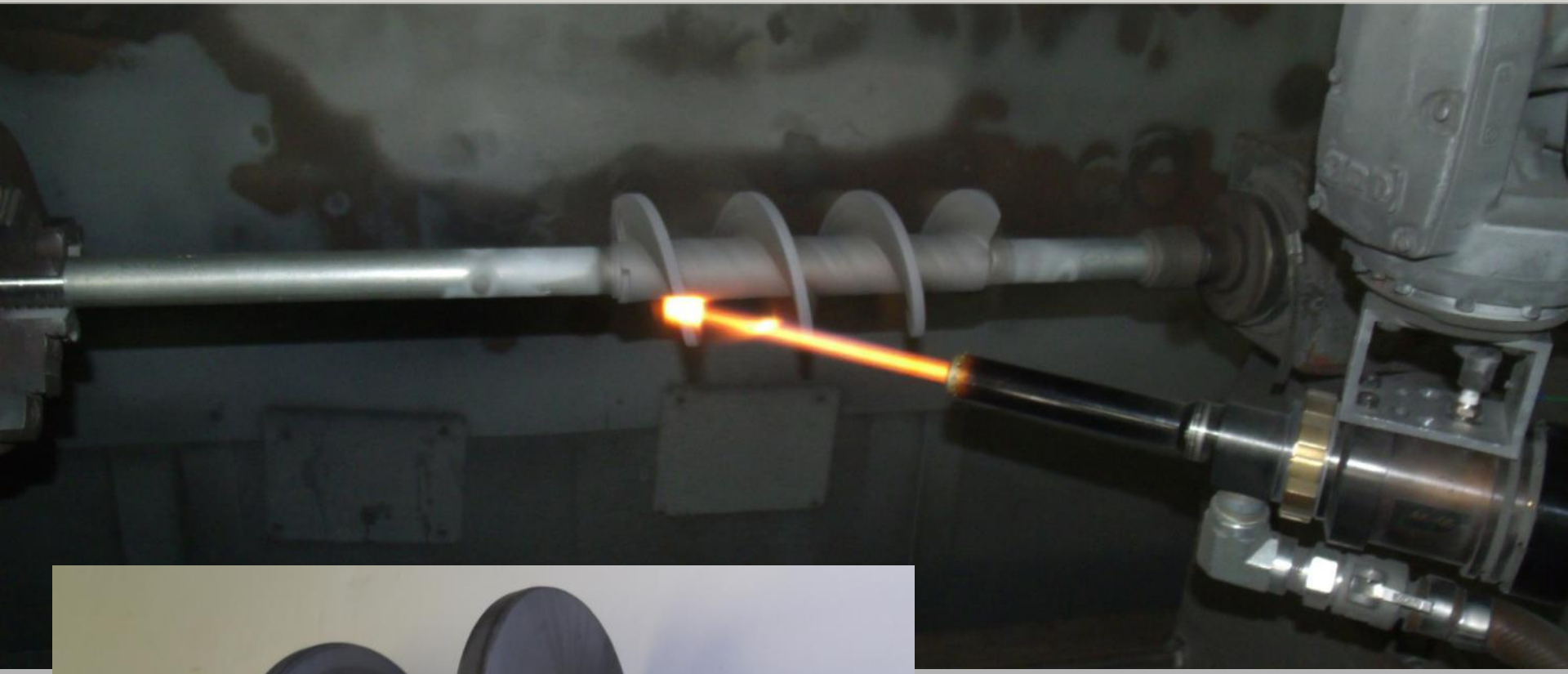

Titanium: HVAF


Titanium:
Shrouded HVAF

Spraying Tin with HVAF SL Gun for Low-Melting Point Metals



Kermetico HVAF

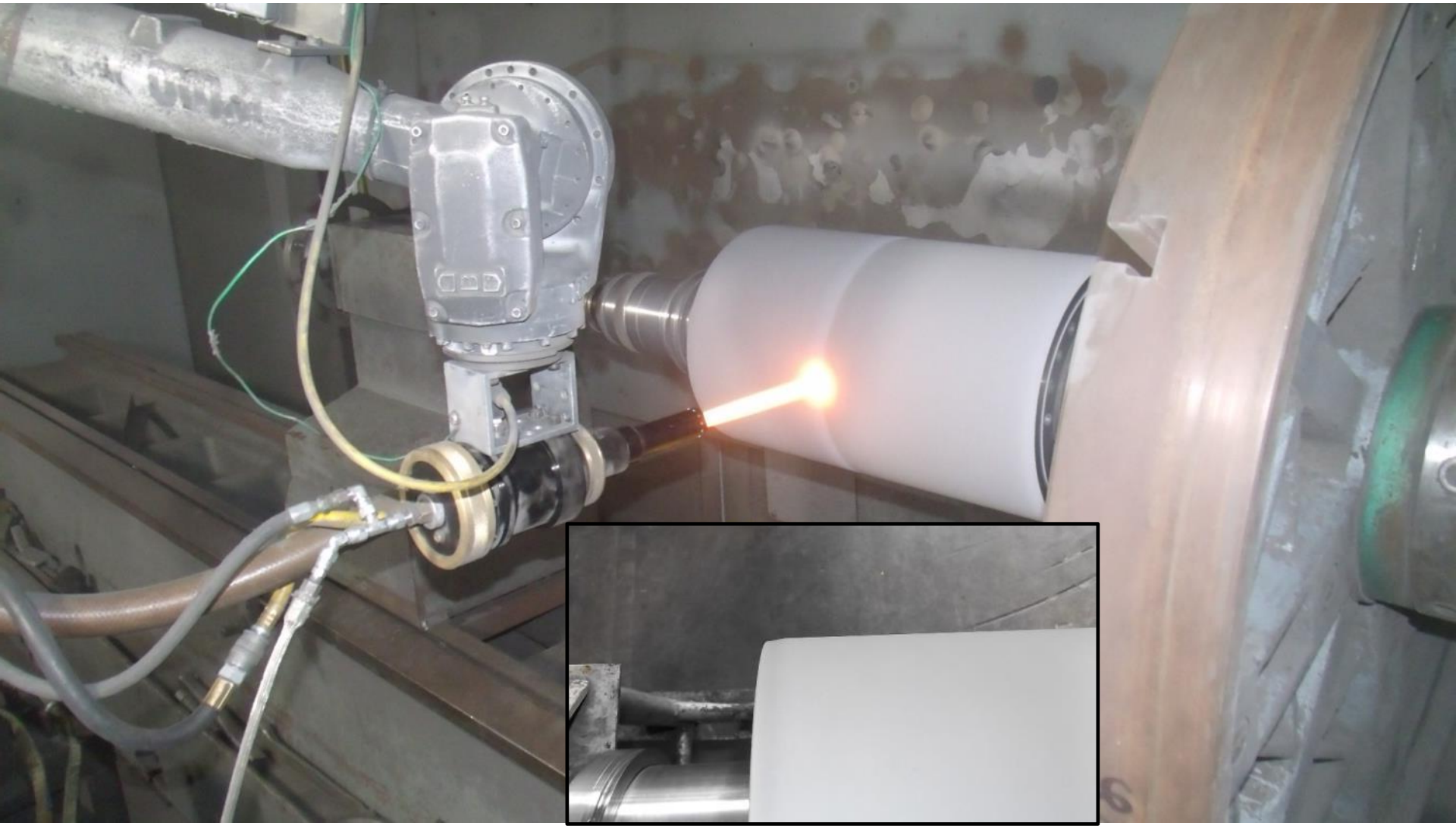


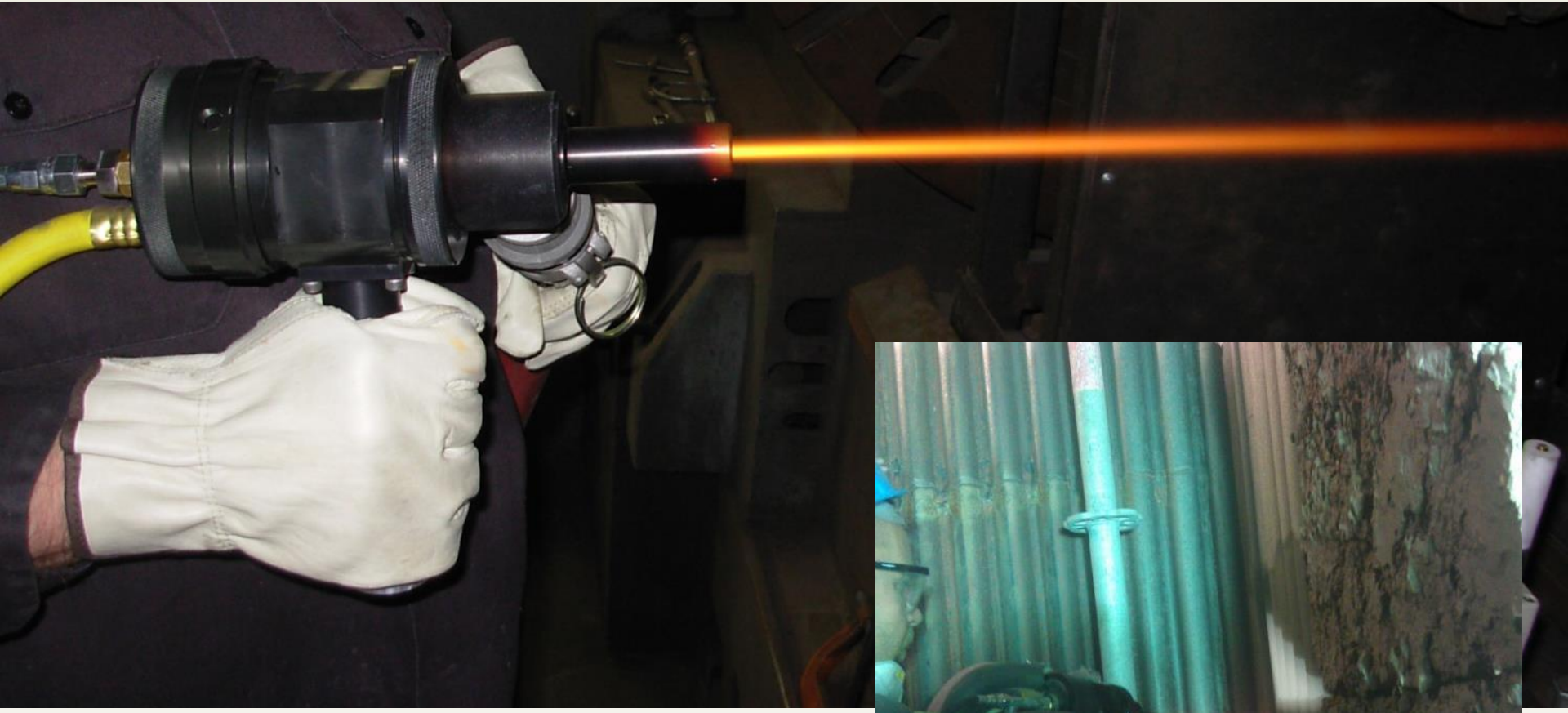
WC-Co-Cr

1 mm thick

Tensiometer Roll:

AK7 HVAF, WC-10Co-4Cr, 1.8 mm Thick





AK-HH: Hand-Held HVAF

Press Pistons, Winemaking