Equipment & Theory…Detonation Spray (4)

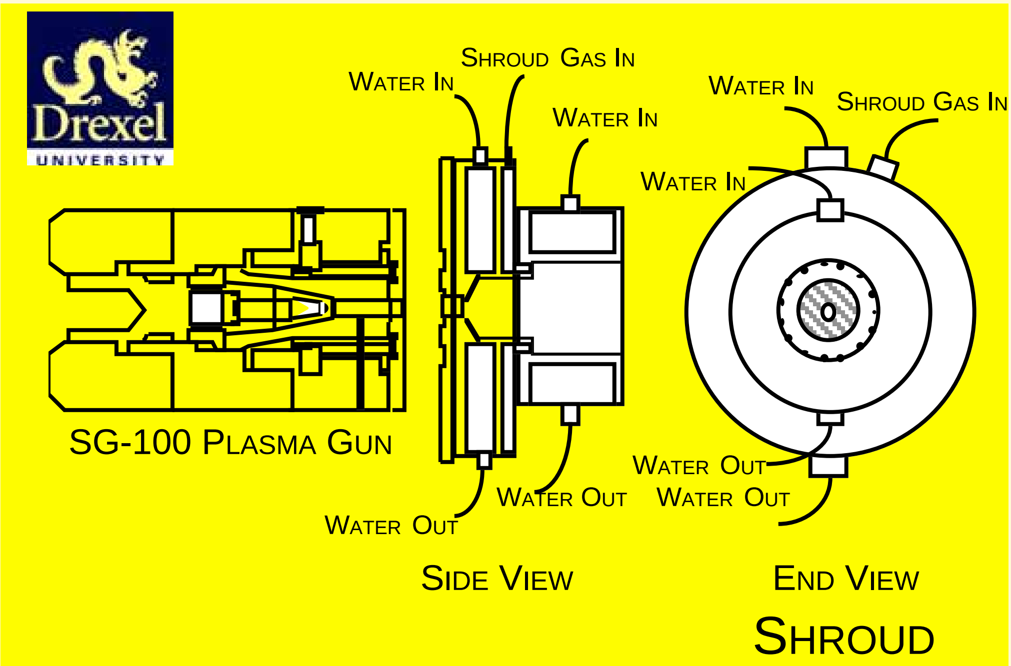
• **Some properties of D-Gun® and plasma sprayed coatings…**

Coating	LW-1	LW-1N40	LW-11B	LA-2	LA-6	LN-2	LS-31
Composition	91/9 WC-Co	85/15 WC-Co	88/12 WC-Co	>99 Al_2O_3	>99 Al_2O_3	>99 Ni	25Cr10Ni7 W Bal Co
Process	D-Gun®	D-Gun®	Plasma	D-Gun®	Plasma	Plasma	Plasma
DPH (kg/mm^2) (300 gm)	1,300	1,050	750	1,100	825	200	350
Tensile Strength* (psi)	>12,000	>12,000	10,000	10,000	7,500	10,000	10,000
Modulus of Rupture (psi)	80,000	100,000	55,000	20,000	20,000	55,000	53,000
Modulus of Elasticity (10^6 psi)	31	31	22	14	5.7	14	8
Density (g/cm^3)	14.2	13.2	12.5	3.4	3.38	7.5	8.0
Porosity (Vol. %)	0.5	1	2	2	3	1	2

**** ASTM C633-69***

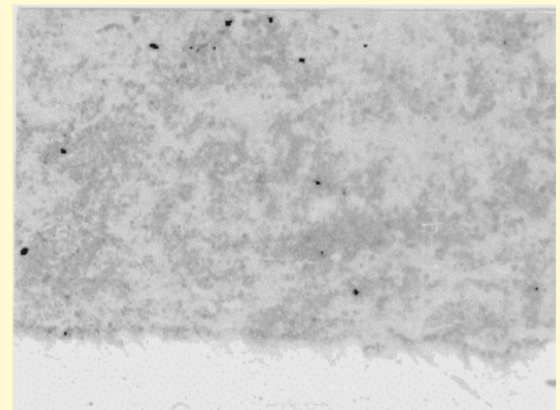
Data courtesy of R. Tucker, Praxair

Equipment & Theory...
Shrouded Plasma Spray (1)

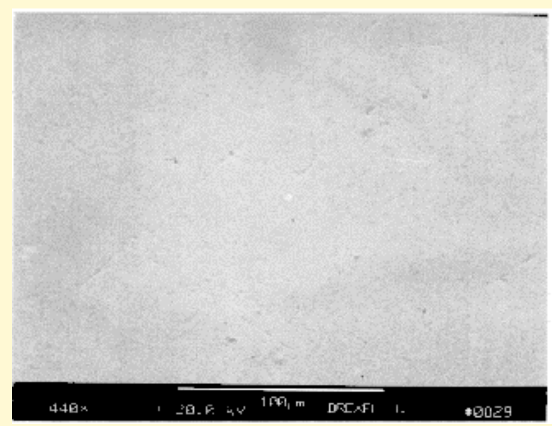


- ***Shroud Characteristics:***
  - *Close coupled…small mean dist. from jet centerline.*
  - *Confined.*
  - *Parallel flow.*
  - *Multi-jet.*

- **Shroud sprayed C.P. Ti coatings @ 80 mm spray distance.**



(a) Shroud flow = 50 % of primary (Ar) plasma gas.



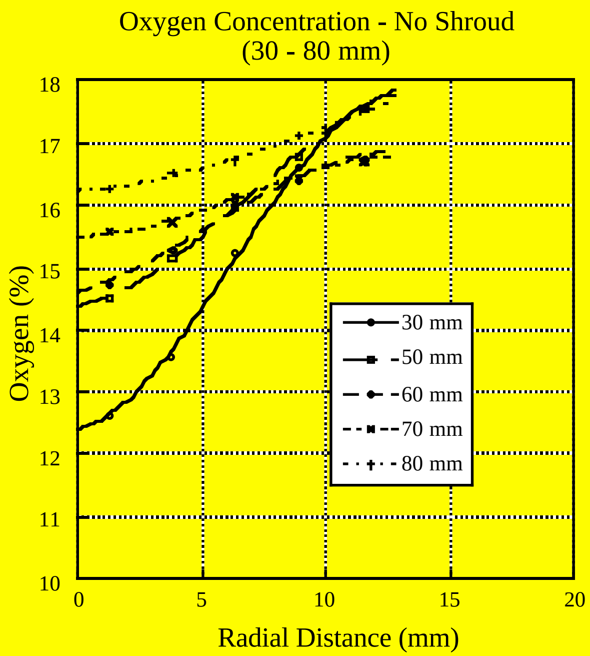
(b) Shroud flow = 30 % of primary (Ar) plasma gas.

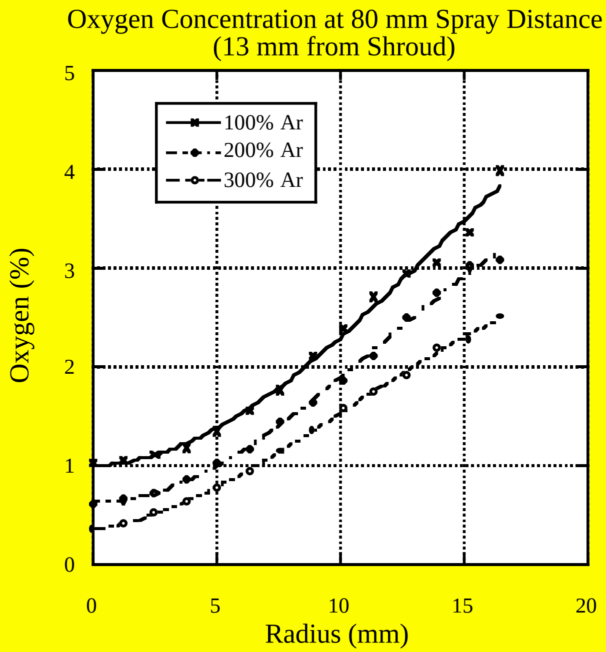
Equipment & Theory…
Shrouded Plasma Spray (2)

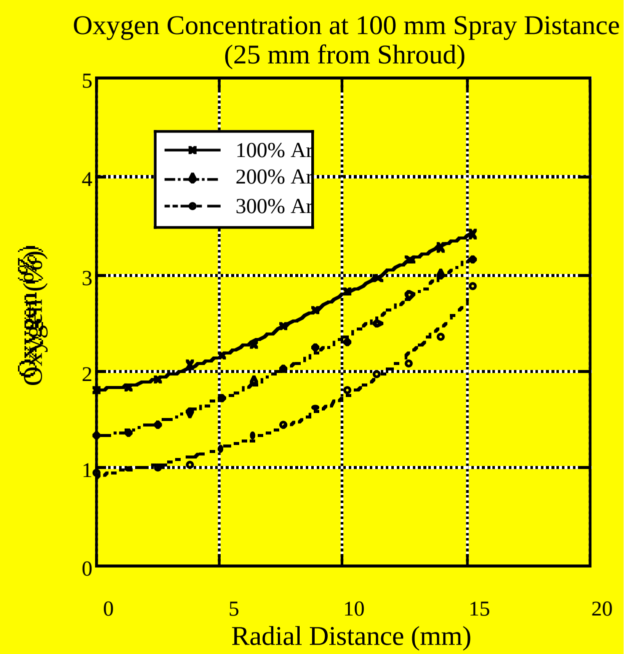
Torch: *Praxair SG-100; 80 kW/Mach II.*

Anode: *2083-300;* ***Cathode:*** *1083A-104*

Plasma Gas: *Ar - 180 SCFH; He - 87 SCFH*





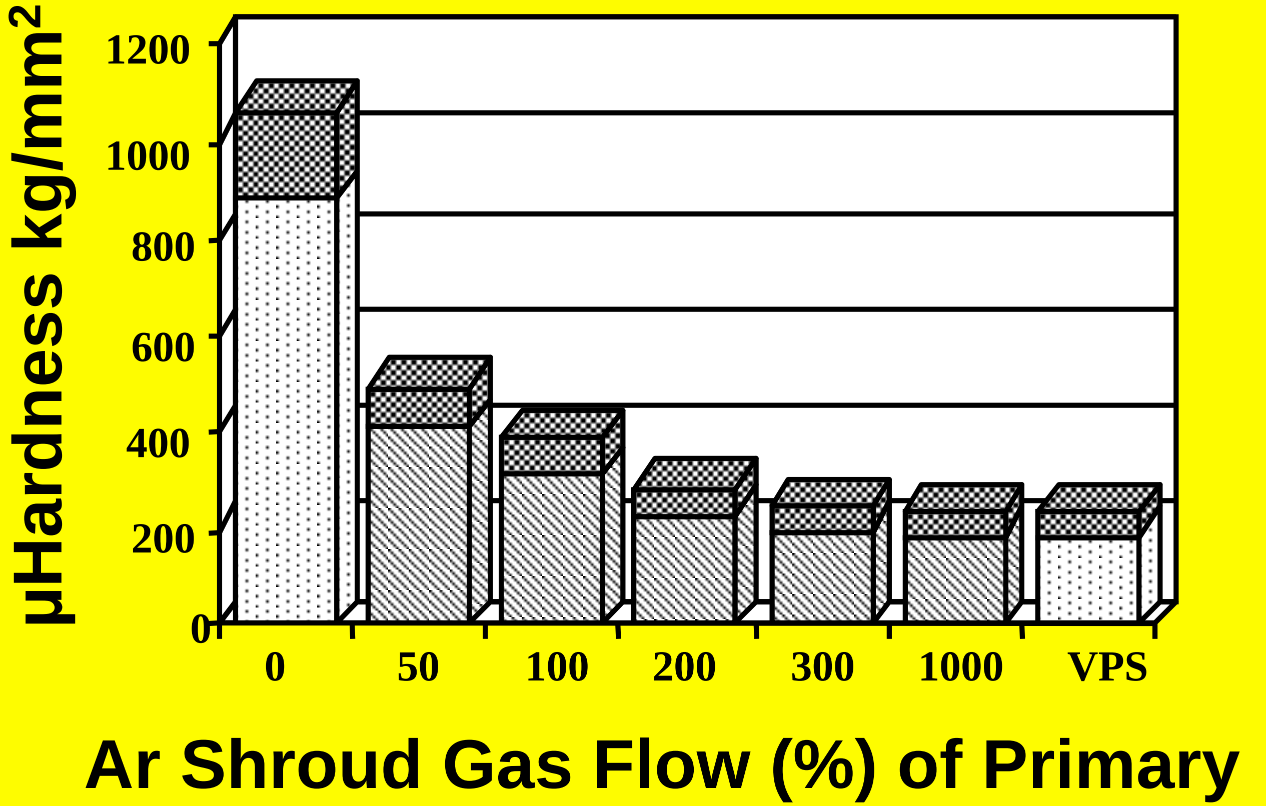


- *12-17 % O_2 @ jet center*
- *15-18 % O_2 @ fringes*

- *0.3-1.0 % O_2 @ jet center*
- *2.5-4.0 % O_2 @ fringes*

- *1.0-1.8 % O_2 @ jet center*
- *2.8-3.2 % O_2 @ fringes*

Equipment & Theory…
Shrouded Plasma Spray (3)



- *Microhardness decreased as shroud gas flow rate increased.*
- *At shroud gas flow > 300 % of primary…VHN ≈ VPS.*
- *At shroud gas flow > 300 % of primary…clean, oxide-free coatings.*

Equipment & Theory…
Process Comparisons (1)

	Thermal Spray Process Characteristic Comparison								
Process	**Gas Velocity**	**Particle Velocity**	**Gas/Particle Temperature**	**Gas Use**	**Bond Strength**	**Density**	**Spray Rates**	**Thermal Efficiency**	**D-E**
	(m/s)	**(m/s)**	**(°C)**	**(slm)**	**(MPa)**	**(% Th.)**	**(kg/hr)**	**(%)**	**(%)**
HVOF	**300-1200**	**100-1000**	**1,400-2500**	**O_2: 250-500** **Fuel (G): 250-800** **Fuel (L): 20-40**	**>70**	**90-99.9**	**2-10**	**50-70**	**70-90**
Arc Spray	**30-500**	**20-300**	**Arc: >20,000**	**500-3,000**	**10-40**	**70-90**	**2-150**	**90**	**70-90**
APS	**200-1200**	**30-800**	**20,000**	**50-300**	**35- >70**	**85-98**	**2-20**	**35-55**	**50-80**
VPS	**200-2000**	**60-600**	**20,000**	**50-300**	**>70**	**95-99.9**	**2-20**	**35-55**	**50-80**
RF/ICP	**15-30**	**10-30**	**10-15,000**	**50-250**	**N/A**	**95-99.9**	**2-7**	**35-40**	**70-90**
Cold Spray	**300-1200**	**300-1200**	**up to 800 °C**	**1,500**	**N/A**	**~99 %**	**3-5**	**N/A**	**~70**

Equipment & Theory… Process Comparisons (2)

PROCESS	**CHARACTERISTICS** (+)	(-)
• Flame Spray	- Low cost - Portable - Ease of use - Polymers (EVA) - Powder/wire/rod feed	- Low jet temp./Particle vel. - Limited materials - Least dense coatings - Oxidation
• Wire-Arc	- Portable - Ease of use - Wire feedstock - Low heat input to part - High deposition rate - Cool spray conditions	- Wire feedstock/limited mat'ls. - Electrical supply - Atomizing gas flow req'd. - Oxidation (but Ar, N_2)
• HVOF/HVAF	- Dense coatings (95%+) - High vel./lower particle temp. - Polymers (Nylon 11, Polyimide, PEEK) - High deposition rate	- Need fuel, oxygen/air supply - Noise (120dBA+) - Higher equip't. cost (~$80k) - Residual stress: tensile/comp. - Narrow powder cut --> ↑ $ - Gen. not ceramics

Equipment & Theory…
Process Comparisons (3)

Process	Characteristics (+)	Characteristics (-)
• Plasma (APS)	- Dense coatings - Spray any material - Higher gas temp. & vel.	- Not as portable - Higher equip't. cost (~$80k) - Narrow process window - O_2 from powder feedstock
• Plasma (VPS)	- V. dense coatings - Lowest oxidation	- Need vacuum chamber etc. - Highest equip't. cost (~$200k) - Wide process window - O_2 from powder feedstock - Off-site; not portable
• Shrouded APS	- No vacuum chamber - Dense coatings - Low oxidation - Lower cost than VPS	- Not off-the-shelf technology - Supply and $ of shroud gas
• Detonation Gun	- V. dense coatings - High adhesion/cohesion	- Off-site; not portable - Noise - Lower deposition rates?