

Solutions Flash

Robust coating solutions for hydropower turbines extend operating life and maintain efficiency

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Today's situation

Increasing global energy demands is driving the growth of renewable energy technologies for primary electrical power production. Overall, renewable energy resources are predicted to increase from a 19% share of electric power production in 2008 to at least 32% by 2035.

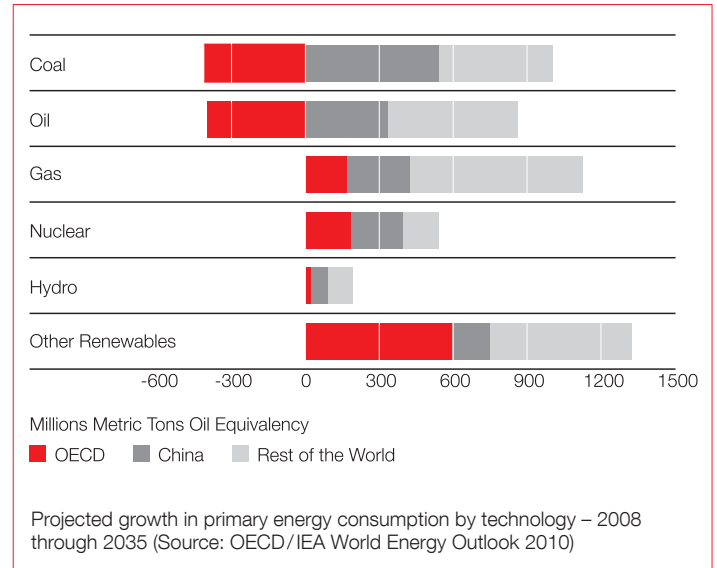
As a result, hydropower is enjoying a worldwide renaissance. Well-recognized as one of the most environmentally-friendly energy production technologies, large numbers of new facilities are currently in development or recently commissioned. In addition, many existing facilities are undergoing expansion; often with retrofits of newer, more efficient technologies.

However, hydropower turbines are subject to efficiency losses from corrosion and erosion (hydro-abrasion, fluid erosion and cavitation). Influencing factors include the type of hydro-electric power plant, the design of the hydro turbine (Francis, Kaplan or Pelton), and the specific operating conditions such as the corrosive potential of the water and the size and amount of the silt, sand or gravel debris in the water. At the same time, as utilities strive for greater profitability, installations exploit higher heads (water pressure and velocity) and have expanded into less accessible, more contaminated waterways. These factors have increased the levels of wear mechanisms acting on the turbine components.

The Oerlikon Metco solution

Oerlikon Metco has partnered with leading hydropower turbine manufacturers and users to provide successful coating and wear prevention solutions since the 1930s. We provide our customers the ability to select the best solution from a number of existing coatings or to further develop an existing coating to fulfill the customer's unique turbine requirements.

Our long experience, backed by extensive in-house testing, gives us a thorough understanding of the mechanisms to which hydropower turbine components are exposed. We tailor coating solutions to withstand the specific operating



environment of your turbine using our broad portfolio of materials and application equipment. In addition, if you need an experienced service partner to apply the coatings, our Coating Service facilities offer robust, off-the-shelf solutions and many years of application know-how.

In many cases, hydropower turbine components coated with our solutions outlast those of uncoated components by 3 to 5 times. Thus, using our solutions, hydropower turbines can operate for longer periods and maintain power output efficiency, further contributing to the effectiveness of these renewable energy resources.

Solution description and validation

Wear Mechanisms in hydropower turbine components

The wear mechanisms in hydropower turbines vary considerably, depending on the service conditions that the individual components are exposed. Turbines operating in high head conditions, such as Pelton turbines, may be exposed to greater wear from water erosion. On the other hand, turbines exposed to low head conditions, such as Kaplan turbines, may be exposed to greater wear from entrained debris in the water.

The type of entrained debris in the water must also be considered. Wear effects will be significantly different depending on whether the entrained debris is silt, sand or

gravel, and differences will also be evident depending on the amount of debris. Finally, different head waters will have different corrosion potentials, further complicating the means to mitigate the wear effects.

Some components may be exposed to sliding wear primarily caused by the dynamic interaction between mating components. Here, wear coatings can also prove to be an effective deterrent.

While no coating will completely stop these effects, coatings are an effective means of greatly prolonging service life and efficiency. But for the coating to be optimally effective, all factors must be considered.



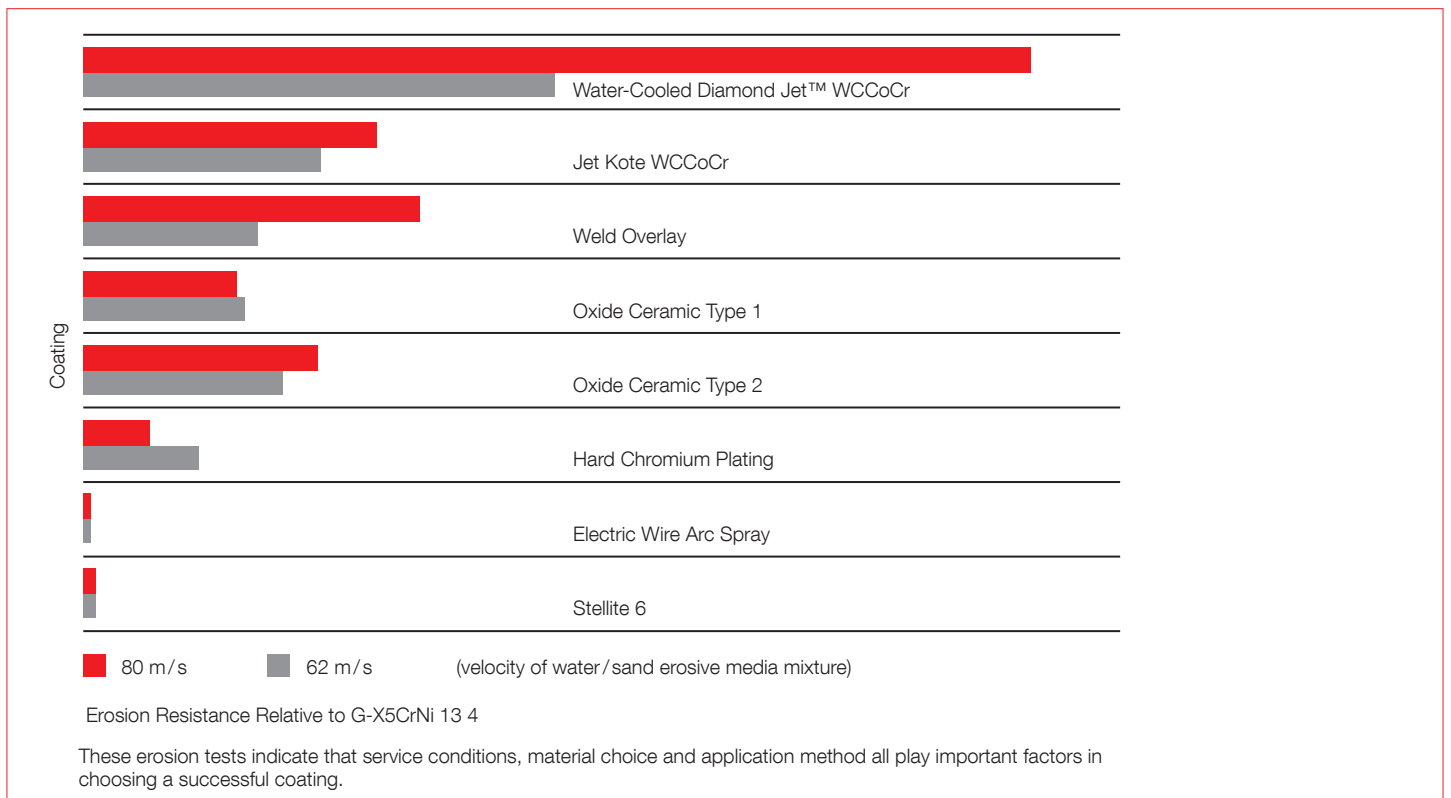
Cavitation damage on a Francis turbine



Worn buckets on a Pelton turbine



Eroded guide vanes on a Francis turbine



Proven Oerlikon Metco hydropower coating solutions

Coatings applied to hydropower turbine components can extend service life, thereby maintaining turbine efficiency and decreasing maintenance costs. Oerlikon Metco has decades of experience with proven and highly effective coating solutions for hydropower turbine components. Some commonly applied Oerlikon Metco coatings are listed below:

Component	Coated Area	Coating	Wear Mechanism
Kaplan Turbine			
Discharge ring	Partial or entire discharge ring	■ Wire combustion sprayed 15 mm thick Metcoloy 2	
Kaplan blade	Partial or entire blade	■ HVOF 0.4 mm thick WCCoCr ■ Wire combustion sprayed 5 mm thick Metcoloy 2	Erosion (hydro-abrasion, fluid erosion)
Guide vane ring	Between planar surface and draft tube liner	■ Wire combustion sprayed 5 mm thick Metcoloy 2	
Protective sleeve	2-part sealing elements	■ HVOF 0.3 mm thick WCCoCr ■ Wire combustion sprayed Metcoloy 2	Seal area, abrasive wear
Radial bearing	Applied to new or repair components	■ Wire combustion sprayed Sprababbitt A	
Crank	Slide bearing area	■ Wire combustion sprayed Sprasteel LS	Sliding wear
Crank pin	Slide bearing area	■ Wire combustion sprayed Sprasteel LS	
Francis Turbine			
Cheek plate	Complete area		
Guide vane	Complete guide vane, also disc and face side seals		
Turbine cover	Clearance and labyrinth area, wear ring area	■ HVOF WCCoCr	Erosion (hydro-abrasion, fluid erosion)
Runner wheel	Clearance and labyrinth area, runner inlet channel		
Pelton Turbine			
Pelton bucket	Inside and edges	■ HVOF WCCoCr	Erosion (hydro-abrasion, fluid erosion)
Pelton needle	Area subject to wear	■ HVOF WCCoCr ■ Plasma sprayed Cr ₂ O ₃	
Needle spear	Area subject to wear	■ Wire combustion sprayed Metcoloy 2 or Sprabronze	Sliding wear
Nozzle tip	Entire internal contour		
Nozzle tip insert ring	Area subject to wear	■ HVOF WCCoCr	Erosive and abrasive wear
Jet deflector	Area subject to wear		
Jet deflector cover	Area subject to wear		

Materials technology

The wear behavior of a material for a hydropower turbine application cannot be predicted by its simple physical and mechanical characteristics such as hardness, elastic modulus and tensile strength.

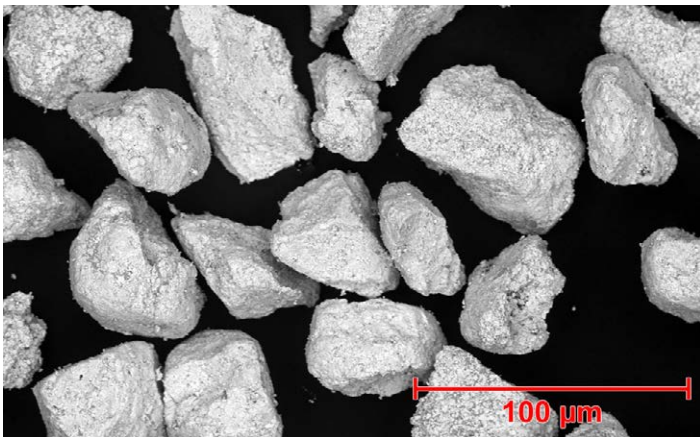
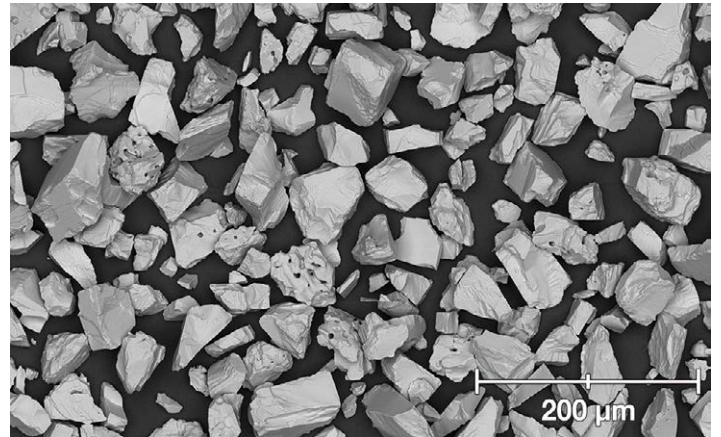
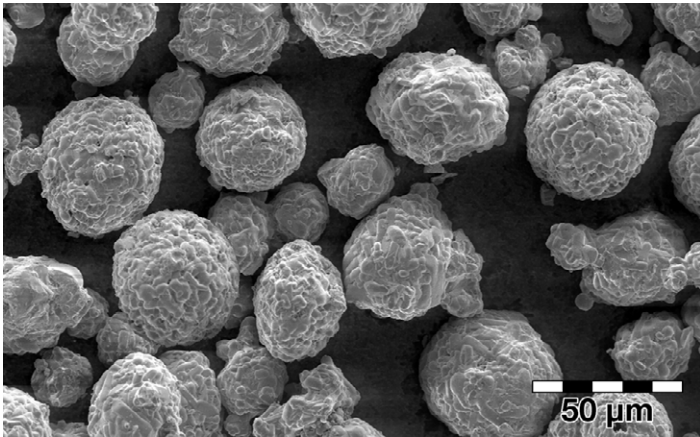
For example, there are many WCCoCr materials available on the market. Despite having practically identical chemical compositions, these products can have different particle shapes, morphologies, particle size distributions, primary carbide sizes and bulk densities. As such, the various products can have substantially different wear behavior in service and under various service conditions. Yet, while these differences may be evident through wear testing and in-service performance, such factors cannot be ascertained through the usual hardness tests carried out for coating quality assurance.

Oerlikon Metco has a broad portfolio of standard carbide materials. Many of those materials, including popular

WCCoCr materials frequently used to protect hydropower turbine components, are offered in variety of products that vary by powder manufacturing process, particle size distribution and apparent carbide size and density. Oerlikon Metco WCCoCr products frequently chosen for hydropower turbine applications include WOKA 3652, WOKA 3652 FC, WOKA 3653, Oerlikon Metco 5847, Amdry 5843 and Diamalloy 5849.

We are also well-known for our portfolio of proven thermal spray wire products used to protect hydropower turbine components applied using our Metco 16E combustion wire spray gun. These include Metcoloy 2, Sprabronze, Sprasteel LS and Sprababbitt A.

A few hydropower components are best protected using chromium oxide applied by atmospheric plasma spray. Here, too, Oerlikon Metco can provide optimized chromium oxide powders and the application equipment.



WC 10Co 4Cr coating materials. Above: An agglomerated and sintered material. Below: A sintered and crushed material. Both of these materials are successfully used to prevent wear in hydropower turbines, however, they are used for different turbine applications and exhibit different in-service characteristics.



Other materials commonly used to protect hydropower turbine components. Above: One of many chromium oxide materials offered by Oerlikon Metco. Below: A variety of wire materials that can be applied using combustion wire spray.

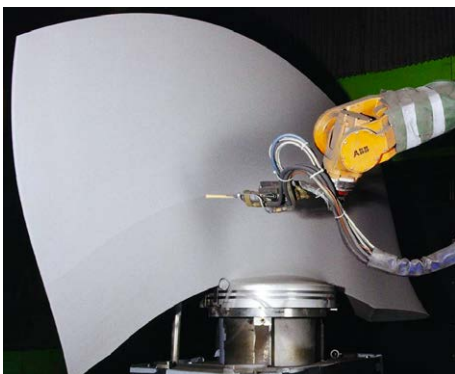
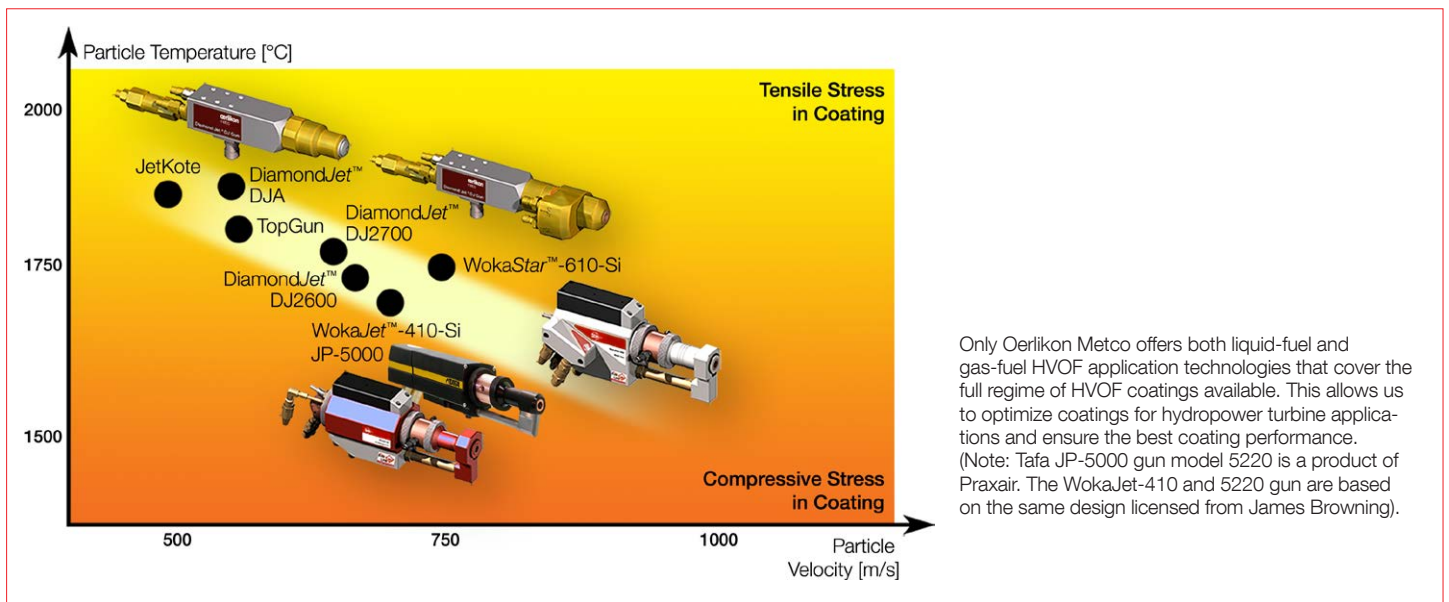
Coating application technology

Just as differences in material characteristics can have a large effect on service performance and coating endurance, the method used to apply the material has an equally important role, particularly for HVOF-applied coatings.

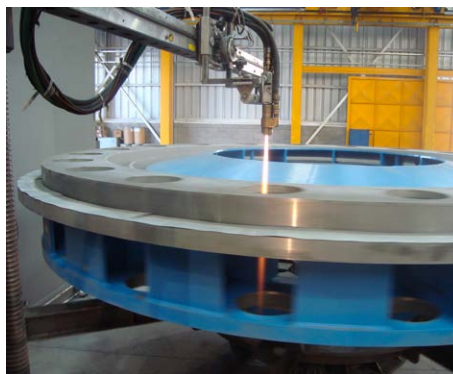
While some customers may feel that lower particle temperatures, higher combustion pressures and higher particle velocities will always result in the “best” coating, in practice the coating application technology and parameters must be as carefully chosen as the coating material. The drivers for the choice of application equipment are always those of in-service coating performance and cost efficiency.

Oerlikon Metco offers both gas-fuel and liquid-fuel HVOF coating application equipment. Each has its place in the application of hydropower turbine coatings. Through decades of hydropower turbine coating experience, we can offer the right combination of material and application technology for the specific turbine component service environment.

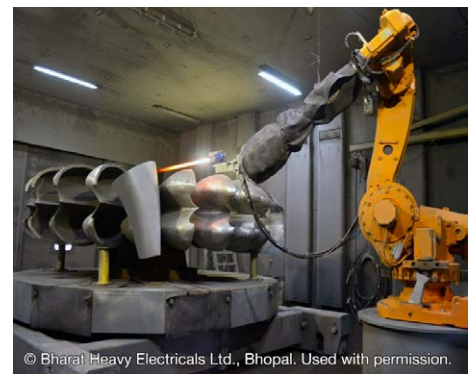
We tailor our coating systems to the specific needs of our customer for part size, weight, manipulation requirements and desired automation level. All systems are designed to the latest applicable safety codes.



Kaplan turbine blade being coated with a Diamond Jet HVOF-GF spray gun



Francis bottom ring being coated with a Diamond Jet HVOF-GF spray gun



Pelton wheel being coated with a WokaStar HVOF-LF spray gun

Testing and analysis

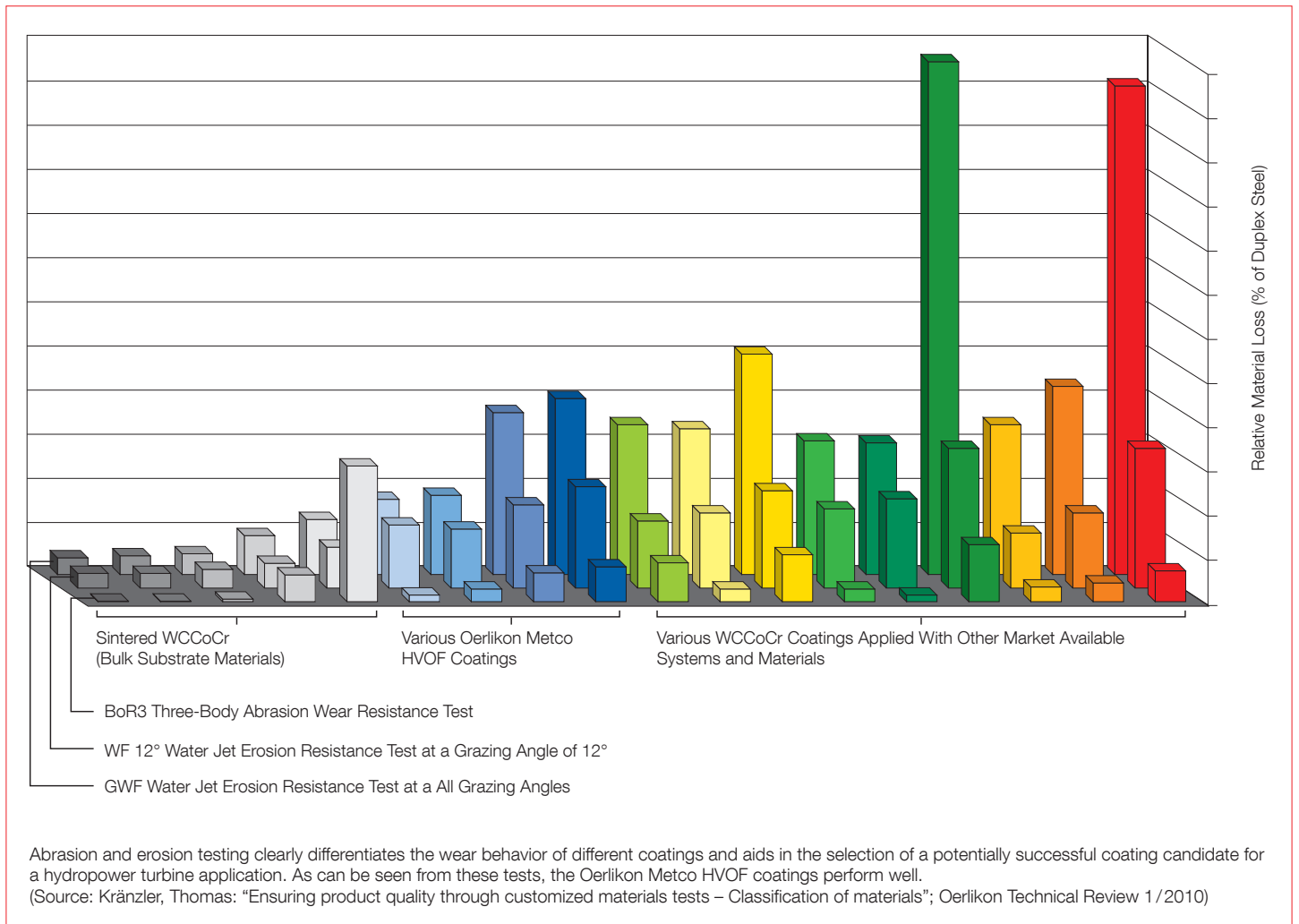
Determining successful coating candidates for hydropower turbine components requires the employment of specialized testing procedures.

While standardized tests are used to determine the basic wear behavior of materials under well-defined loading conditions, specialized testing is needed for specific conditions and components. The results of these tests can usually be transferred directly to the operating conditions for the turbine component.

Oerlikon Metco has access to fully equipped test benches for both standardized behavior studies and tailored, application-specific coating development. These include a variety of cavitation, erosion, abrasion, sliding wear and corrosion test benches.



Cavitation test rig at Oerlikon Metco



Summary

Protective coatings can greatly extend the service life of hydropower turbine components. However, the coating material, application equipment and parameters must be carefully chosen for optimal coating performance. Seemingly similar materials and application technologies can perform very differently in service.

Customer benefits

Environmentally friendly

- Application of optimized coating solutions enhance hydropower turbines, and have a positive influence on hydropower as a renewable, environmentally-friendly source of power.

Efficient

- Oerlikon Metco's proven, high-performance coating solutions help to maintain overall turbine output efficiency.
- Oerlikon Metco has a wide range of standard materials appropriate for hydropower turbines that allows for the optimal material selection for the application.
- Oerlikon Metco's coating application systems (HVOF-GF, HVOF-LF, atmospheric plasma spray and wire combustion spray) can be tailored to meet customer-specific processing needs.
- If desired, Oerlikon Metco Coating Services are available for coating application at our facilities or on-site, using personnel highly experienced in the application of coatings for hydropower turbines.

Oerlikon Metco has extensive experience in coatings for hydropower turbine applications. Our broad portfolio of materials, equipment, application know-how and our testing capabilities allow us to provide both standard and application-specific coating solutions that are optimized for hydropower turbines.

Effective

- Oerlikon Metco long experience with all types of hydropower turbines (Francis, Pelton and Kaplan) is your assurance of a partner who can deliver a total solution package.
- Oerlikon Metco can optimize coating solutions to the specific service environment of the turbine, through the correct selection of material, application equipment and coating parameters.
- As a full-source supplier, Oerlikon Metco works in close cooperation with its customers, from initial consultation through coating production and beyond.
- State-of-the-art materials technology for coatings that results in very minimal seal wear during rub interactions and maintains steam path design clearances.
- Only Oerlikon Metco offers all coating application technologies, including the full range of gas-fuel and liquid-fuel HVOF equipment; thus we can provide the best coating application technology for the application.

Economical

- Optimized coatings can increase the service life of components up to 3 to 5 times that of uncoated components, reducing operating and replacement costs.
- Working with an experienced partner, such as Oerlikon Metco, will decrease your overall project time and cost.

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