

# ADDITIVE MANUFACTURING

## Printing Solutions for the Future



## ELMET TECHNOLOGIES - YOUR PARTNER FOR AM

Combining 100 years of experience in refractory metals with competency in 3D printing technologies, Elmet Technologies provides cutting edge knowledge in the quickly evolving field of additive manufacturing (AM).

### Additive Manufacturing at Elmet Technologies

Elmet Technologies' expertise in AM methods as well as refractory metal part manufacturing makes us the ideal partner for our customers' current applications, as well as for the development of solutions to their future challenges. Our competency in material selection, part design, process validation and full scale manufacturing provides a leading edge in the fast-paced AM industry. With refractory metal powder, we are able to support multiple AM methods and our refractory metal parts portfolio covers all key markets.

### Materials

Based on 100 years of experience in manufacturing and development of refractory metals, Elmet Technologies has powder with tailored properties perfectly suited for AM. The company's core competencies of W, Mo, Ta and Nb, in pure and alloyed forms, ensure materials with the highest quality and performance for our customers.

As an integrated player, we use our powders, and turn them into innovative finished products using the best suited additive manufacturing methods.

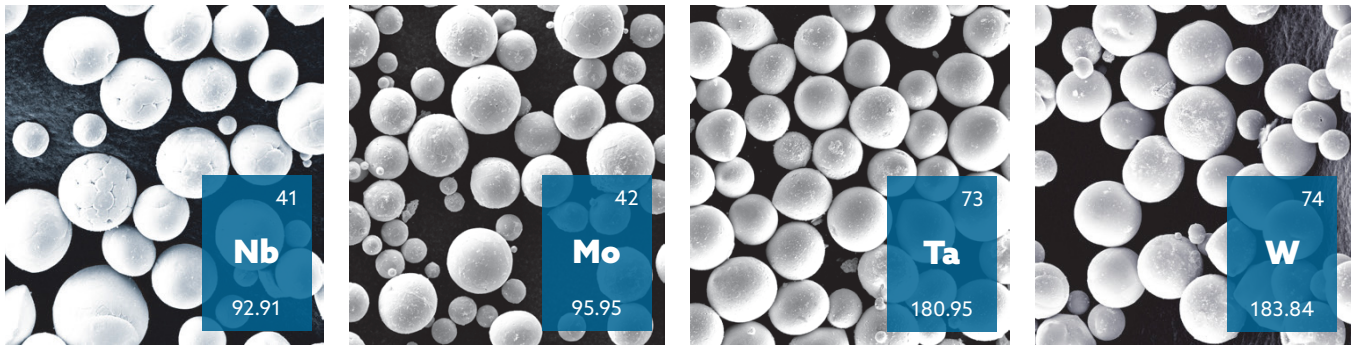
### Methods

Since the introduction of AM, a large variety of process technologies have been developed of which no single method fits all applications. Elmet Technologies works closely with its customers and partners to select the correct feedstock and method that will provide the most value to any given application. We have successfully demonstrated refractory metal AM with multiple methods.

### Markets

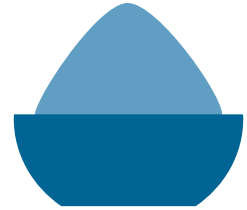
Elmet Technologies' refractory metal 3D printing solutions support our customers in all key end markets and enable them to benefit from the unique advantages of AM.

Industries currently served include Medical, Aerospace, Industrial, Nuclear and Defense. Elmet Technologies continuously broadens its portfolio and works on innovating and designing parts for applications in markets that have not previously utilized refractory metals.



## MATERIALS

Elmet Technologies' AM powder offers world class quality and performance with perfectly tailored properties suited for all relevant AM methods.



### Our Feedstock Solutions

Elmet Technologies' innovative powder manufacturing technology coupled with our vertically integrated supply chain and metallurgical expertise ensures the highest quality materials for demanding applications and environments. Our advanced technological processes enable us to customize our refractory metal powders to precise requirements, achieving outstanding material properties and optimum performance for additive manufacturing.

### Our Powder Advantage

Elmet Technologies' powders are specifically designed to meet the demanding requirements of additive manufacturing technologies. Their properties exceed traditional production specifications and offer:

- > High purity
- > High bulk density
- > Spherical powder morphology
- > Exceptional flowability
- > Low oxygen
- > PSD optimized for specific printing methods

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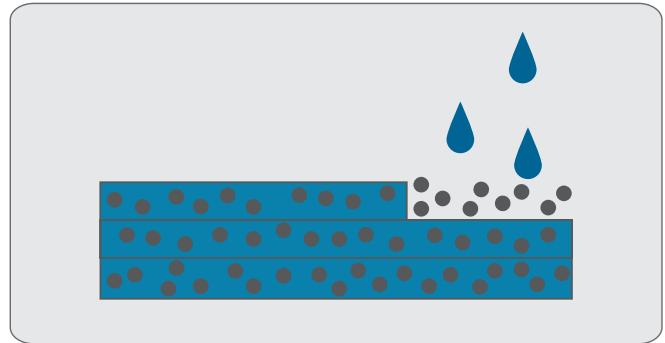
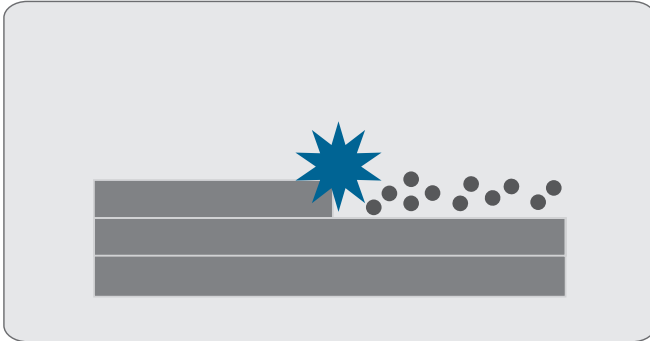
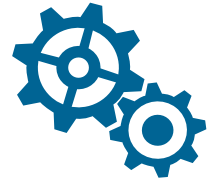
- > **Tantalum Alloys:** Ta-3W, Ta-10W
- > **Molybdenum Alloys:** TZM, Mo-La, Mo-Re
- > **Tungsten Alloys:** WHA, W-Re
- > **Niobium Alloys:** Nb C-103

## TYPICAL PROPERTIES OF AM POWDERS FOR PBF-L

	NIObIUM- C103	NIObIUM - 103	MOLYBDENUM	MOLYBDENUM
Type	LBPF	DED	LBPF	DED
Mean Particle Size D50	-50+15	-150+45	-50+15	-150+45
Bulk Density (g/cc)	>4.5	>4.5	>5	>5
Hall Flow (s/50g)	<15	<15	<15	<15
Oxygen (ppm)	<500	<400	<400	<300

## METHODS

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Cross sectional view of a high efficiency heat exchanger

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Binder jet printed tungsten heavy alloy components

With 3D printing being one of our focus growth areas, we are continuously expanding product functionality and always unlocking new refractory metal applications by taking advantage of AM design.

## MARKETS

Elmet Technologies' promise of highest quality and optimal performance make us an ideal partner for even the most critical application areas of AM refractory materials.

### Radiation Imaging

Elmet Technologies' diverse AM product portfolio includes 3D lead-free products for complex-geometry collimators and anti-scatter grids for CT scanners, SPECT and gamma cameras.

The high radiation attenuation, high elastic modulus and high temperature mechanical properties of our refractory metals are also used throughout the Medical Technology industry in applications such as:

- > Radiation/Isotope shielding
- > Beam collimation
- > High Temperature X-ray technology



Medical Imaging

### Aerospace and Defense

Elmet Technologies provides high performance AM solutions for critical applications in Aerospace and Defense industries including propulsion, ballistics and warheads.

Our refractory metals have robust physical and mechanical properties with high-density and high-temperature characteristics for the most demanding applications and products:

- > High temperature rocket nozzles and vanes
- > Counter-balance weights
- > Fragmentation warheads
- > EFP (Explosively Formed Penetrator) and MEFP liners



Space Propulsion

The reach of AM in end industries is expanding daily. Elmet Technologies' constant research into new applications and materials allows us to actively participate in the design of future solutions.

### Biomedical

AM offers definite performance advantages for various medical applications in its ability to form porous structures to enhance bone osteointegration, tailor material properties to enhance implant design, and reduce overall part mass.



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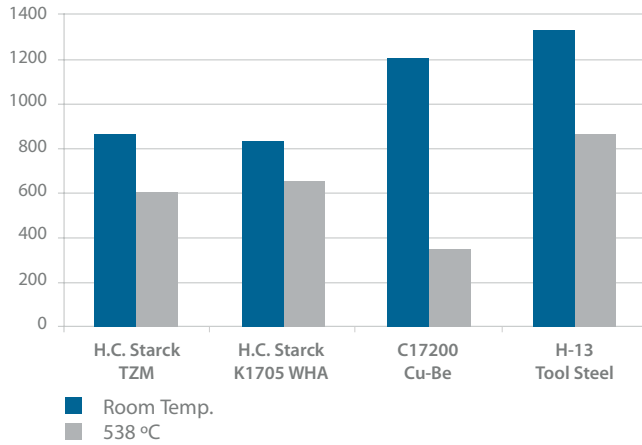


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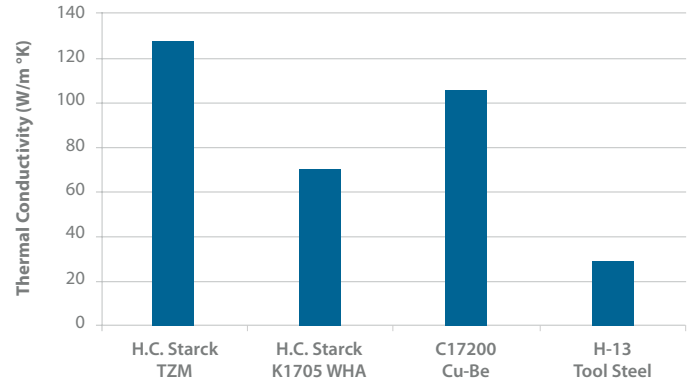
## COMPARISON OF HOT RUNNER NOZZLE MATERIALS

### Yield Strength



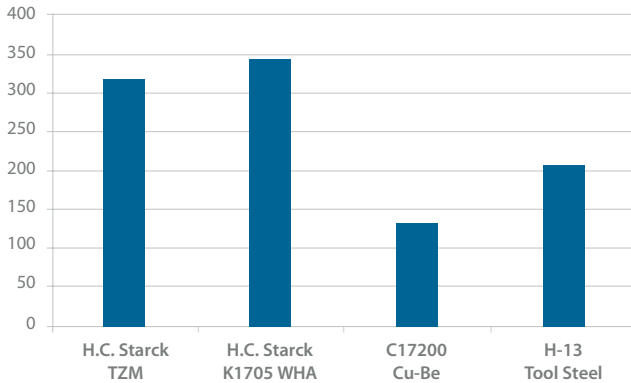
Elmet Technologies materials have higher stiffness than Cu-Be or H-13.

### Thermal Conductivity (Room Temp)



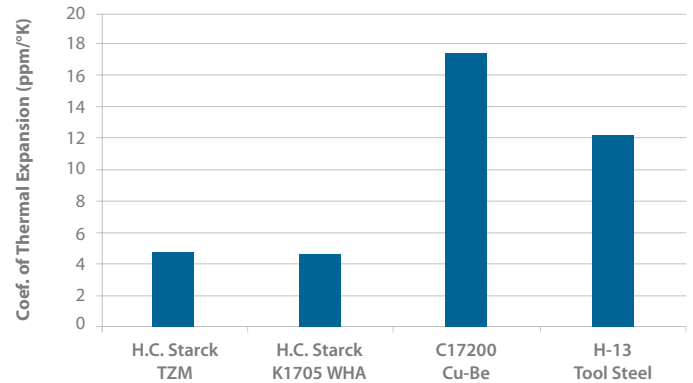
Elmet Technologies materials have much lower CTE than Cu-Be or H-13.

### Elastic Modulus



Elmet Technologies materials have higher stiffness than Cu-Be or H-13.

### Coefficient of Thermal Expansion (20-100 °C)



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