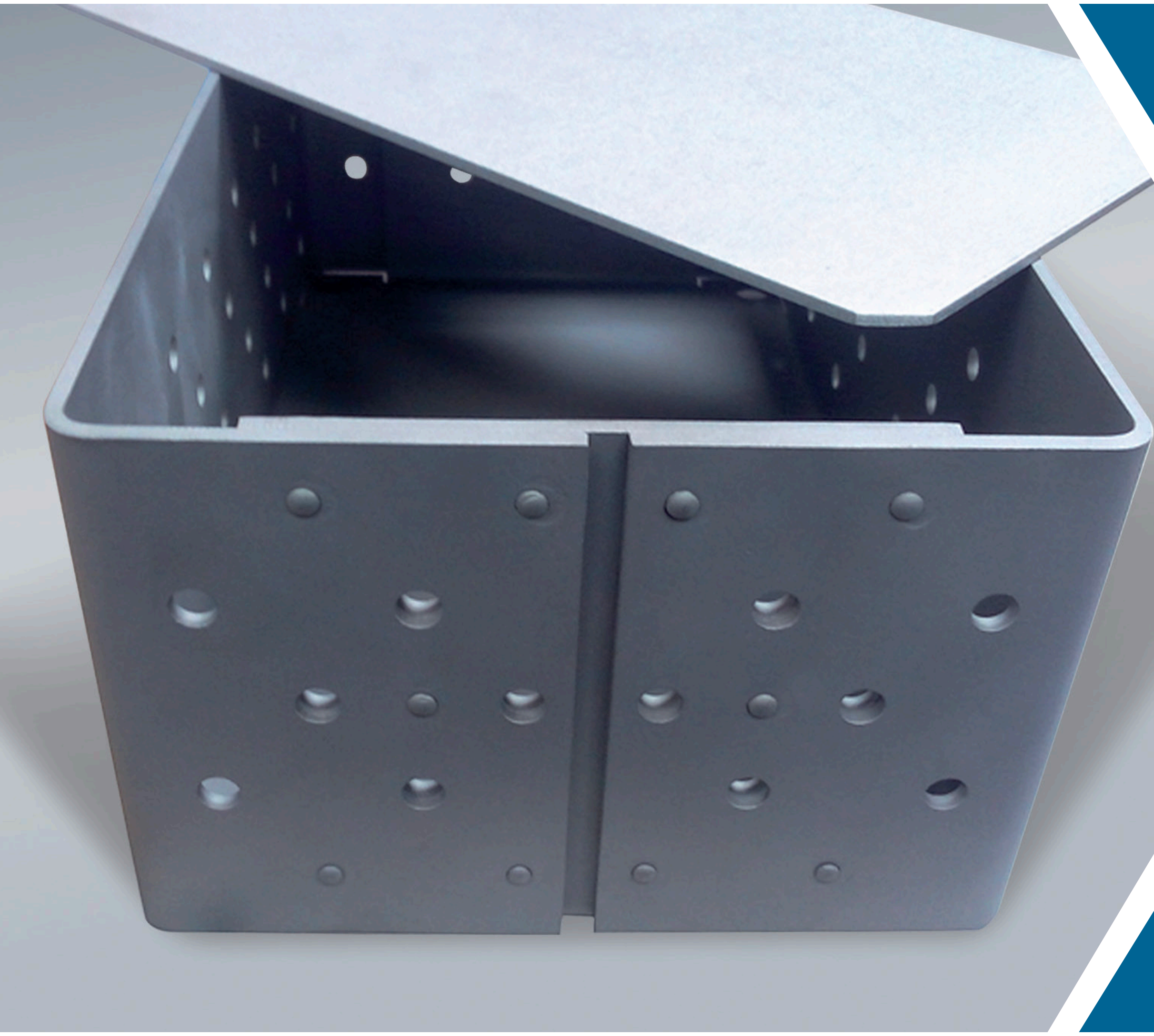
MOLYBDENUM AND TUNGSTEN FOR NUCLEAR FUEL PROCESSING



ELMET TECHNOLOGIES

With the latest in cutting-edge technology, zirconium and uranium raw materials can be easily and safely converted into finished components for nuclear fuel production to generate clean energy power.

Elmet Technologies' offers fabricated product solutions from molybdenum alloys and tungsten high density alloys:

> Sintering Boat
> Corrugated Sheets
> Spacer Sheet
> Frame
> Base Plate
> Heating Elements

Providing both build-to-print components and design assistance, Elmet Technologies' serves leading industries in energy, aerospace and medical.

Molybdenum-Lanthana (MoLa) Alloys

Elmet Technologies'' research team has developed and fabricated molybdenum-lanthana (MoLa) alloy components for high temperature sintering of nuclear fuels.

ODS MoLa contains lanthanum oxide (0.3 wt %, 0.6 wt. % and 1.1 wt. % lanthana) and is an oxide-dispersion strengthened material that contains a mixture of molybdenum with a very fine array or dispersion of lanthanum oxide particles. ODS MoLa has extraordinary resistance to recrystallization, improved ductility, and high-temperature formability.

These materials are applied in environments requiring dimensional stability and strength at temperatures above the capabilities of either pure molybdenum metal or TZM alloy.

Titanium-Zirconium-Molybdenum (TZM) Alloy

Elmet Technologies'' TZM (0.50 Ti, 0.08 Zr, 0.42 Mo) is consolidated by either the powder metallurgy or vacuum arc-casting processes. The titanium and zirconium carbides increase strength and creep resistance at elevated temperatures.

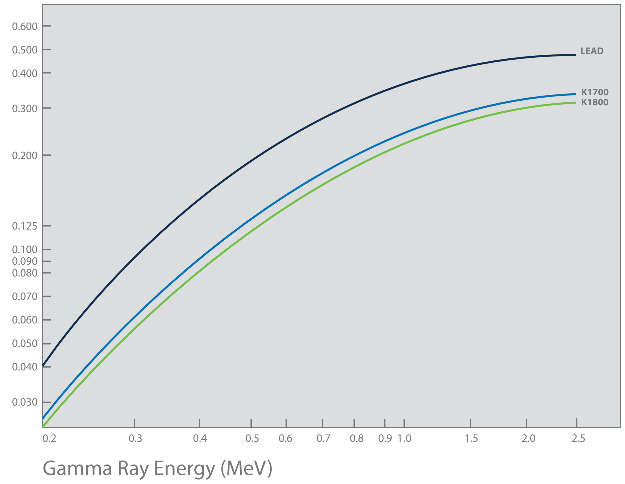
TZM molybdenum alloy also permits higher service temperatures without loss of toughness in comparison to pure molybdenum. Arc-cast material resists abrasion and is widely used for injection molding nozzles.

Tungsten Alloy Products

As a global leader in the manufacturer of high density tungsten alloys with radiation shielding, Elmet Technologies' offers complex-shaped components with density ranging from 17.2 to 18.5 g/cc per customer design.

In general, absorption of x-rays and gamma radiation is in direct proportion to the density of the shielding material. Elmet Technologies'' tungsten alloys are more than 1.5times as effective as lead and provide extremely efficient protection, particularly where space is limited.

Tungsten's Radiation Absorption Efficiency



Tungsten Alloys (K1700 thru K1850)

ALLOY DESIGNATION		K1700	K1701	K1750	K1800	K1801	K1850
Tungsten content (%)	(%)	90	90	92.5	95	95	97
Density	(g/cm^3)	17	17	17.5	18	18	18.5
	(lb/in^3)	0.61	0.61	0.63	0.65	0.65	0.67
Hardness	(Rc)	23	22	24	25	24	26
Ultimate Tensile Strength	(psi)	125,000	110,000	125,000	125,000	110,000	120,000
	(N/mm^2)	860	760	860	860	760	830
Yield Strength	(psi)	85,000	80,000	90,000	90,000	85,000	95,000
	(N/mm^2)	590	550	620	620	590	660
Elongation	(% in 1 inch)	12	4	10	8	2	6
Modulus of Elasticity	($psi \times 10^6$)	45	40	46	48	45	50
	(kN/mm^2)	310	280	320	330	310	345
Magnetic Properties		slight	none	slight	slight	none	slight
Magnetic Permeability	(μ)	> 1.05	< 1.05	> 1.05	> 1.05	> 1.05	> 1.05
Thermal Expansion Coefficient	(×10-6/0 °C) (200 °C – 5000 °C)	5.1	5.4	4.9	4.8	5.0	4.8
Thermal Conductivity	(cgs)	0.20	0.23	0.24	0.27	0.32	0.26
Electricial Conductivity	(% IACS)	11	14	12	15	16	16
MIL-T-21014(D)	class	1	1	2	3	3	4
ASTM B777	class	1	1	2	3	3	4

Exceeds requirements of the following specifications: MIL-T-21014, ASTM B777 and AMS 7725

Typical Properties of Tungsten Composite Materials (HPM 1700 thru HPM 1850)

INSPECTION CRITERION	DIMENSION	HPM 1700	HPM 1710	HPM 1701	HPM 1705	K1801	HPM 1750 SHEET
Tungsten content	%	90.0	90.0	90.0	90.0	92.5	92.5
Density	g/cm^3	17.0 ± 0.2	17.0 ± 0.2	17.0 ± 0.2	17.3 ± 0.2	17.5 ± 0.2	17.6 ± 0.2
Hardness	HV 30	≤ 320	≤ 320	≤ 320	≤ 360	≤ 325	≤ 460
Tensile Strength (Typical Value)	MPa	850	850	670	900	840	870
Minimal Yield Strength	MPa	520	520	520	520	520	520
Elongation (Typical Value)	%	12	12	3	8	14	16
Young's Modulus (Average Value)	GPa	320	320	300	330	340	340
Median Coefficient of Linear Thermal Expansion 20 – 100 °C 20 – 300 °C 20 – 450 °C	 10-6/K 10-6/K 10-6/K	 6.1 6.2 6.3	 6.3 6.5 6.6	 6.0 6.2 6.4	 4.5 5.1 5.3	 5.5 5.7 5.8	 5.5 5.7 5.8
Thermal Conductivity	W/mK	12	≥ 70	≥ 90	≥ 70	≥ 75	≥ 75
Electrical Conductivity (Average Value)	%IACS MS/m	11 6.4	11 6.4	14 8.1	13 7.5	12 6.9	12 6.9
Specific Electrical Resistance (Average Value)	μΩm	0.16	0.16	0.12	0.13	0.15	0.15
Permeability μ		> 1.05	> 1.05	< 1.05	> 1.05	> 1.05	> 1.05

INSPECTION CRITERION	DIMENSION	HPM 1751	HPM 1760	HPM 1800	HPM 1810	HPM 1801	HPM 1850	HPM 1850W
Tungsten content	%	92.5	92.5	95.0	95.0	95.0	97.0	97.0
Density	g/cm^3	17.5 ± 0.2	17.6 ± 0.2	18.0 ± 0.2	18.0 ± 0.2	18.0 ± 0.2	18.5 ± 0.2	18.5 ± 0.2
Hardness	HV 30	≤ 325	≤ 325	≤ 332	≤ 332	≤ 332	≤ 340	£ 340
Tensile Strength (Typical Value)	MPa	690	870	830	830	700	830	890
Minimal Yield Strength	MPa	520	520	520	520	520	520	520
Elongation (Typical Value)	%	3	16	14	14	2	12	12
Young's Modulus (Average Value)	GPa	330	340	370	370	330	380	380
Median Coefficient of Linear Thermal Expansion 20 – 100 °C 20 – 300 °C 20 – 450 °C	10-6/K 10-6/K 10-6/K	5.7 5.8 5.9	5.5 5.8 5.9	4.9 4.9 5.2	5.2 5.3 5.5	5.4 5.5 5.6	5.1 5.1 5.2	4.8 4.9 5.0
Thermal Conductivity	W/mK	≥ 85	≥ 75	≥ 80	≥ 80	≥ 85	≥ 75	≥ 80
Electrical Conductivity (Average Value)	%IACS MS/m	15 8.5	12 6.9	13 7.7	13 7.7	15 9.0	12 6.9	16 9.3
Specific Electrical Resistance (Average Value)	µΩm	0.12	0.15	.14	0.14	0.11	0.15	0.10
Permeability µ		< 1.05	> 1.05	> 1.05	> 1.05	< 1.05	> 1.05	> 1.05

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