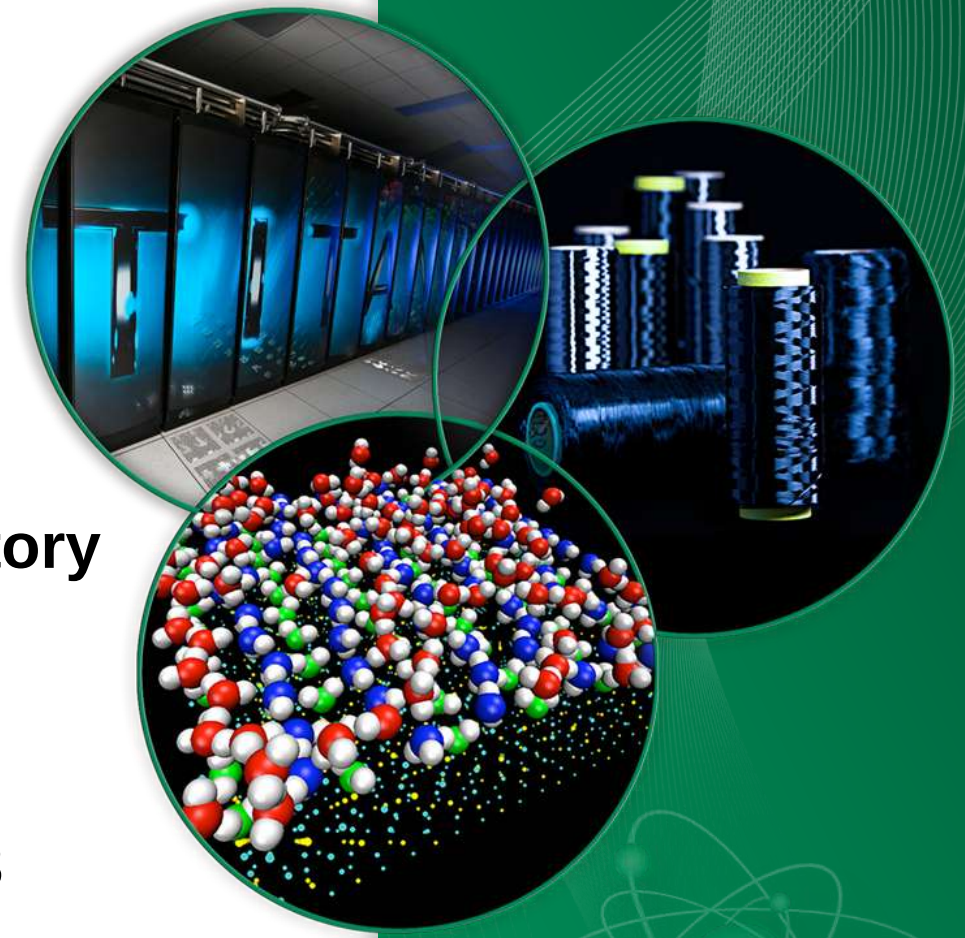
Compaction and Sintering of Mo Powders

Stephen D. Nunn
James O. Kiggans, Jr.
Chris Bryan

Oak Ridge National Laboratory



Mo-99 Topical Meeting 2013

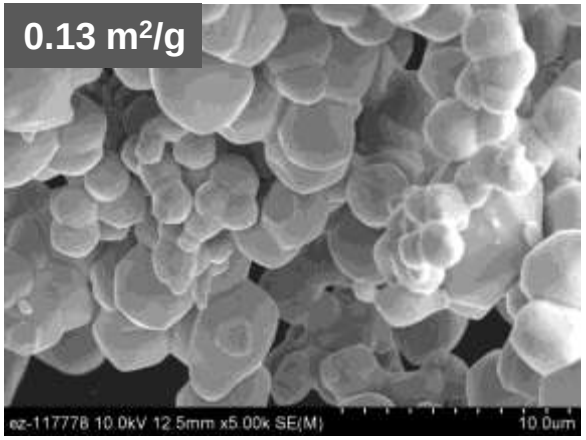
April 1-4, 2013

Purpose of the Project

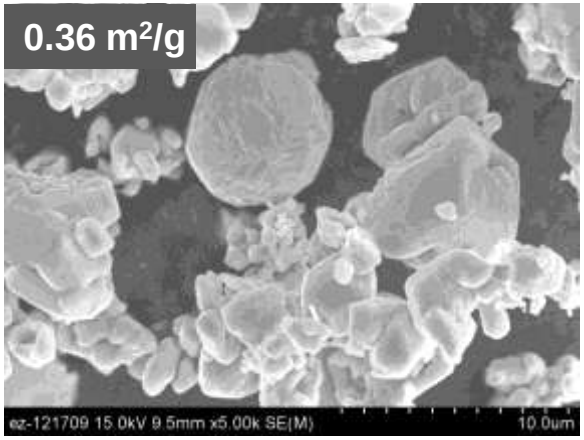
- **Support NorthStar Mo-99 production method**
- **Understand fabrication of Mo-100 target disks that are used to produce Mo-99 via the (γ, n) reaction in an electron accelerator**
- **Develop a process for making target disks with a density of 90% or greater**
- **Identify disk characteristics that increase the dissolution rate of target disks**
- **Develop a process for recycling Mo-100 from spent Mo-99 material**

Mo Powders – Morphology and Surface Area

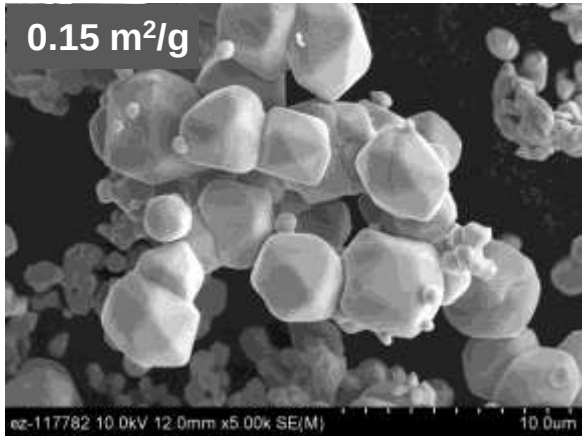
Alfa-Aesar



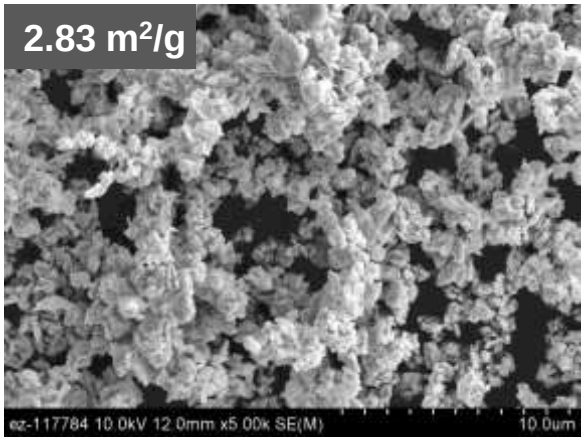
Atlantic Equip. Eng.



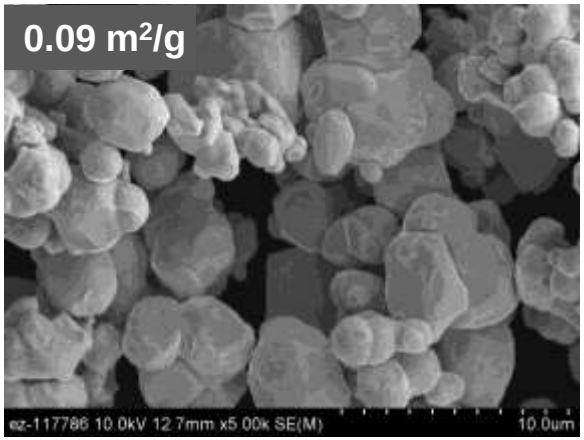
Climax Mo EM2



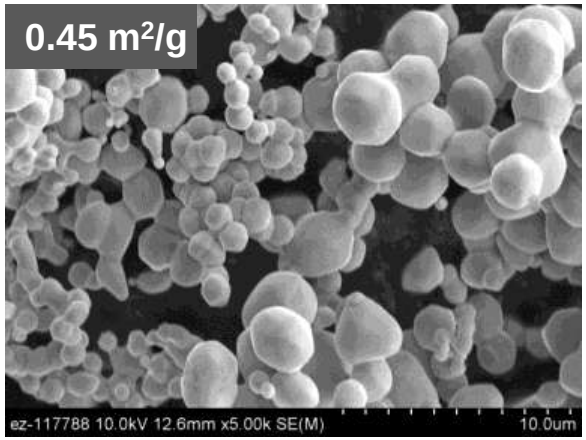
Climax Mo EM-NM3



Climax Mo HDFM



Climax Mo NPA



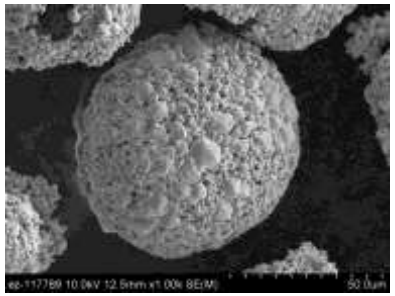
Powders vary in particle size, shape, agglomeration, and surface area

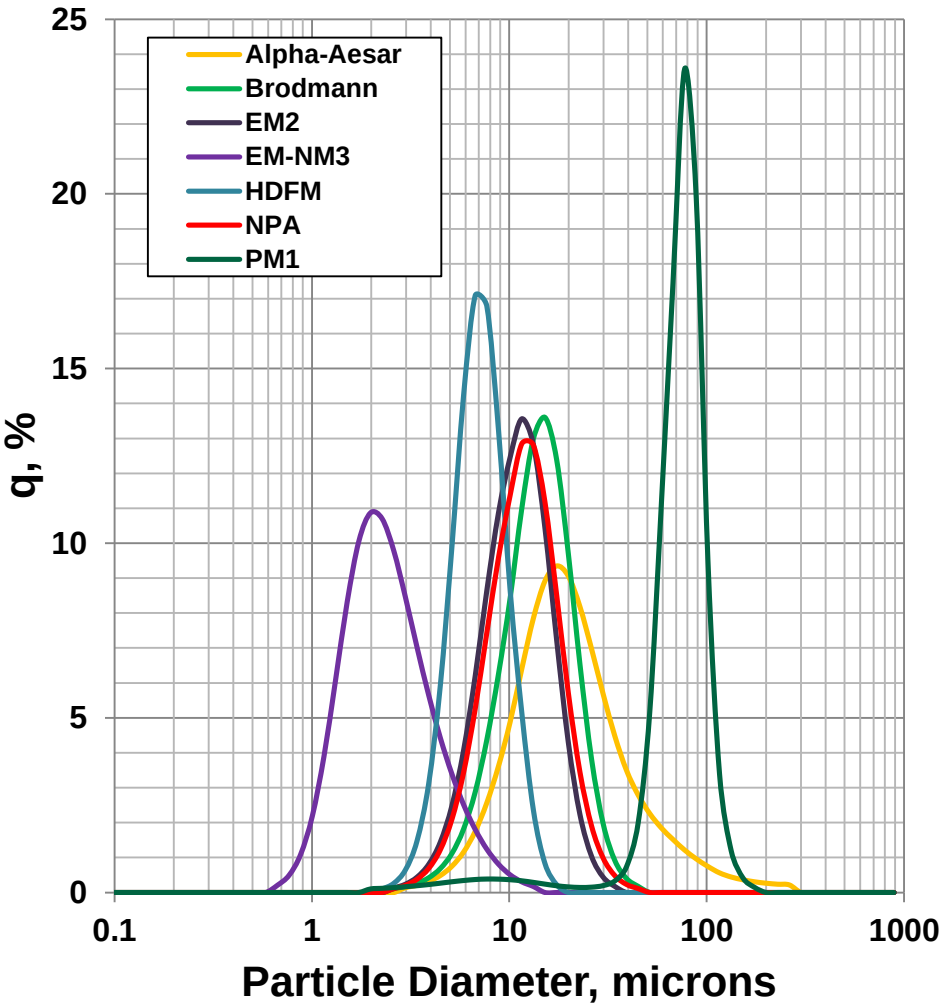
Mo Powders – Particle Size

Powder	Median Size	Mean Size
Alfa-Aesar	17.8	25.4
Brodmann	13.2	13.9
EM2	10.3	10.9
EM-NM3	2.1	2.4
HDFM	6.6	6.9
NPA	11.0	11.9
PM1	70.7	69.8

Climax PM1

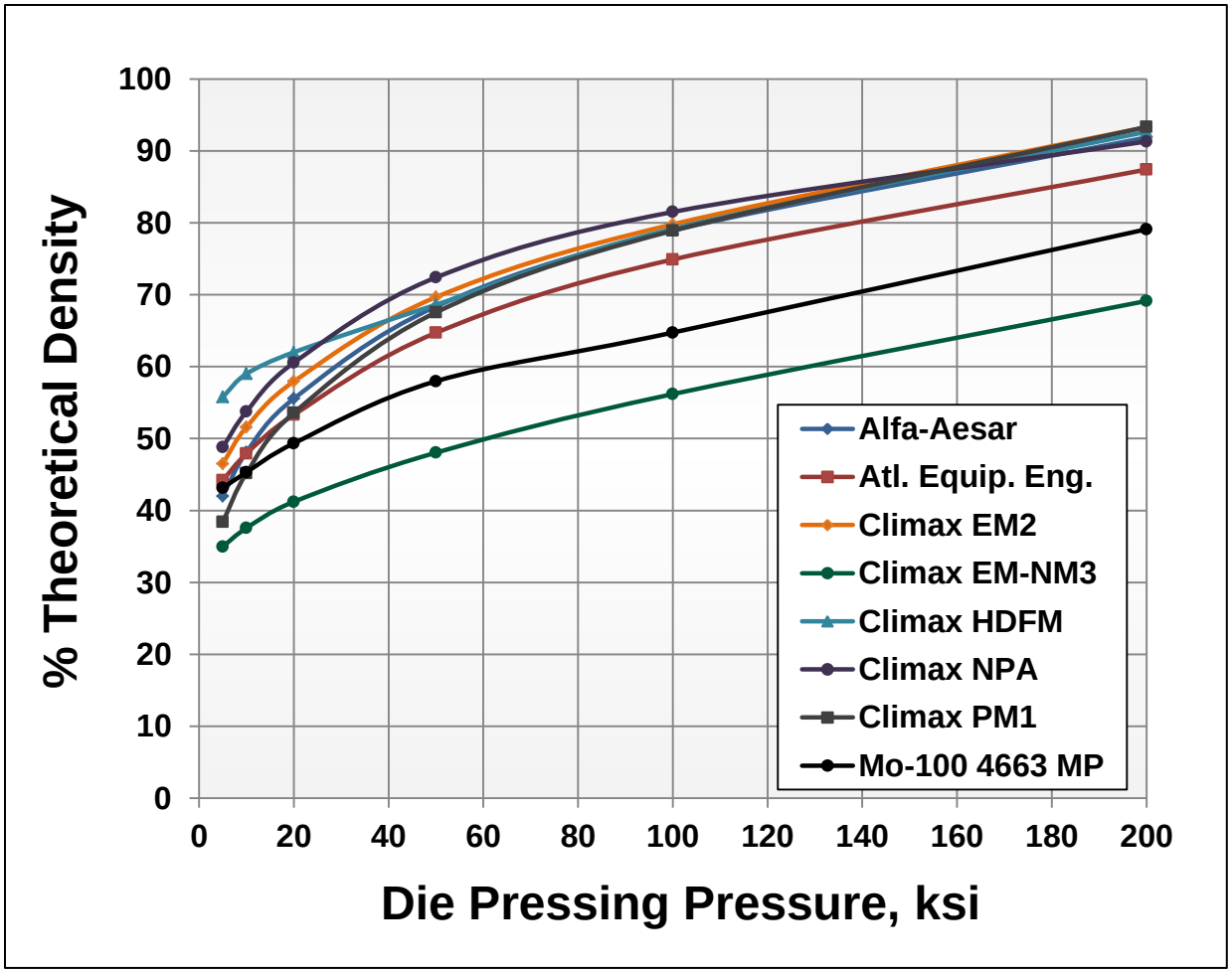
35 μm





Average particle size measurement is dominated by the agglomerate size in the powders

Mo Powders – Compaction Density



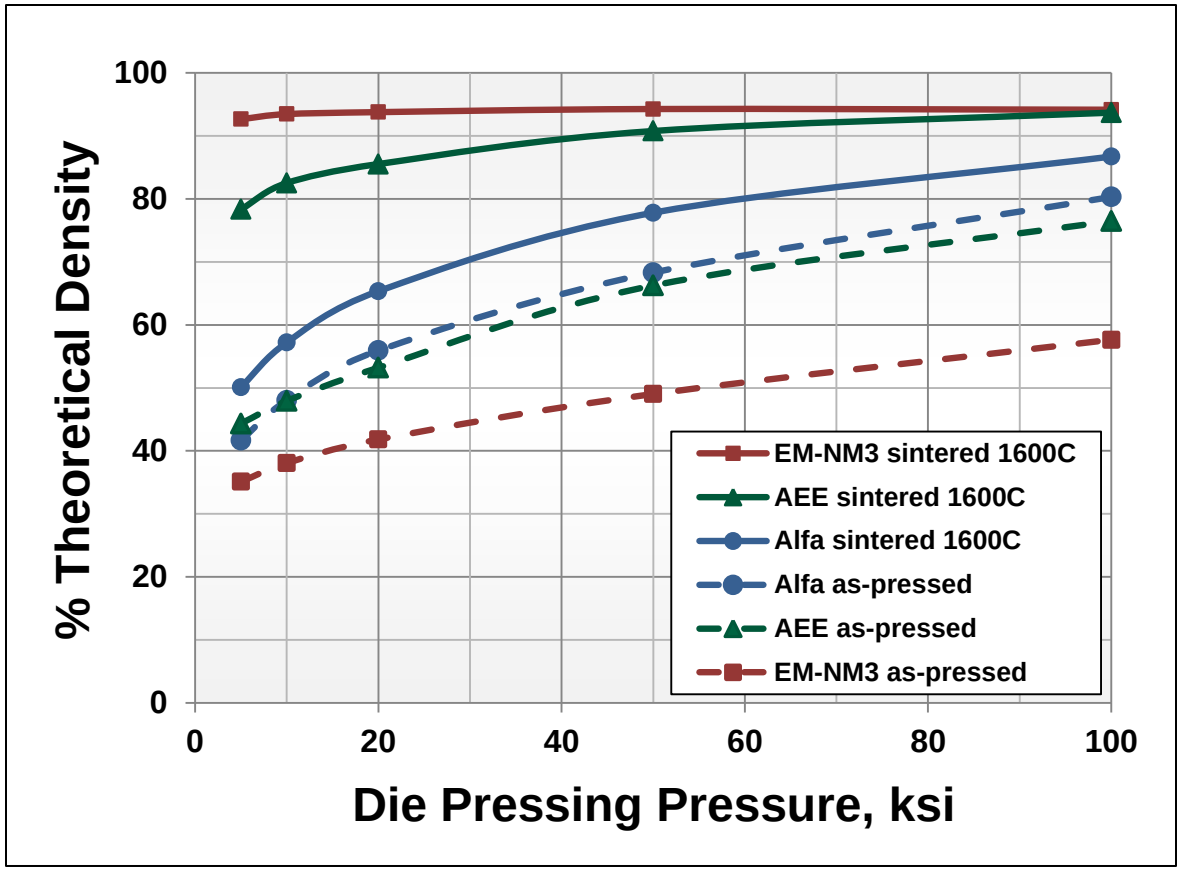
Hydraulic Press and Steel Die

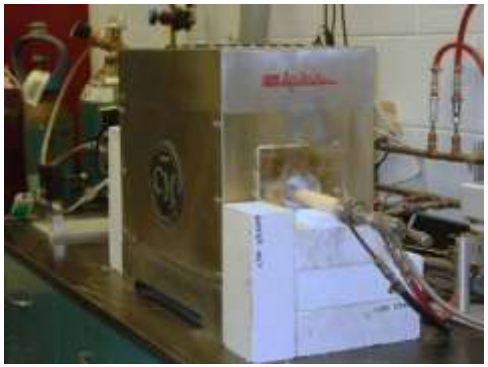
Pressed Disks

Powder particle characteristics affect the compaction density after cold pressing

Mo Powders – Sintering Kinetics

Disks sintered at 1600°C for 1 hr.



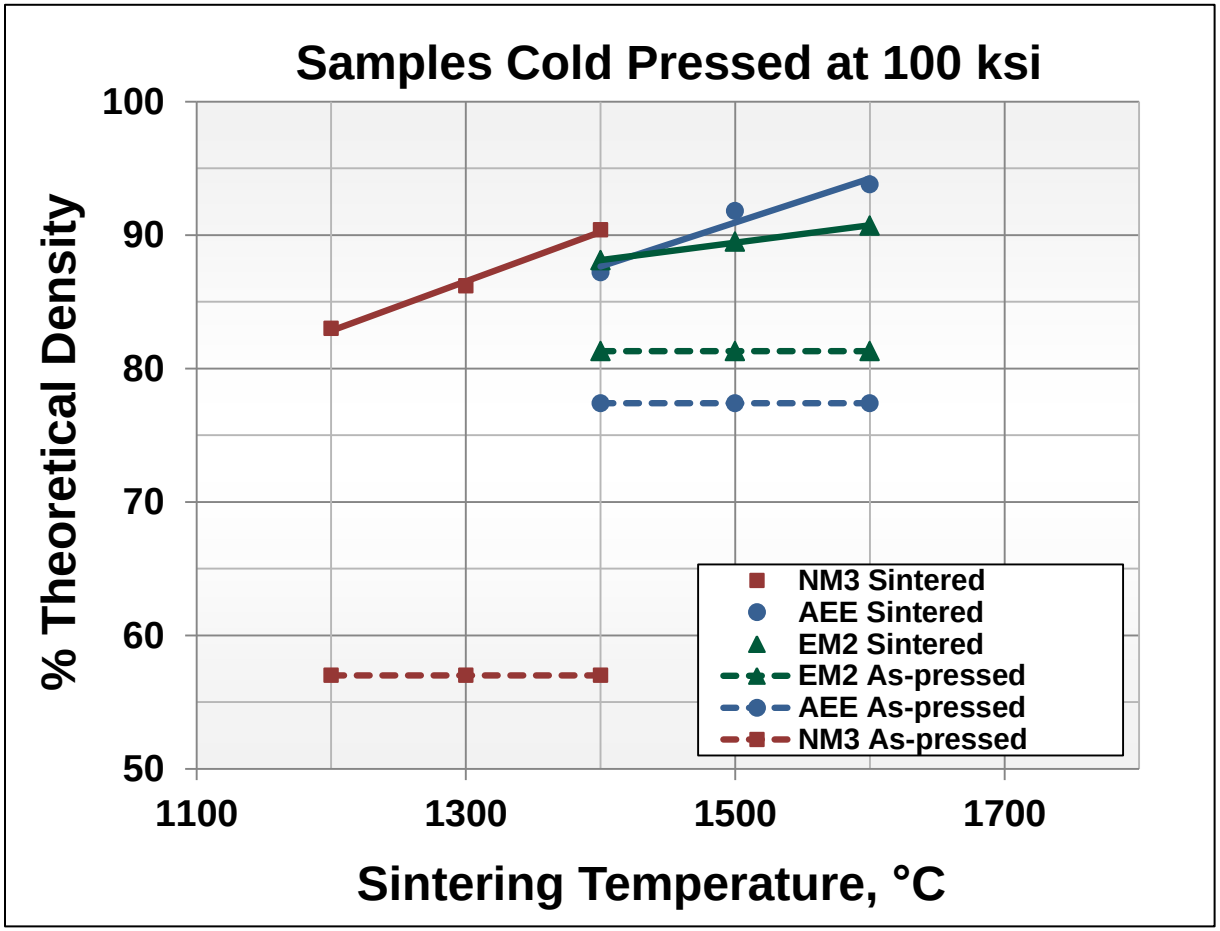


Tube Furnace

Sintered Disks

The sintering kinetics of pressed disks vary with powder particle characteristics

Mo Powders – Sintering Temperature Effect for Different Powders



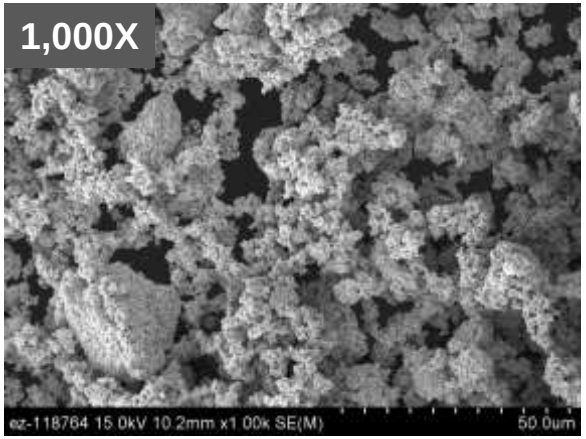
Density increase with 200°C change in temperature:

NM3	7.4%
AEE	6.6%
EM2	2.6%

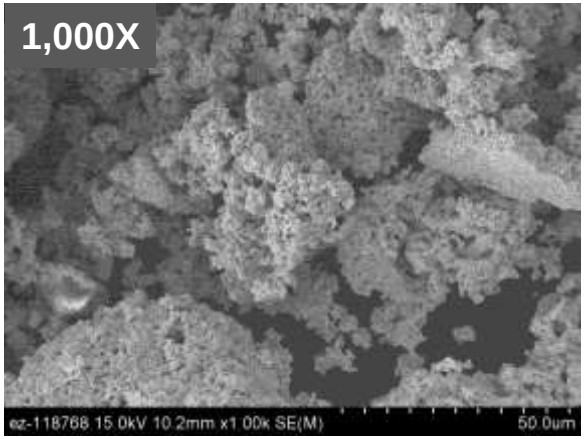
Temperature response varies with powder characteristics

Mo-100 Powders – Morphology

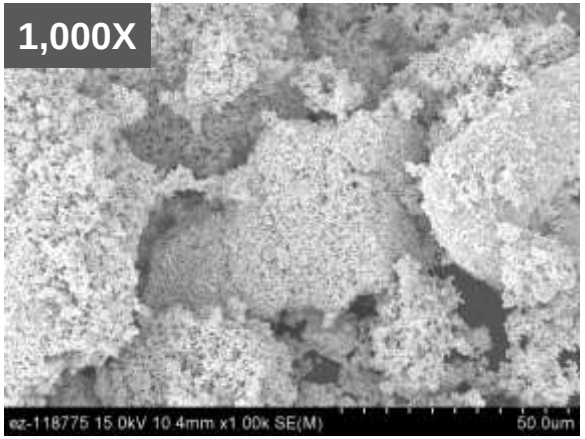
Lot 3857



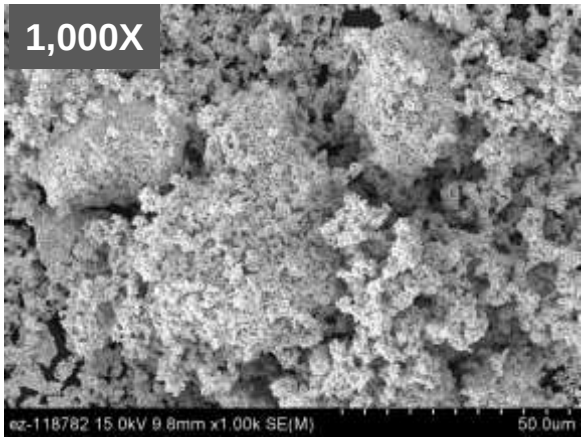
Lot 3955



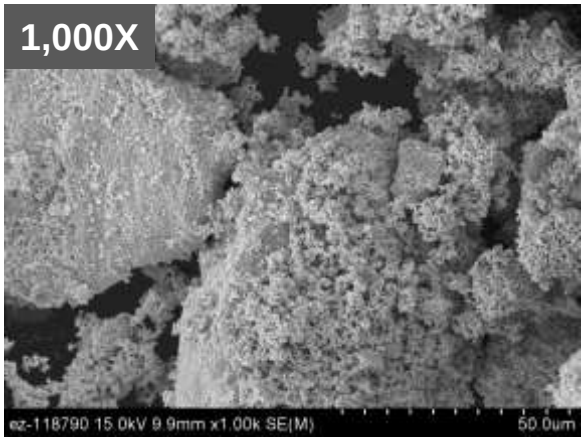
Lot 4178



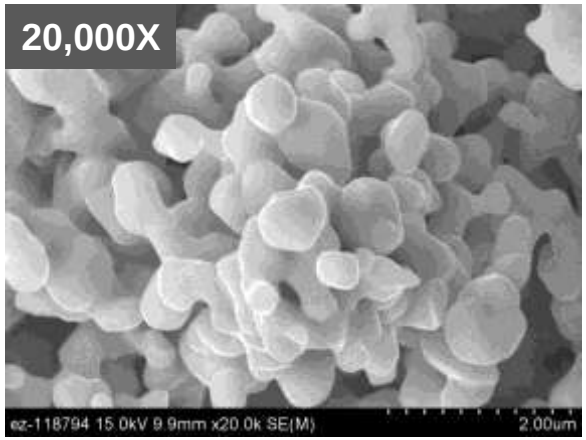
Lot 4381



Lot 4663

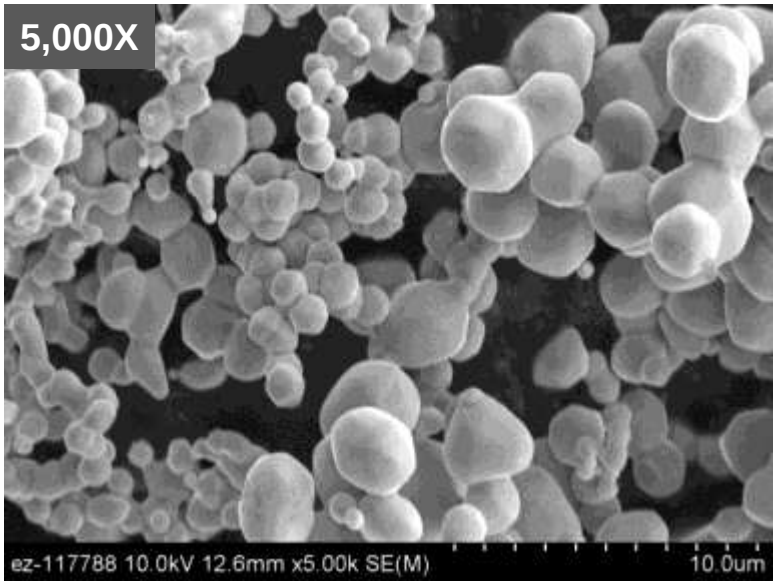


Lot 4663



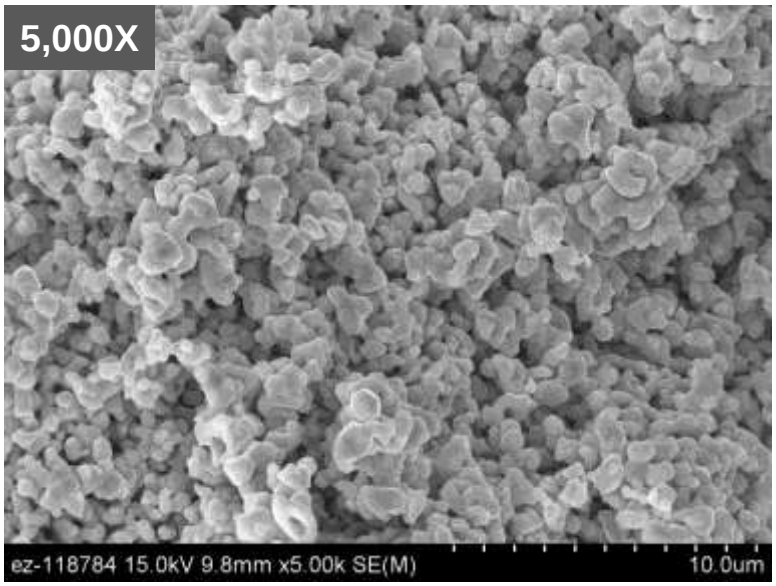
IsoFlex Mo-100 lots showed uniform primary particle size with variation in the degree of agglomeration

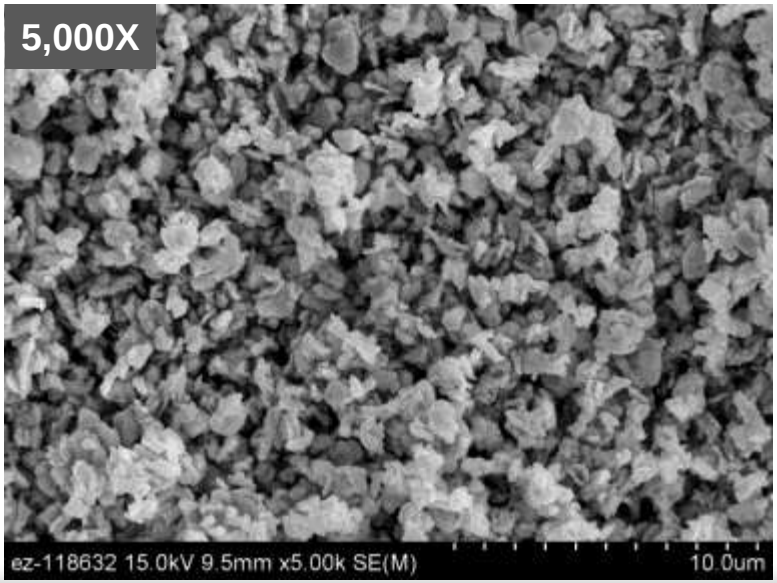
Mo-100 Powder – Comparison to Natural Mo



Climax Mo Type NPA
Surface Area = 0.45 m^2/g

IsoFlex Mo-100-4381
Surface Area = 1.17 m^2/g

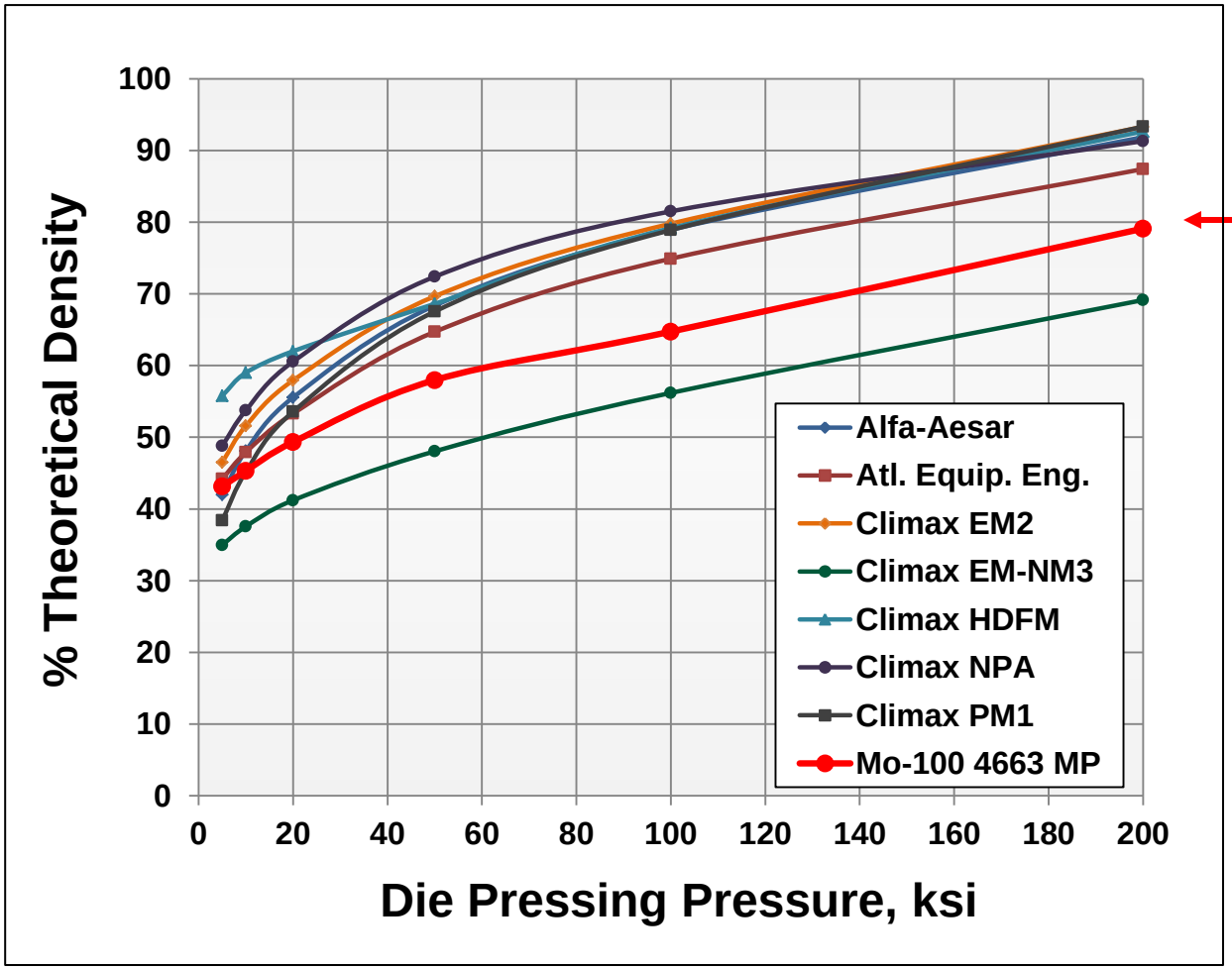




Mo-100 powders show intermediate characteristics

Climax Mo Type EM-NM3
Surface Area = 2.85 m^2/g

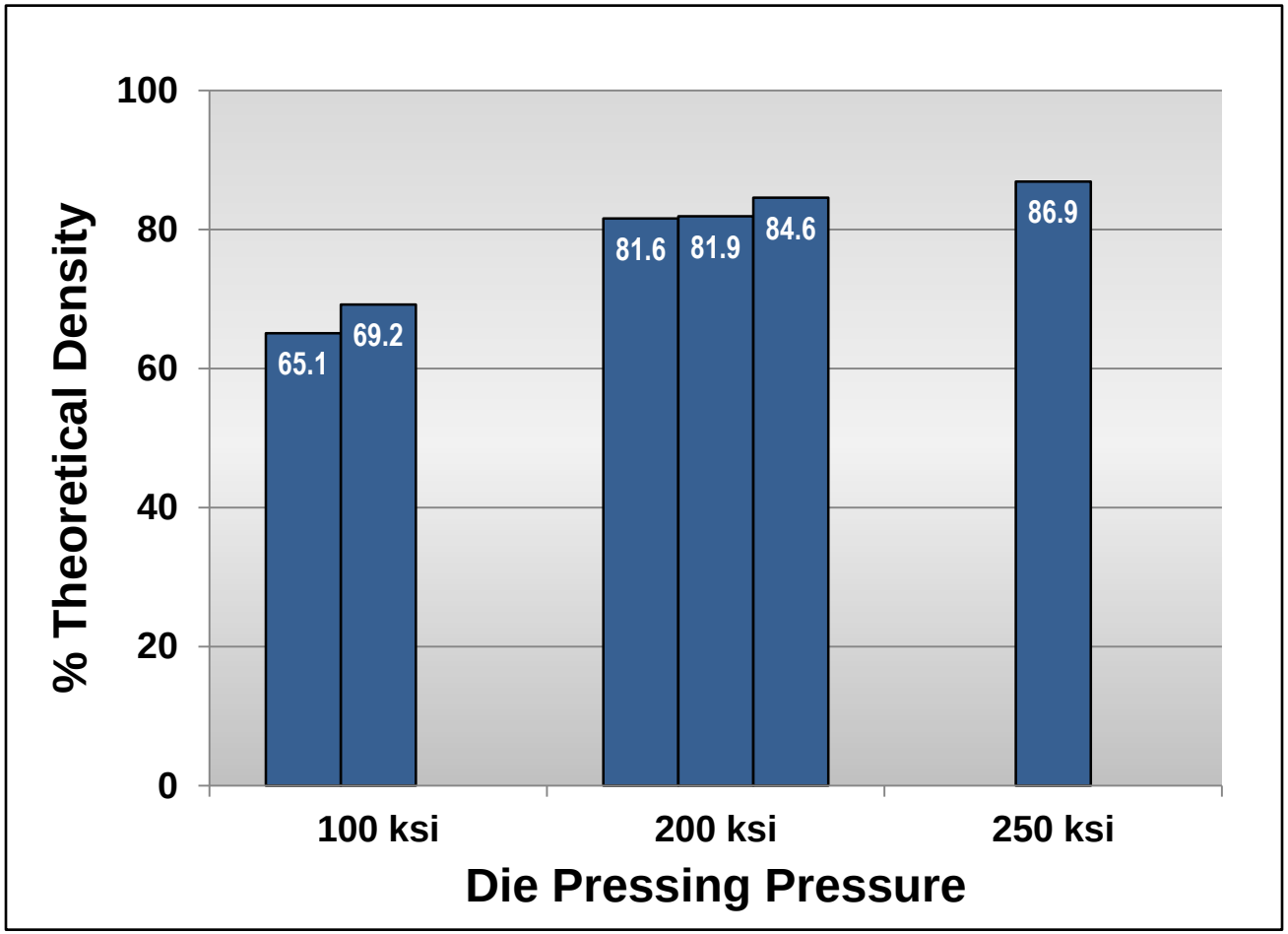
Mo-100 Powder – Compaction Density



Mo-100 powder compaction density is intermediate within the range observed for natural Mo powders

Mo-100 Powder – Compaction

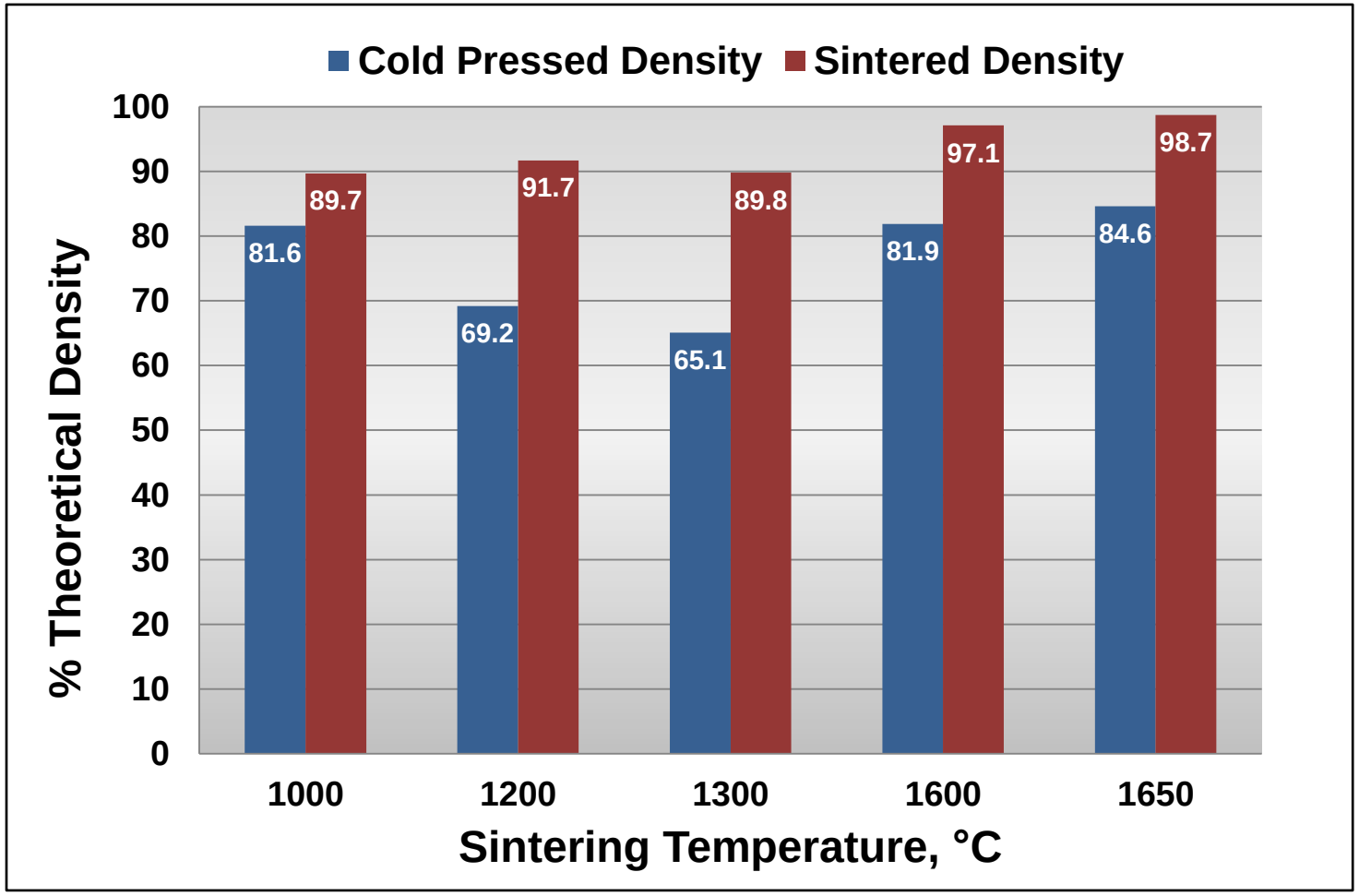
Cold Pressing of Mo-100 Powder from Multiple Lots



Mo-100 lots show some variability in as-pressed density

Mo-100 Powder – Sintering

Sintering of Mo-100 Powder from Multiple Lots



Mo-100 was sintered to ≥90% density

Summary

- **Mo powders of different types show variations in the powder characteristics: particle size, shape, surface area, and agglomeration**
- **Powder characteristics have an effect on the density of cold compacted and sintered disks**
- **Many of the natural Mo powders were cold pressed directly to 90% density or greater**
- **All Mo powders, including Mo-100, could be sintered to 90% density or greater**

Future Work

- **Define processing parameters for fabricating Mo-100 target disks**
- **Identify primary characteristics which determine the dissolution rate of target disks**
- **Develop a process for converting Mo-100 that is recovered from spent target disks as MoO_3 to Mo metal powder for processing into new target disks**