



Manufacture of ODS Alloys by Mechanical Alloying ... Processing and Applications

**Huntington Alloys
Special Metals Corporation
a PCC Company**



ODS High Temperature Alloys

- Superior strength and creep resistance at highly elevated temperatures**
- Improved heat resistance over conventional solid solution Ni-Cr alloys**
- Increase in usage range from 200 to 300°F over conventional solid solution alloys**
- Fe-Cr-Al alloy offered unique heat resistance, even to sulfidation**

SMC ODS Alloys

Chemical Composition

Alloy	Ni	Cr	Fe	Al	Ti	Y₂O₃	Others
MA754	Bal.	20	1	0.3	0.5	0.6	---
MA758	Bal.	30	1	0.3	0.5	0.6	---
MA6000	Bal.	15	1	4.5	2.5	1.1	W-4; Mo-2
MA956	---	20	Bal.	4.5	0.5	0.5	---

INCOLOY MA956 Tubing



Production of INCOLOY MA956 Tubing

- **Manufacture powder**
- **Characterize & blend**
- **Fill, evacuate & seal cans**
- **Soak / sinter / homogenize**
- **Extrude**
- **Cut, straighten, deglass & pickle**
- **Cold work - pilger or draw**
- **Anneal, pickle, straighten & cut**
- **Test & certify**

INCOLOY MA956 Tubing

Sizes Manufactured at SMWL – Hereford, UK

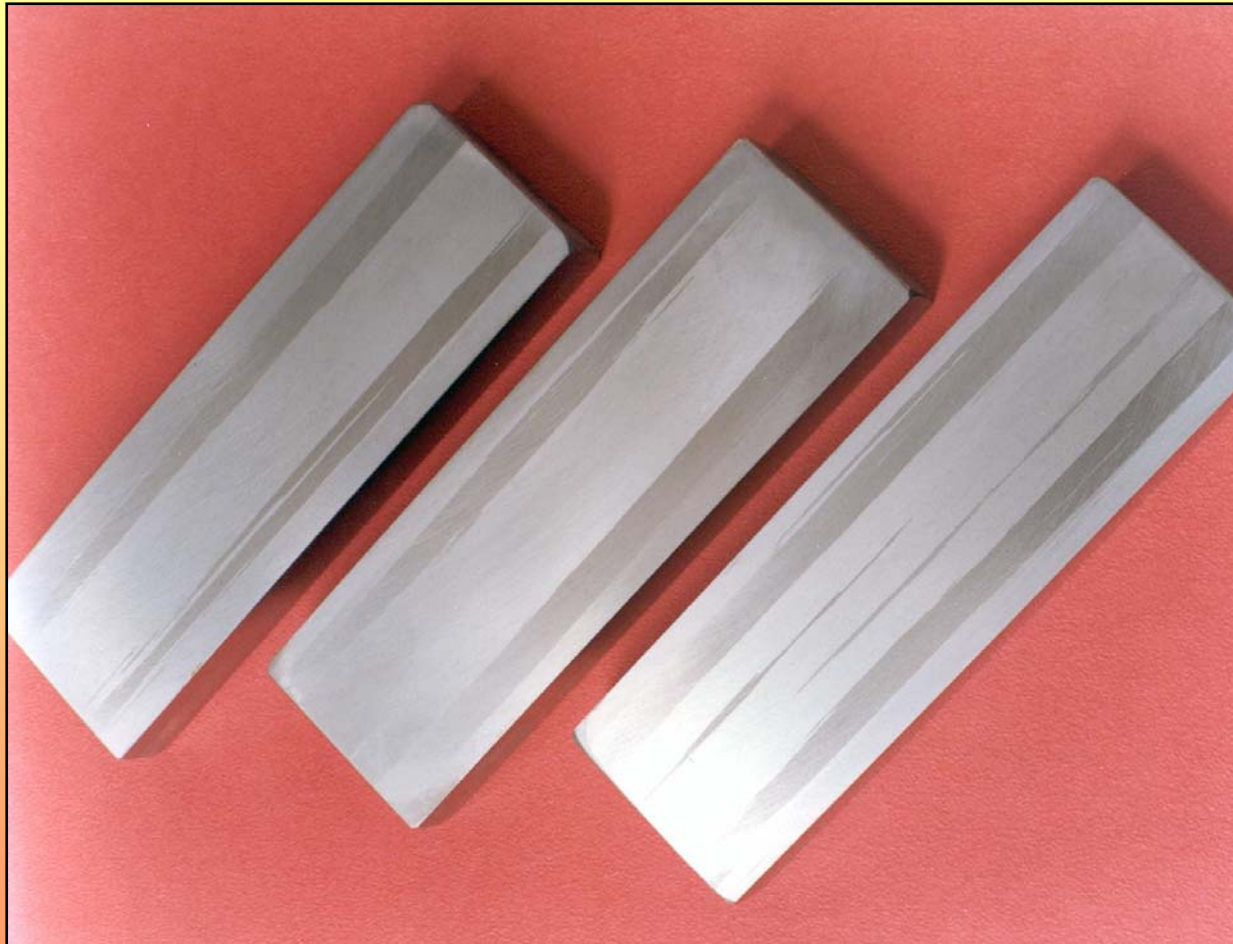
Largest - 114 mm OD X 6 mm AW
(4.5" OD X 0.236" AW)

Smallest - 25 mm OD X 2 mm AW
(1.0" OD X 0.78" AW)

Smaller tubes made by specialist redrawers

INCOLOY alloy MA956

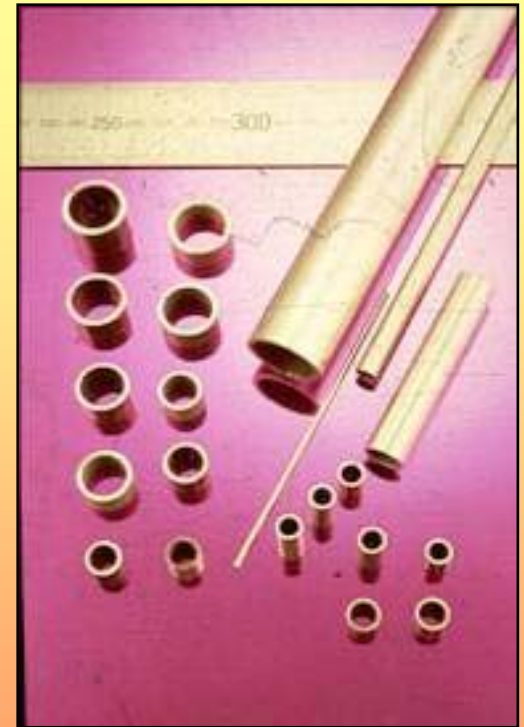
Elongated Grain Structure



INCOLOY MA956 Flow Formed Tube Longitudinal Microstructure (50X)



INCOLOY MA956 Tubes

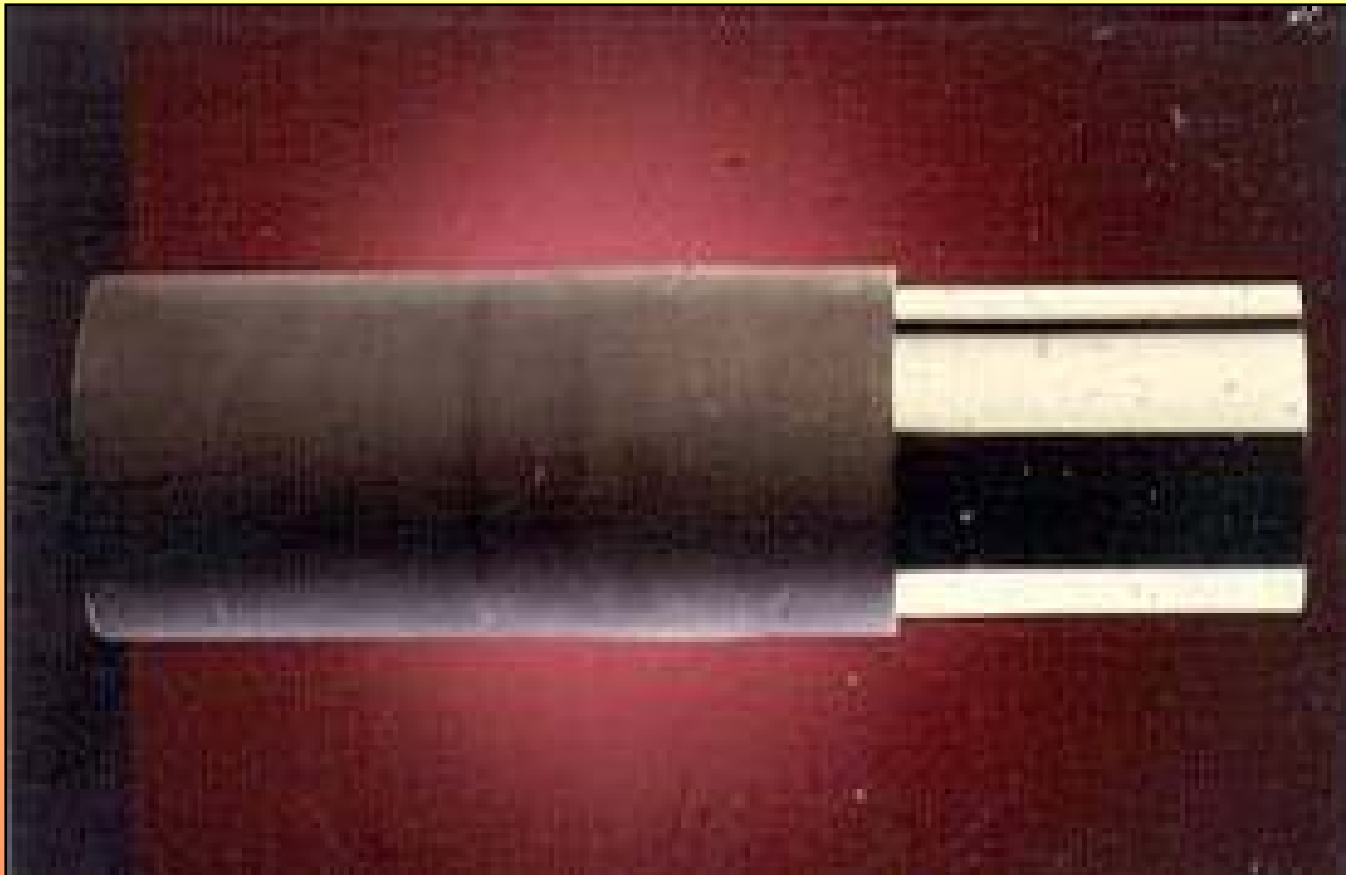


INCOLOY MA956

Flow Formed Tubes



***INCOLOY MA956 Tube
Explosively Bonded to an
INCOLOY alloy 800H Tube***



INCOLOY alloy MA956

Tubes Joined by Friction Welding



Weld Clad Tube



INCOLOY MA956
Rolled & Riveted Tube



Applications for MA ODS Alloys

Aerospace

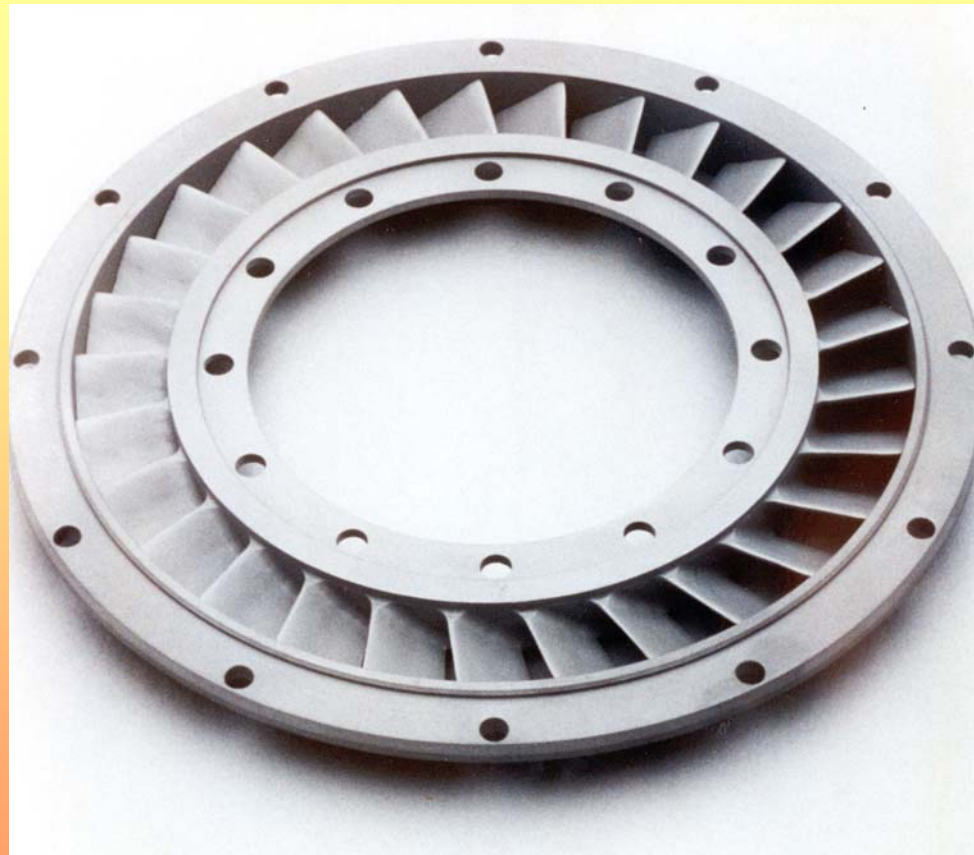
- **Vanes and bands** - GE and Honeywell engines. MA754. Primarily military. Texture criticality. Either machined from rolled bar or forged by GE or Doncasters (UK). About 2M lbs. delivered. Replaced by single crystal castings ~2005.
- **Blades** - Rolls-Royce / Allison Military engines. MA6000 blades forged by Doncasters. Lost out to single crystal casting.

Applications for MA ODS Alloys

Aerospace

- **Combustors and nozzles** - NASA, GE and Rolls-Royce. MA956 and MA754. Numerous projects over 15-yr period. Proposed Title III project to support F22 engine dropped when engine down-rated for stealth capability. Several classified USAF applications.
- **Thermal protection systems** - Honeycomb construction using MA956 foil. Classified.

INCOLOY MA956
Turbine Nozzle for WR24 7 Engine



INCOLOY MA956

Transition Liner



INCONEL MA754

Stator Blade for GE Engine

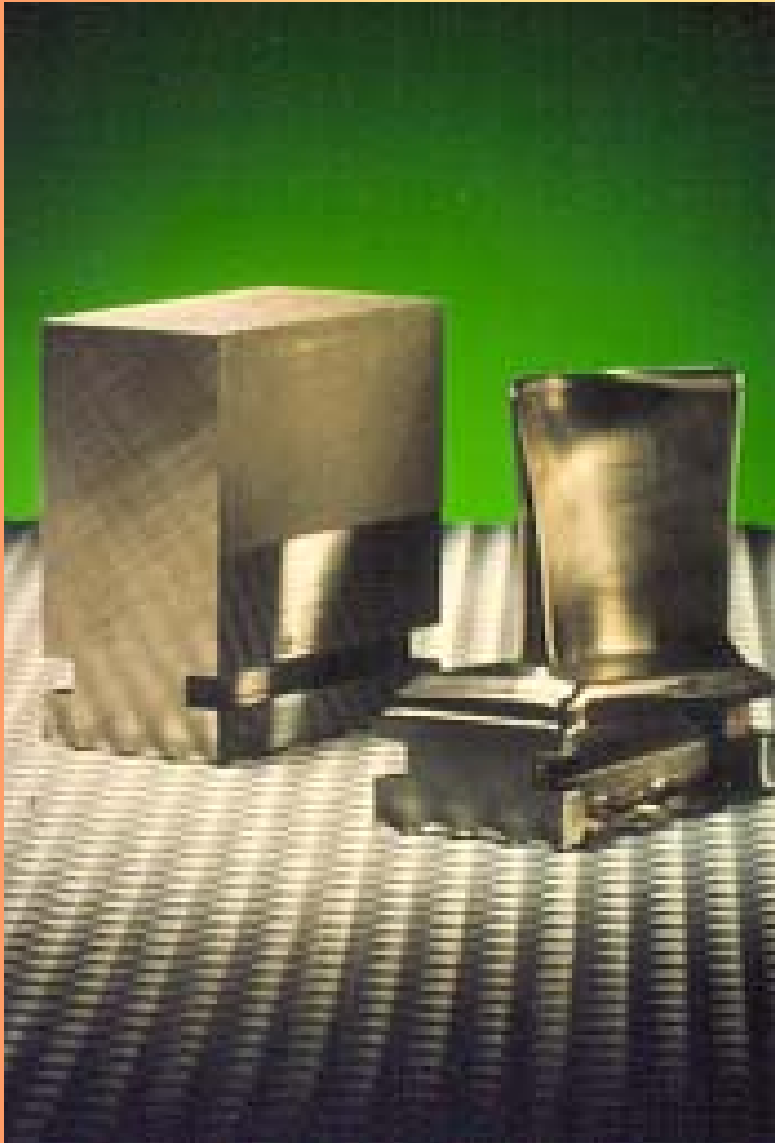


Applications for MA ODS Alloys

Industrial Gas Turbines

- **Vanes - ABB / Alstom)** - MA6000 and MA760. Intense development program in 1980's. Never commercialized.
- **Other Components** - GE, Solar, Siemens, Westinghouse, ABB, Mitsubishi, Hitachi, Toshiba. MA956. Never commercialized

INCONEL MA6000 LBGT Turbine Blade



Applications for MA ODS Alloys

Glass Production

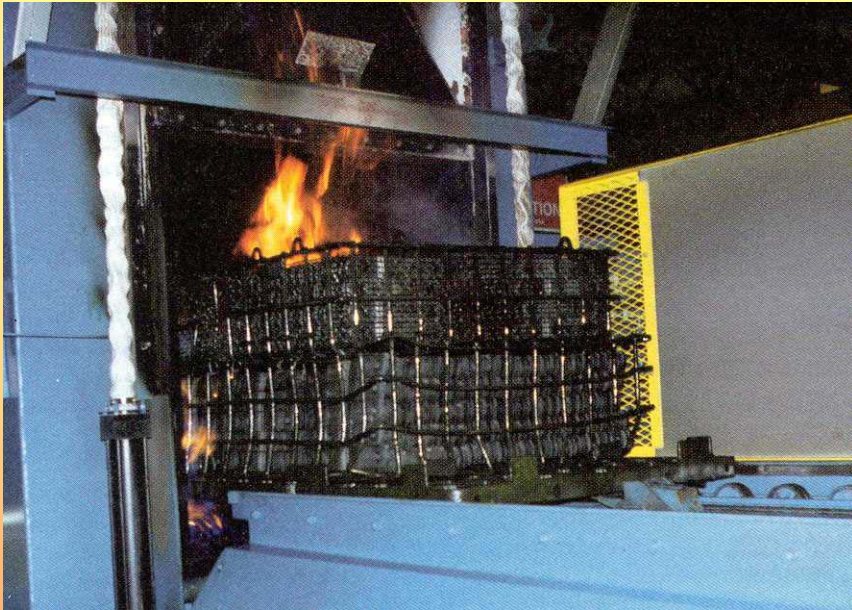
- **Fiberglass Spinners** - Owens-Corning, Pilkington, San Gobain. MA758, EX3010. Bowl shaped spinner. Replacing cast cobalt-base alloys. Limited commercial production. Problem was reproducible production of desired microstructure by hot shear spinning.
- **Drawn Fiberglass** - MA754. Continuing small one-company application.
- **Radioactive Waste Vitrification** - Various components such as stirrers and gas pipes. MA758. USA DOE and France. Continuing application.

Applications for MA ODS Alloys

Industrial Equipment

- Radiant Heaters - MA956**
- Reactor vessels - MA956**
- Gas fired heat treatment muffles - MA956**
- Combustion fans - MA956**
- Ethylene production reactor tubes - MA956**
- HIP shields and muffles - MA956**
- Impellers for floating zone annealing furnaces - MA754**
- Steel heating furnace skid rails - MA956, MA758**
- Laboratory testing grips & hardware - MA754, MA6000**

Heat Treating Baskets



INCOLOY MA956 Furnace Muffle for Manufacture of Ceramics

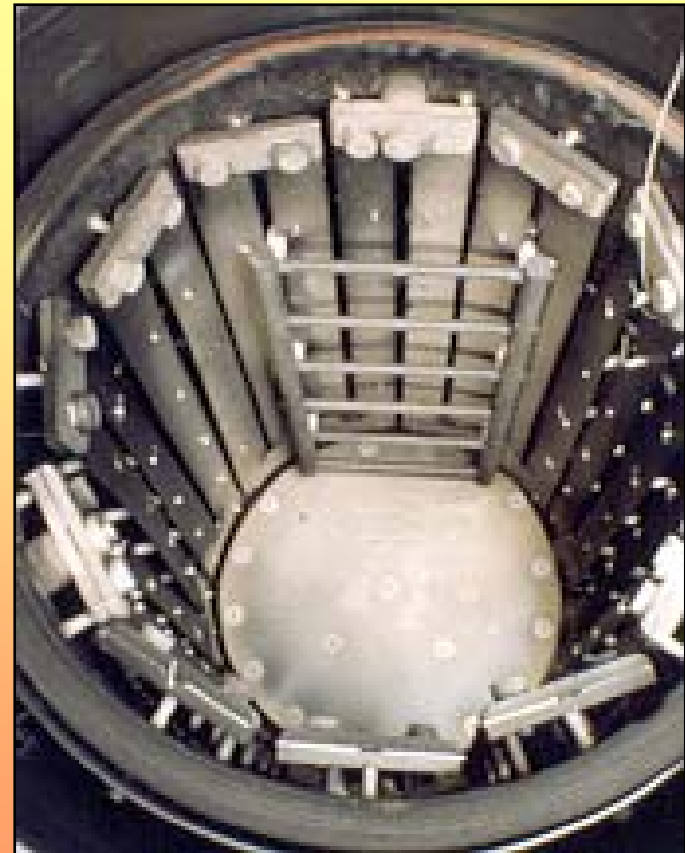




***INCOLOY MA956
Radiant Tubes for
Ceramics Manufacture***

INCOLOY MA956

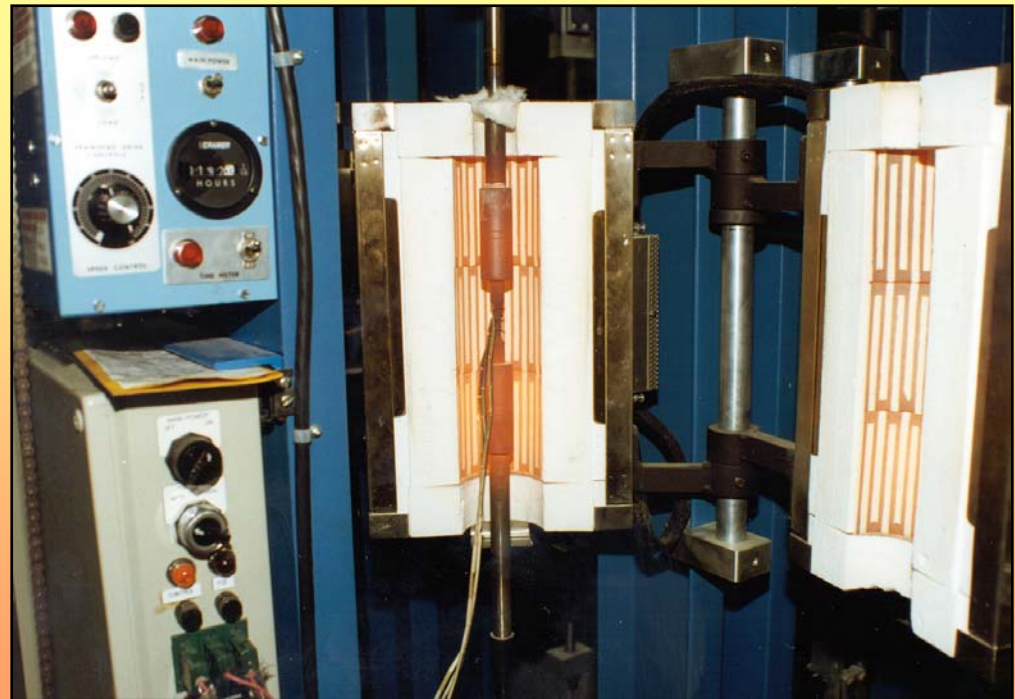
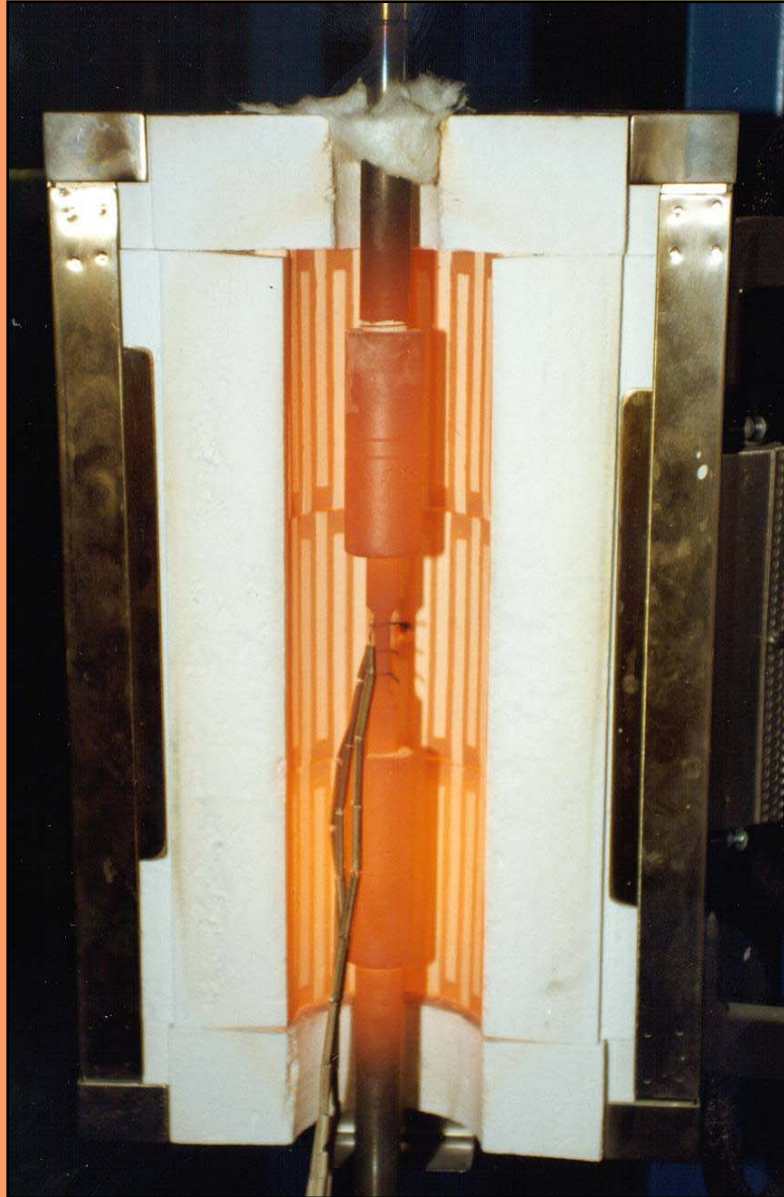
Vacuum Furnace Tray



MA ODS Alloy Heat Treating Furnace Skid Rails



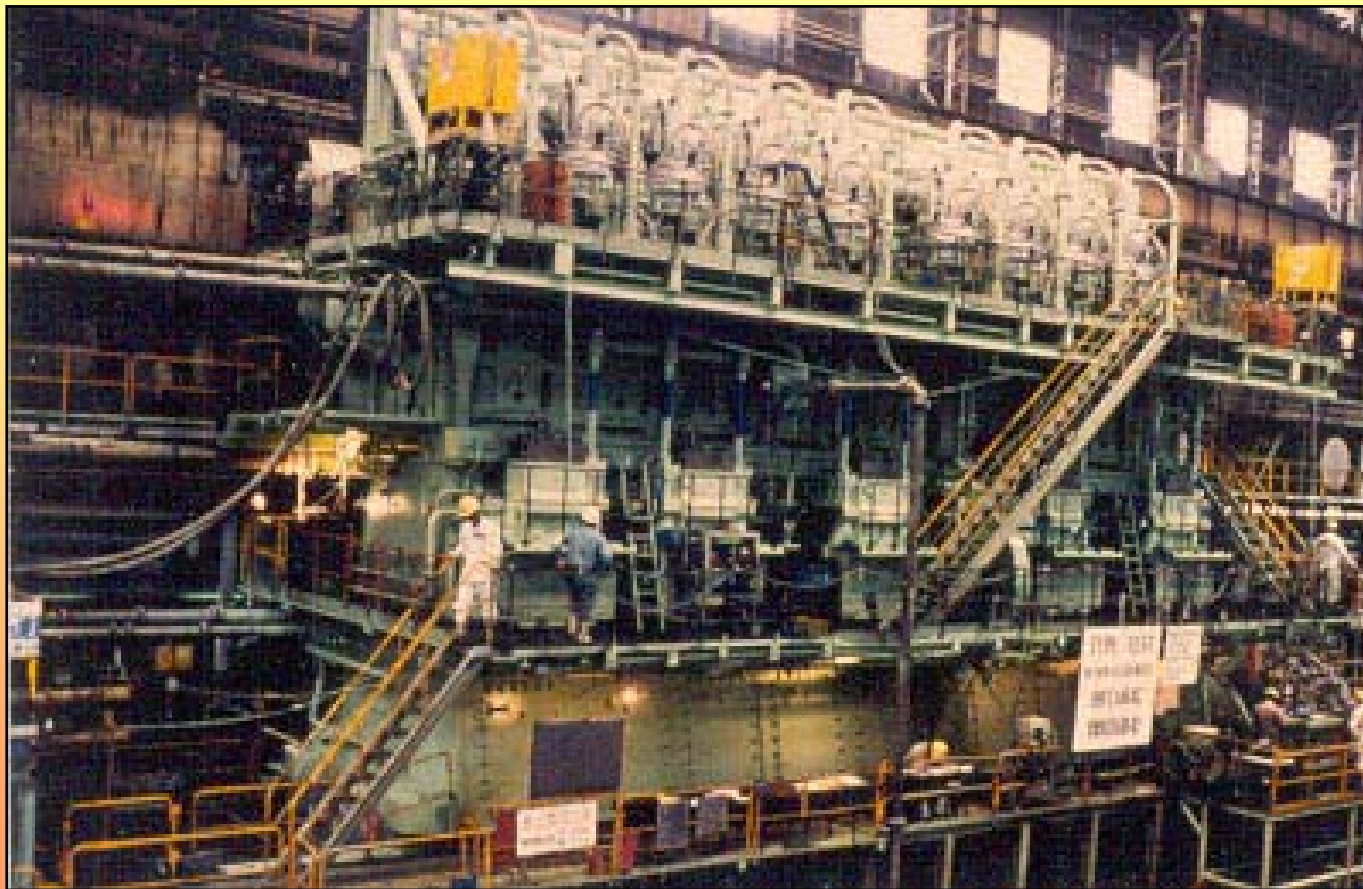
INCONEL MA754 Test Furnace Grips



Applications for MA ODS Alloys

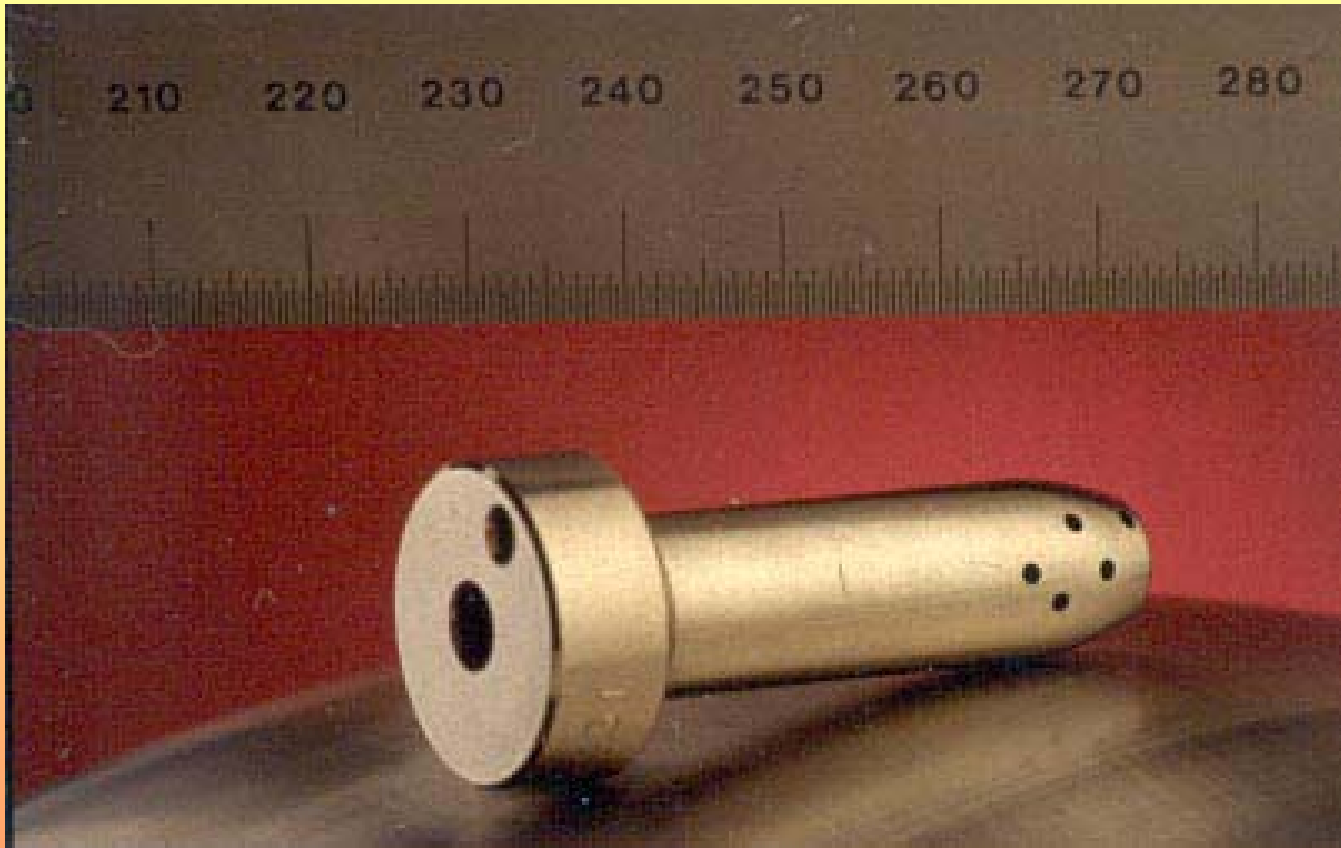
- **Automotive** - Glow plugs for Daimler Benz
 - MA956
- **Nuclear - Fuel cladding** - DOE initiated contact in 1980, intense interest in France and Japan. MA957 (Dourmetal had a slightly different formulation). Inadequate hoop strength is limiting factor.
- **Nuclear** - HTGR heat exchanger - MA956

Diesel Engine Using INCONEL MA758 Valves



INCONEL MA758

Fuel Injection Valve



INCONEL MA758

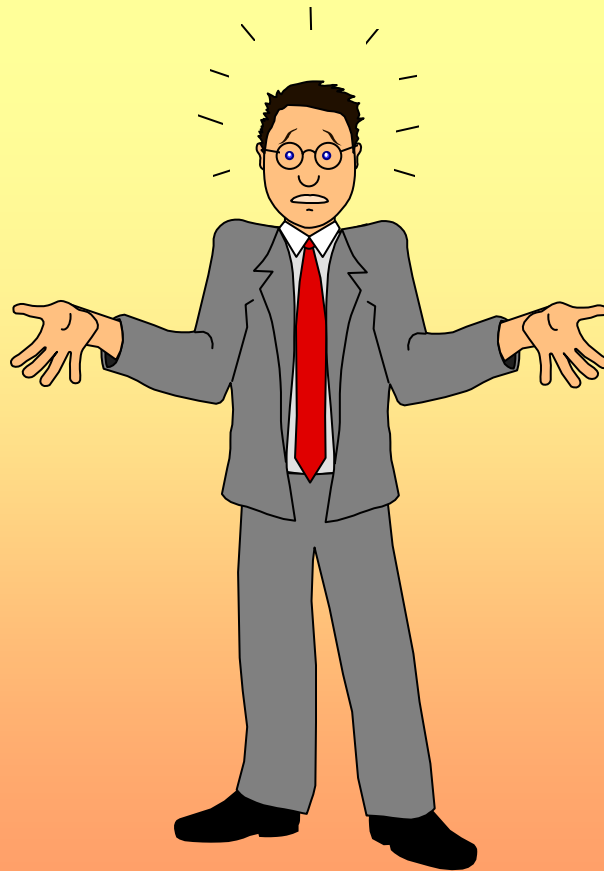
Radwaste Vitrification

- Molten, aggressive phosphate glass**
- High chromium alloys required**
- INCONEL alloys 690, 693, MA758**
- MA 758 – Strength + Resistance**
- Glass Stirring Tubes & Components**
- Agitator Blades**

Summary

- **ODS materials offer a unique combination of properties not attainable from conventional alloys.**
- **Many applications for the products have been identified.**
- **Unfortunately, material requirements have not been sufficient to justify continued production.**

Questions ???



Thanks !!!