



High Density Composites Replace Lead for Reactor Vessel Head Shielding

Robert Durkee

Ecomass Technologies

Austin, Texas

www.ecomass.com

What are Ecomass[®] Compounds ?



A Line of Nontoxic, High Density, Composite Materials that can Replace Lead and Other Traditional Materials

Goal: To Provide Lead-Free Solutions for Radiation Shielding, Weighting, and Balancing Applications



What are Ecomass[®] Compounds ?



Ecomass[®] Compounds are comprised of:

- ❖ **Thermoplastic Resins (Binders)**
- ❖ **Nontoxic Metal Powders (Fillers)**

Ecomass[®] Compounds can be:

- ❖ **Custom Formulated**
- ❖ **Processed on Conventional Injection Molding, Compression Molding and Extrusion Equipment**



Lead is a Problem

- ❖ **Lead is a cumulative poison that can be ingested, inhaled, and absorbed through the skin**
- ❖ **Lead is toxic at very low blood levels to the central nervous system, kidneys, cardiovascular system, and developing red blood cells**
- ❖ **Lead is especially toxic to developing fetuses and children. It causes delayed development, diminished intelligence, and altered behavior**
- ❖ **Lead is ranked number two (behind arsenic) on EPA's Top 20 Hazardous Substances Priority List**

Problem Statement



Lead Has Been Banned:

- ❖ **Additive in Paint**
- ❖ **Additive in Motor Fuel**
- ❖ **Water Pipe and Fittings**
- ❖ **Shot for Hunting Migratory Waterfowl**
- ❖ **Certain Military and Law Enforcement Firing Ranges**
- ❖ **Fishing Weights less than 1 oz. (in 3 states and E.U.)**
- ❖ **Wheel Weights (E.U. – July 1, 2005)**
- ❖ **Electric and Electrical Equipment (E.U. – July 1, 2006)**



Problem Statement



Lead: a “Back-Loaded” Material

- ❖ **Low Initial Cost**
- ❖ **Many Hidden Costs**
 - ◆ **Worker Training**
 - ◆ **Handling**
 - ◆ **Decontamination**
 - ◆ **Storage**
 - ◆ **Regulatory Compliance**
 - ◆ **Disposal**



Results in a Very Expensive Material and a Potential Mixed Hazardous Waste

Ecomass[®] Features and Benefits



- ❖ **Non-Hazardous / Nontoxic**
- ❖ **Density up to 11 g/cc**
- ❖ **No Mixed Hazardous Waste Threat**
- ❖ **Radiation Shielding Comparable to Lead**
- ❖ **Can be Encased in SS for Critical Service Applications**
- ❖ **Can be Formulated to Attenuate Neutrons and Gamma**
- ❖ **Available in:**
 - ◆ **2mm x 3mm Pellets**
 - ◆ **Injection Molded Parts**
 - ◆ **Compression Molded Parts and Sheet**
 - ◆ **Extruded Film and Sheet**



Powdered Metal / Polymer Composite Materials

- ❖ **Binders – PE, PA, TPU, PMP, ABS, PS, PPS, PEEK, TPEs and Others**
- ❖ **Fillers - Tungsten, Steel, Stainless Steel, Copper, Aluminum, and Barium Sulfate Powders**
- ❖ **Over 20 Materials Commercially Available**
- ❖ **Binders and Fillers Selected to Meet Physical Property Requirements**

Tensile Strength

Impact Strength

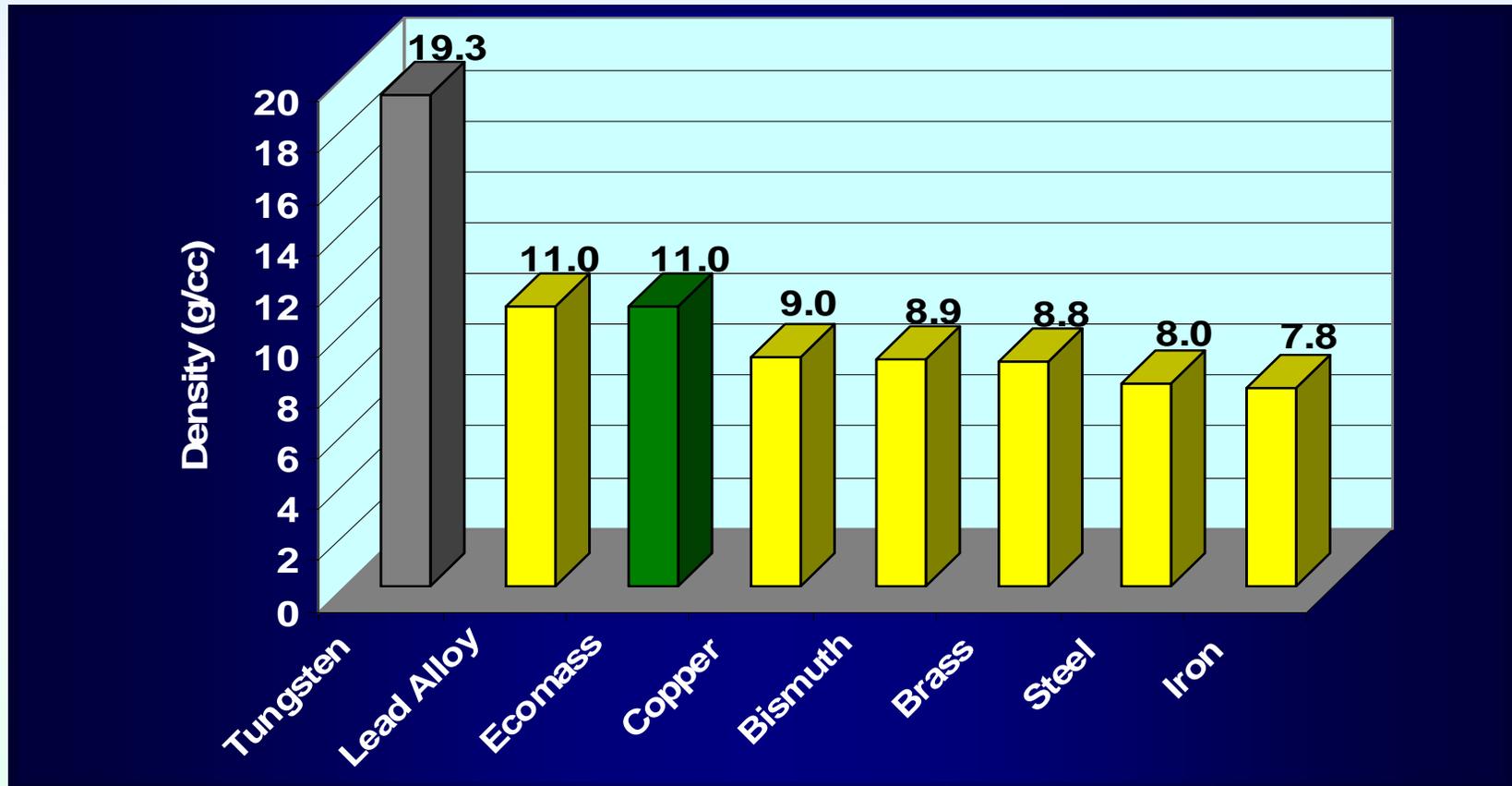
Flexural Modulus

Density

Ecomass[®] Compounds



- ❖ Formulated to Meet a Wide Range of Physical Property Requirements
- ❖ Density from 2 g/cc up to 11 g/cc +/- 0.1 g/cc





Ecomass[®] Product Formats: 2mm x 3mm Pellets

- ❑ **Processing Parameters**
 - ❖ **Drying Time/Temperature**
 - ❖ **Processing Temp. Profile**
 - ❖ **Mold Temperature**
 - ❖ **Cycle Times**

- ❑ **Secondary Operations**
 - ❖ **Painting**
 - ❖ **Powder Coating**
 - ❖ **Electroplating**
 - ❖ **Vapor Deposition**
 - ❖ **Heat Staking**
 - ❖ **Sonic Welding**



Ecomass® Pellet-Filled Shield Wall



**Ecomass®
Pellets in the
Installed
Wall**

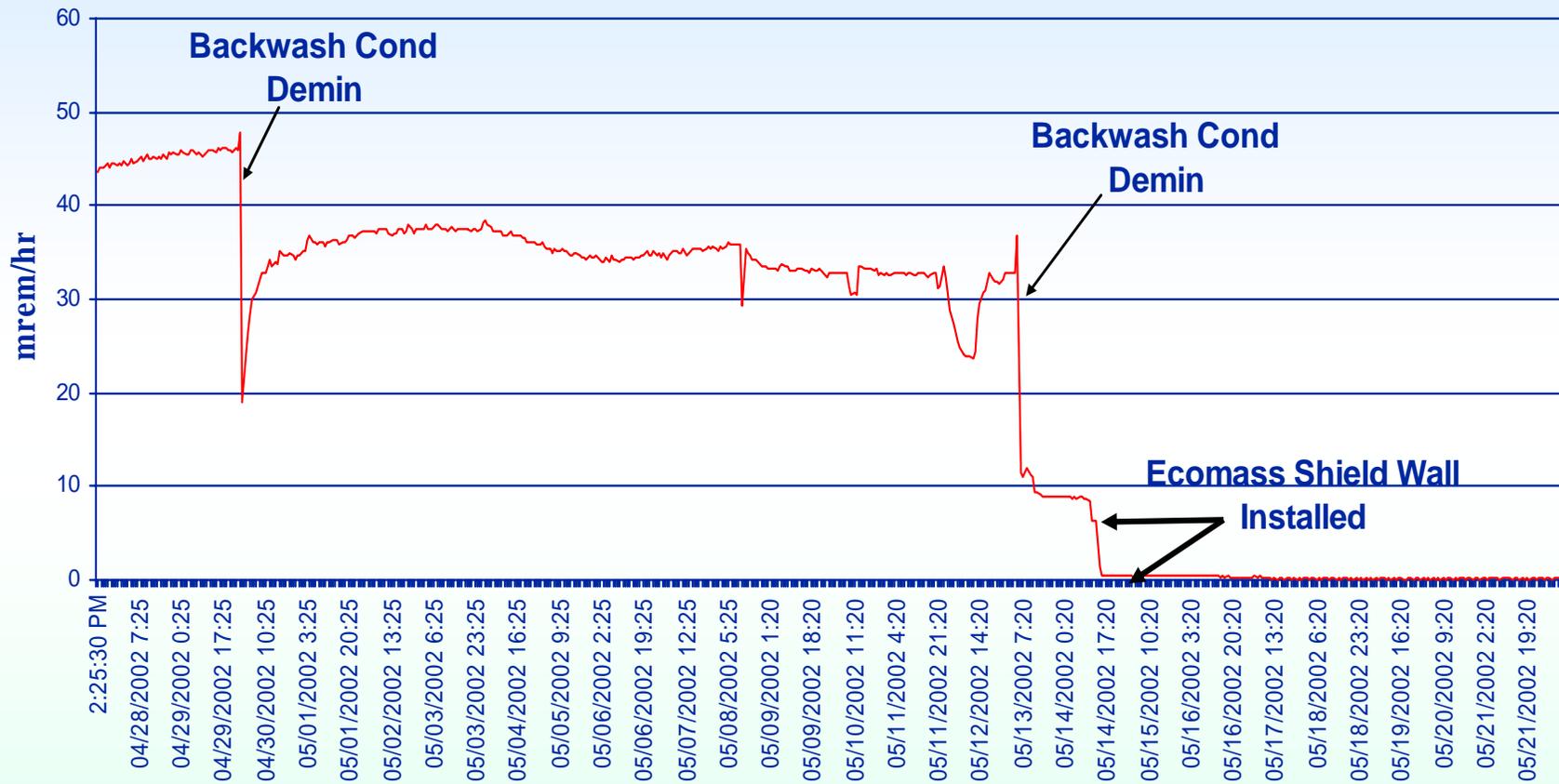


Shield Wall: Top Section

Ecomass[®] Pellet-Filled Shield Wall



Unit 1 Extended Power Uprate Mod Dose Trending

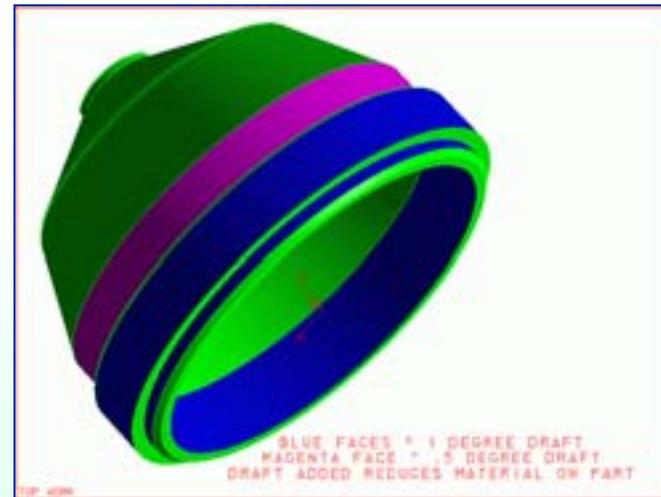




Ecomass[®] Product Formats:

Injection Molded Parts

- ❖ Parts can be molded on conventional equipment
- ❖ Complex Designs
- ❖ Meets ISO 10993-5 (USP Class V) Standard for Cytotoxicity
- ❖ Typical Cycle Times
- ❖ Low Unit Mfg. Costs



Ecomass[®] Compounds



Ecomass[®] Product Formats: Compression Molded Parts and Sheet

- ❖ **Parts can be molded on conventional equipment**
- ❖ **Thick wall parts**
- ❖ **Sheet dimensions up to 4 ft. x 10 ft. x 1 in.**



Ecomass[®] Compounds



Ecomass[®] Product Formats: Extruded Sheet and Film

- ❖ **Sheet and Tape**
 - ◆ **Width Range:**
1" to 8"
 - ◆ **Thickness Range:**
0.020" to 0.125"
- ❖ **Shielding for Piping and Fittings**
- ❖ **Can be encased in various fabrics (Alpha Maritex 8459-2 FR, 500F max service temp. is shown)**





Applications

Radiation Shielding / Weighting / Balancing

Isotope Shipping Containers	Fishing Tackle
Personnel Shielding	Automobile Wheel Weights
Reactor Shielding	Golf Club Weights
Medical Device Shielding	Aircraft Fuel Valve Weights
Military and Law Enforcement Projectiles	Consumer Appliance Weighting

Radiation Shielding Medical Devices





Radiation Shielding Reactor / Personnel



Radiation Shielding Effectiveness



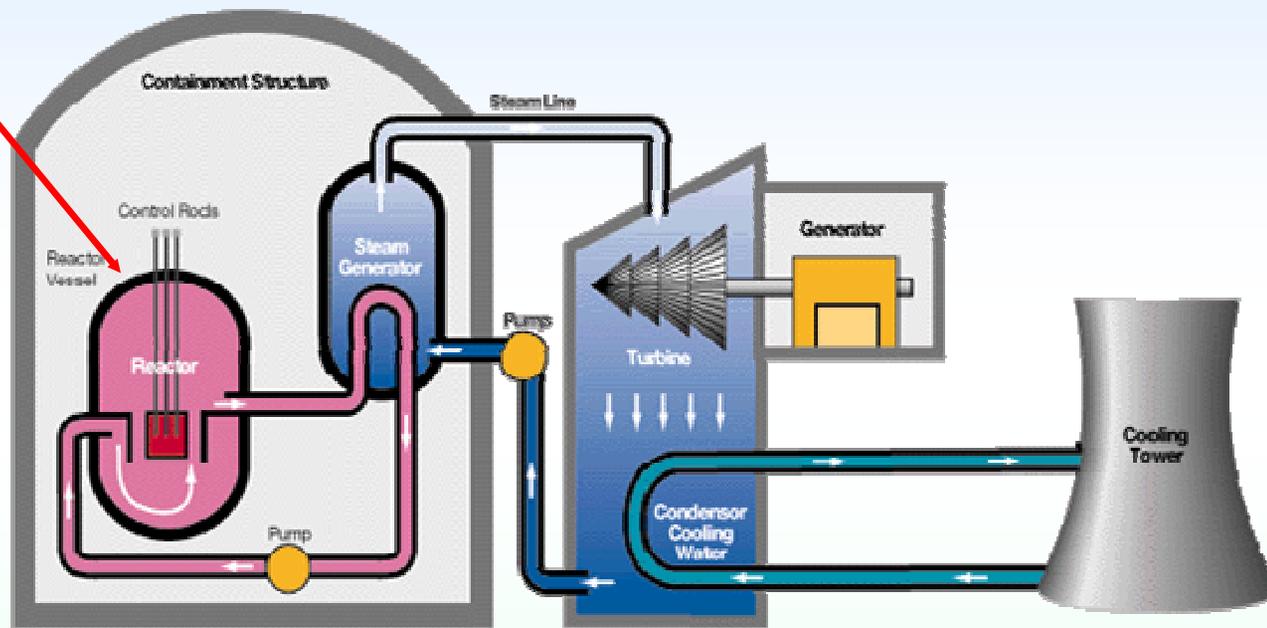
Isotope	Major Radiation Energy	Shielding Effectiveness (vs. Lead)
Iodine 125	35.5 keV gamma	100%
Thallium 201	71 keV gamma	100%
Xenon 133	81 keV gamma	100%
Technetium 99m	152 keV gamma	100%
Cobalt 60	1173 keV gamma	100%
	1332 keV gamma	100%

Test results provided by the University of Texas at Austin

Ecomass[®] RVH Shielding Case Study

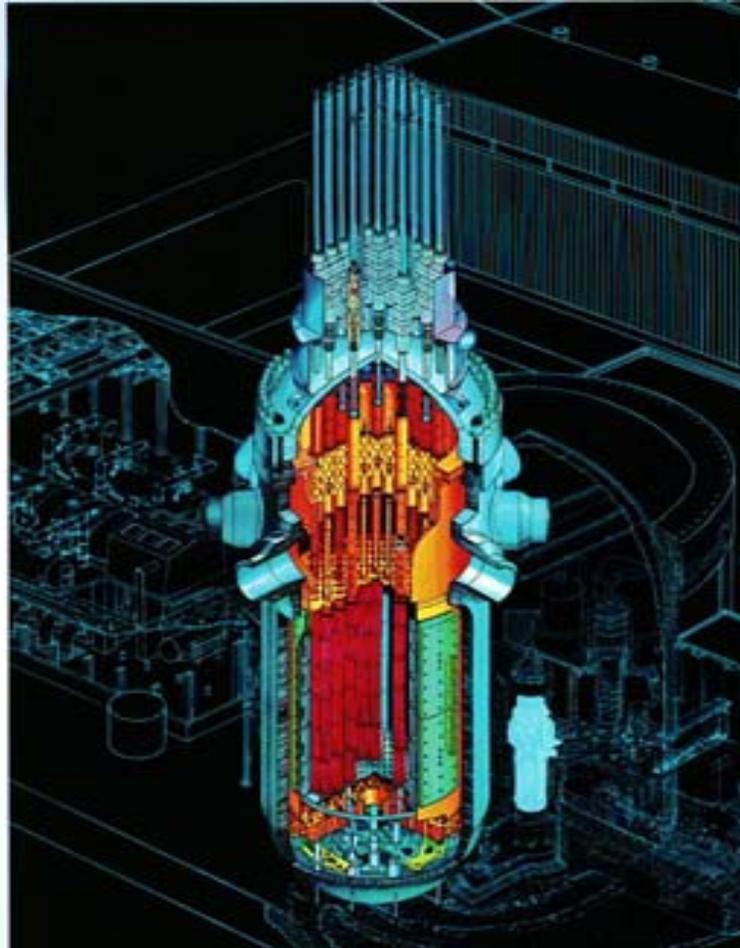


**Reactor
Vessel Head**



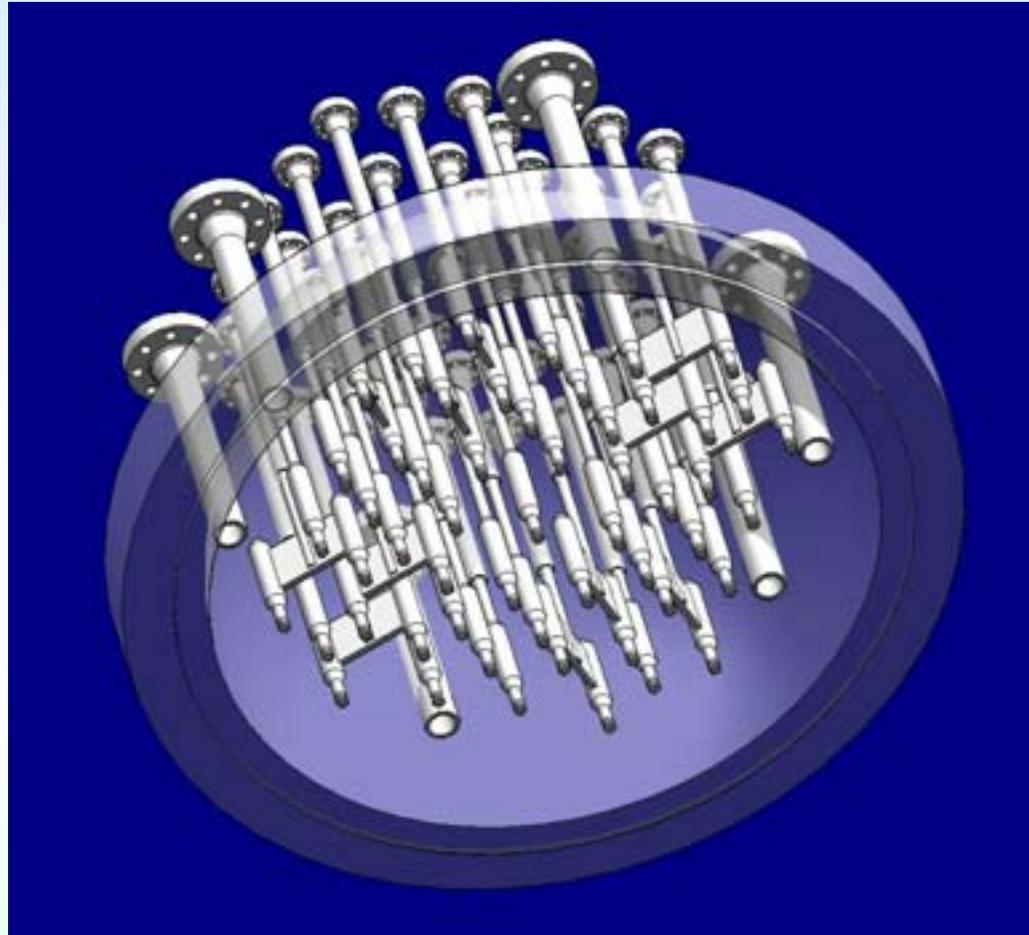
PWR Cycle

*Ecomass[®] RVH Shielding
Case Study*



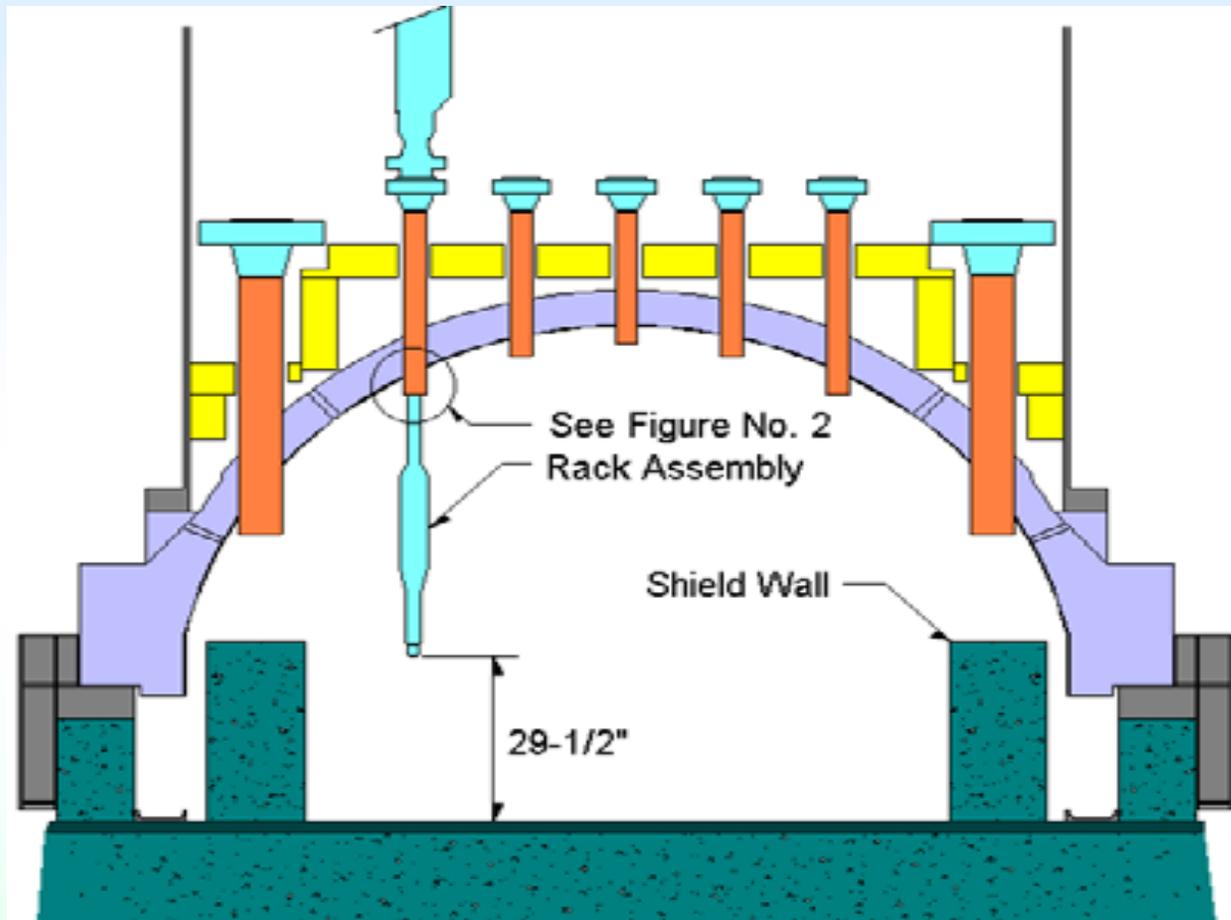
Reactor Vessel

*Ecomass[®] RVH Shielding
Case Study*



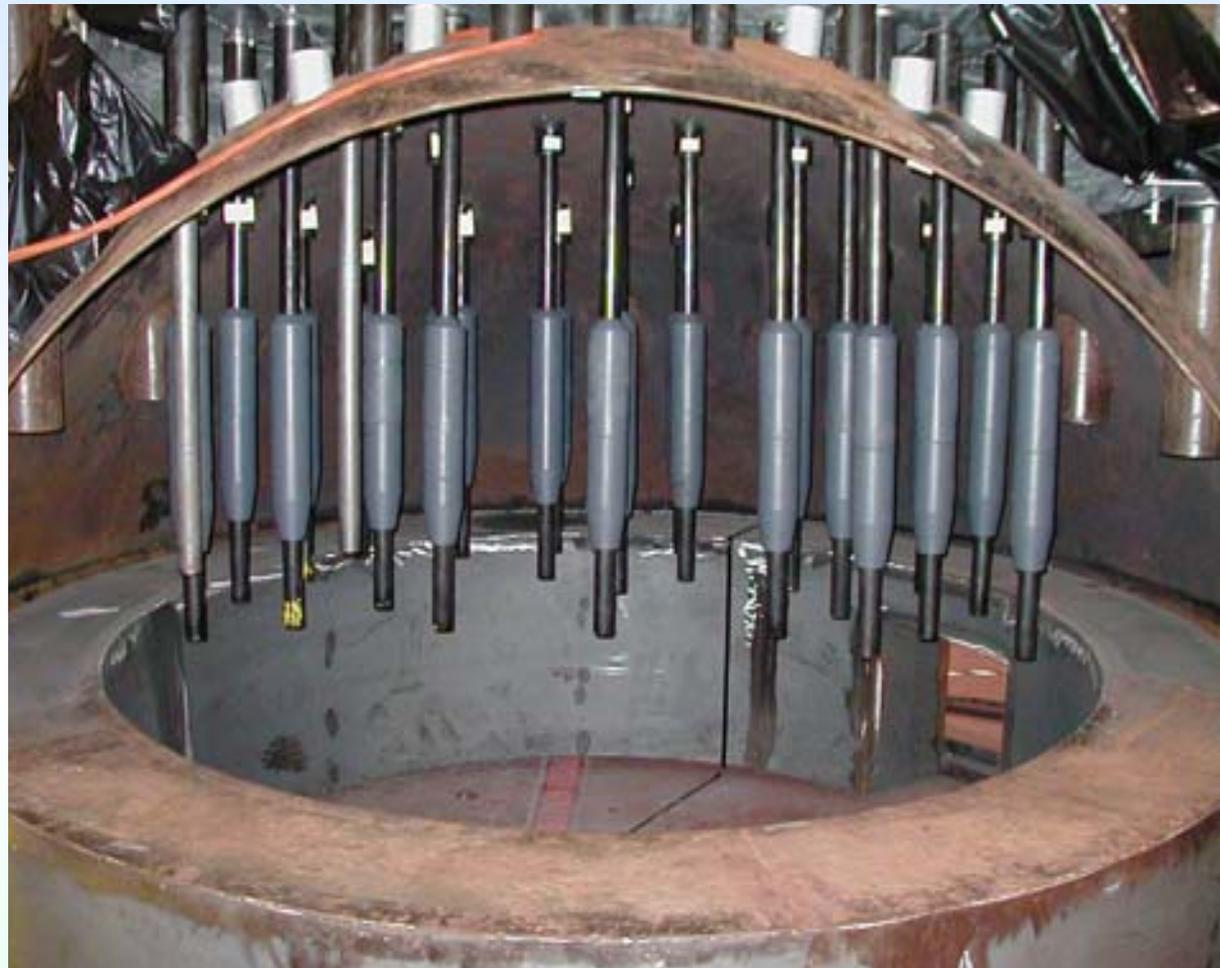
Reactor Vessel Head with CEAs

*Ecomass[®] RVH Shielding
Case Study*



X-Section of RVH on the Stand

*Ecomass[®] RVH Shielding
Case Study*



Mock-up of RVH on the Stand

*Ecomass[®] RVH Shielding
Case Study*



Composite Shield Wall in Fabrication

*Ecomass[®] RVH Shielding
Case Study*



Composite Shield Walls

*Ecomass[®] RVH Shielding
Case Study*



Radius Wall and Roof Framing

*Ecomass[®] RVH Shielding
Case Study*



Radius Wall and Roof Framing

*Ecomass[®] RVH Shielding
Case Study*



CEA Shielding Devices



**Nontoxic, High Density, Composite Materials that
can Provide Lead-Free Solutions for Radiation
Shielding, Weighting, and Balancing Applications**





High Density Composites Replace Lead for Reactor Vessel Head Shielding

Robert Durkee

Ecomass Technologies

Austin, Texas

www.ecomass.com