Radiation Curing of Composites for Vehicle Component and Vehicle Manufacture

Marshall R. Cleland[a], Richard A. Galloway[a],
Daniel Montoney[b],
Dan Dispenza[c], Anthony J. Berejka[d]

[a]IBA Industrial, Inc., Edgewood, NY
[b]Strathmore Products, Syracuse, NY
[c]Nordan Composite Technologies, Patchogue, NY
[d]Ionicorp⁺, Huntington, NY

IAEA/ANS AccApp '09
Vienna, Austria
4-8 May 2009

Presentation Outline

Advantages of Composites in Vehicles

Radiation Processing in Automobiles

Use of Composite Materials in Automobiles

Advantages of X-ray Curing Versus Thermal Curing for Composites

Advantages of Composites in Vehicles

Reduced Vehicle Weight

Increased Fuel Efficiency

Reduced Use of Fossil Fuels

Reduced Environmental Pollution

Reduced Corrosion of Body Parts

Radiation Processing in Automobiles

Weight reduction:

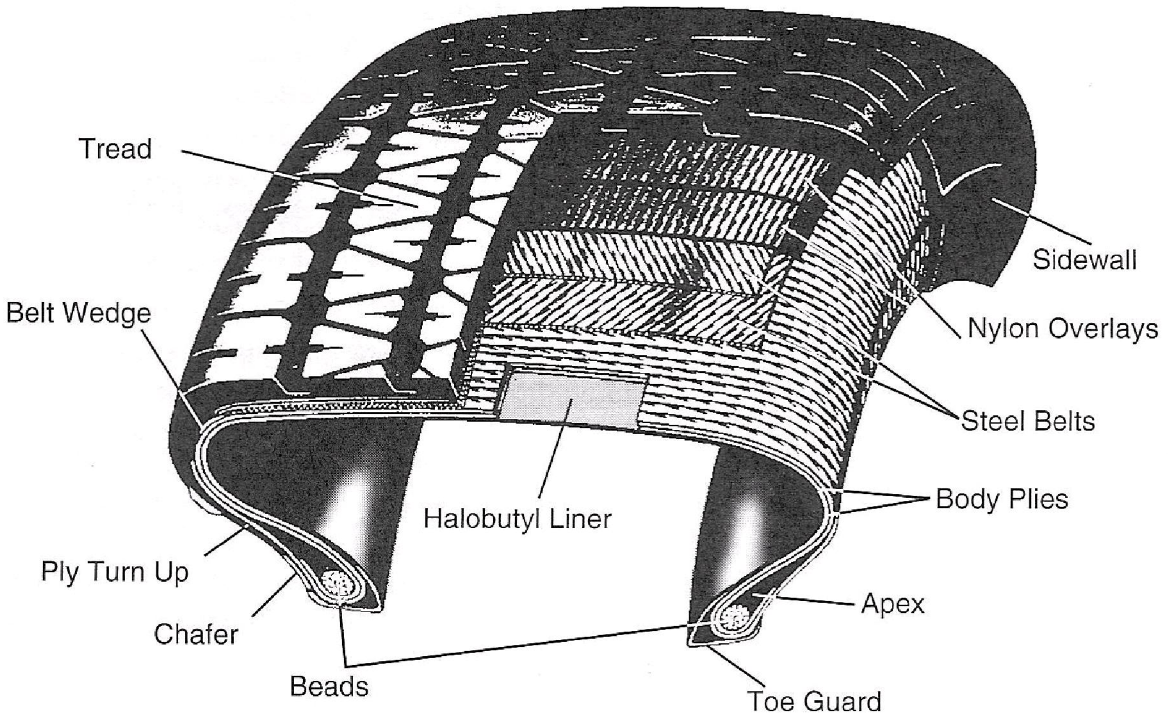
- **In tire manufacture**
- **In use of closed cell foams**

Safety benefit:

- **Crosslinked under-hood wiring**

EB Processing in Tire Manufacture

Controlled Partial Cure to Improve Quality



EB Processing in Tire Manufacture

Benefits of Radiation Processing:

Stabilize tire cords during molding

Reduce weight of innerliners and other tire components

Cost-effective processing

EB Processing in Foam Manufacture

Interior side panels and header

EB Processing in Foam Manufacture

Benefits of Radiation Processing:

Crosslinking of the polymer is separate from the foam blowing process

Controlled size of closed cells

Controlled stiffness and cushioning

EB Crosslinking of Electrical Wire

Flame retardant under-hood wiring

EB Crosslinking of Electrical Wire

Benefits of EB Crosslinking:

- **Prevents insulation melting and dripping**
- **Tolerates high temperature environment**
- **Flame retardancy inhibits under-hood fires**

Composite Materials in Automobiles

GM Corvette:

- **1953 – outer body**
- **1984 – leaf springs**

Automotive Composites Consortium (ACC):

- **1996 – crash test of front end section**

Light weight components used in high-performance autos

Composite Materials in Automobiles

Weight reduction:

- **GM Corvette**
- **Current high performance autos**

Safety benefit:

- **Crash testing by ACC**
- **High speed racing cars**

Composite Materials in Automobiles

1953 Corvette

Composite Materials in Automobiles

Porsche Carrera GT subframe

Composite Materials in Automobiles

Tesla Motors electric car body

Composite Materials in Automobiles

1996 Ford composite crash testing

Composite Materials in Automobiles

Race car safety

X-ray Curing versus Thermal Curing

Advantages of X-ray vs Thermal Curing:

- **Greater penetration**
- **Complex product shapes**
- **Shelf-stable materials**
- **Shorter cure cycles**

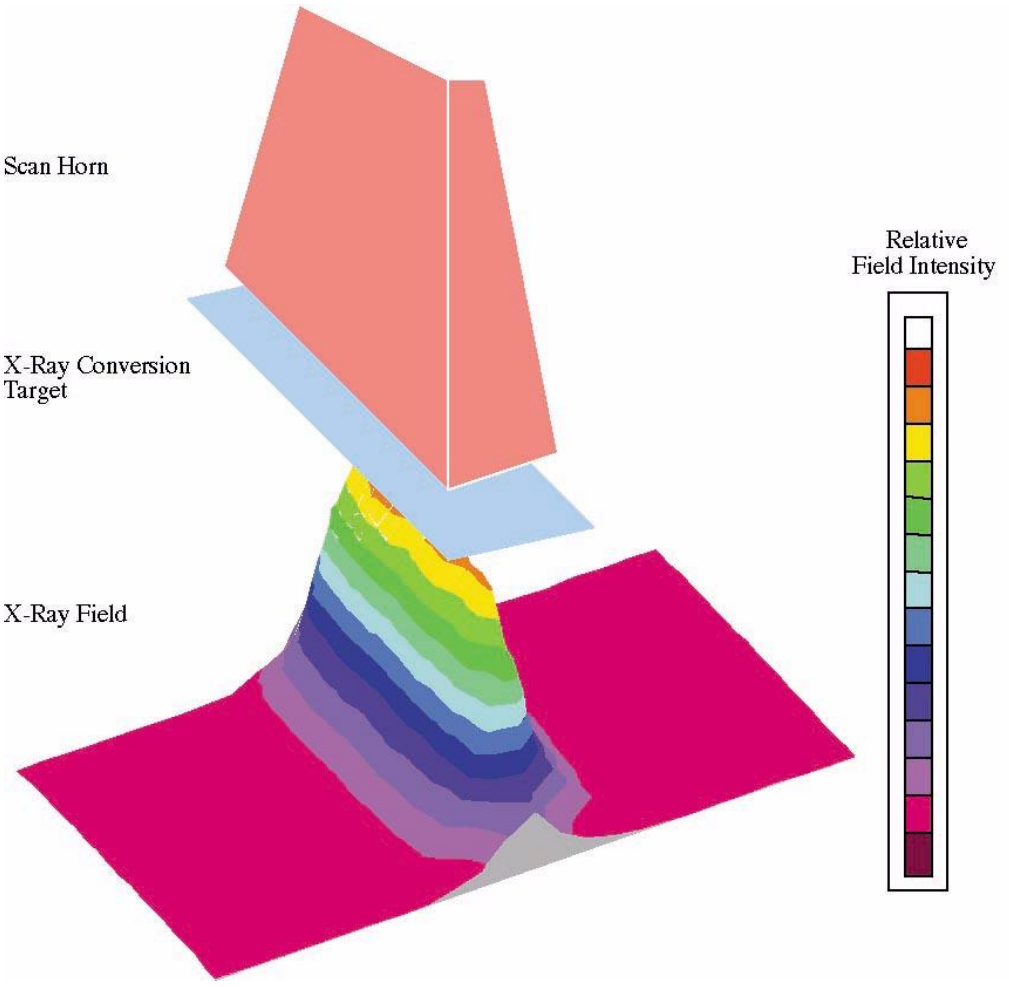
X-ray Sources and Properties

Sources: High-energy, high-current industrial electron beam (EB) accelerators.

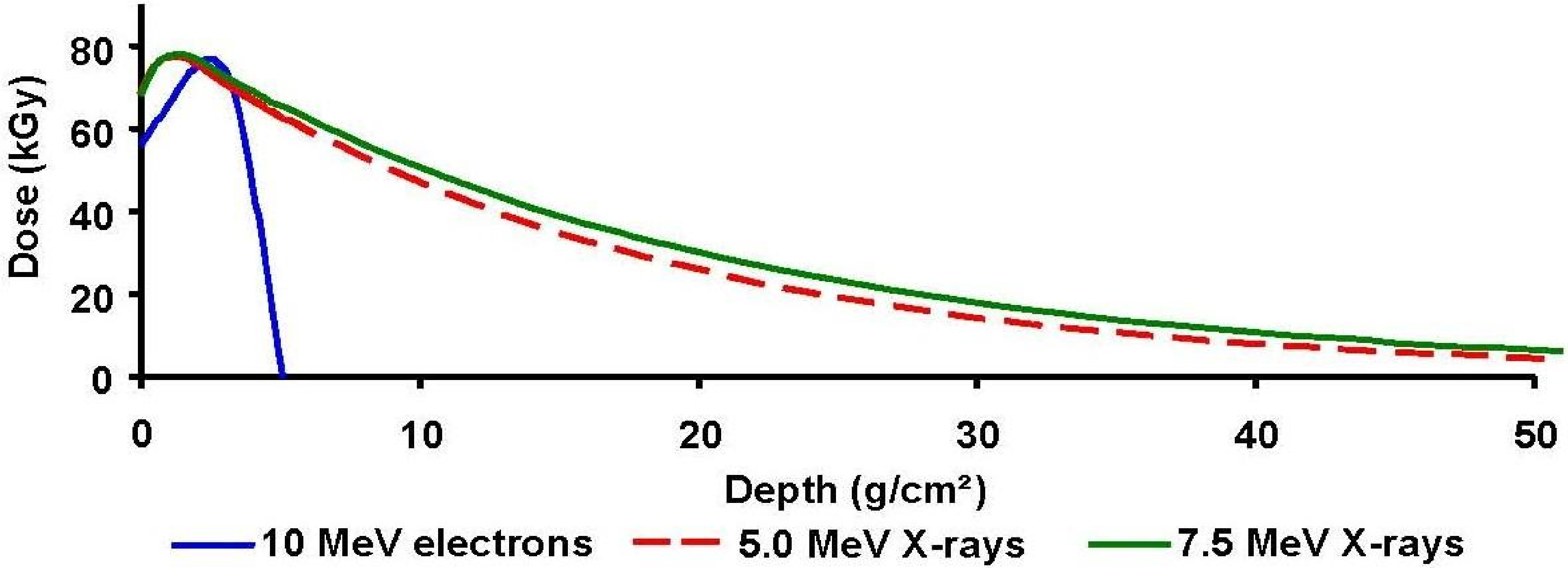
X-rays are generated by electrons hitting water-cooled tantalum targets.

X-rays can provide penetrating, non-thermal energy transfer processes.

Forward Peaked X-ray Penetration

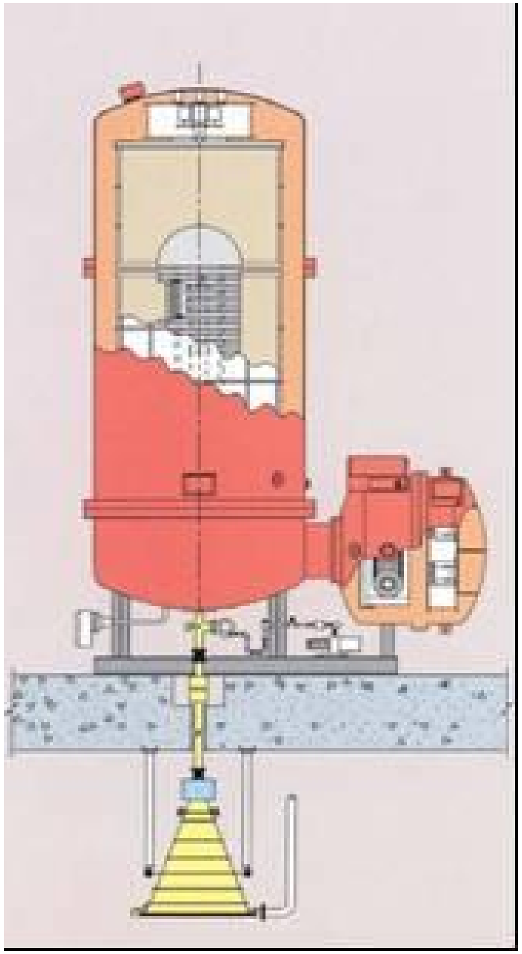


Depth-Dose Distributions – EB and X-ray



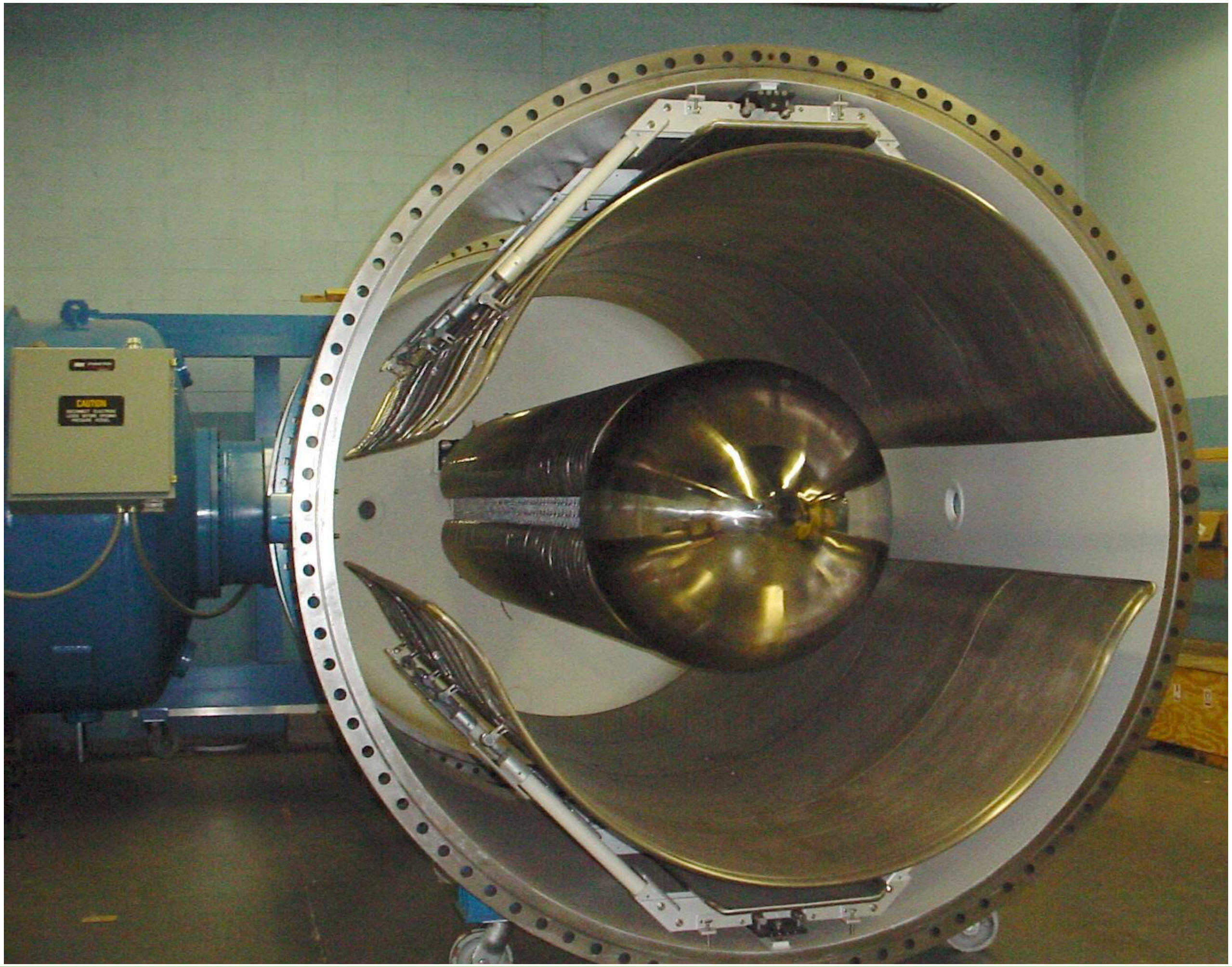
X-ray Sources and Properties

Dynamitron® 5.0 MeV, 300 kW electron accelerator



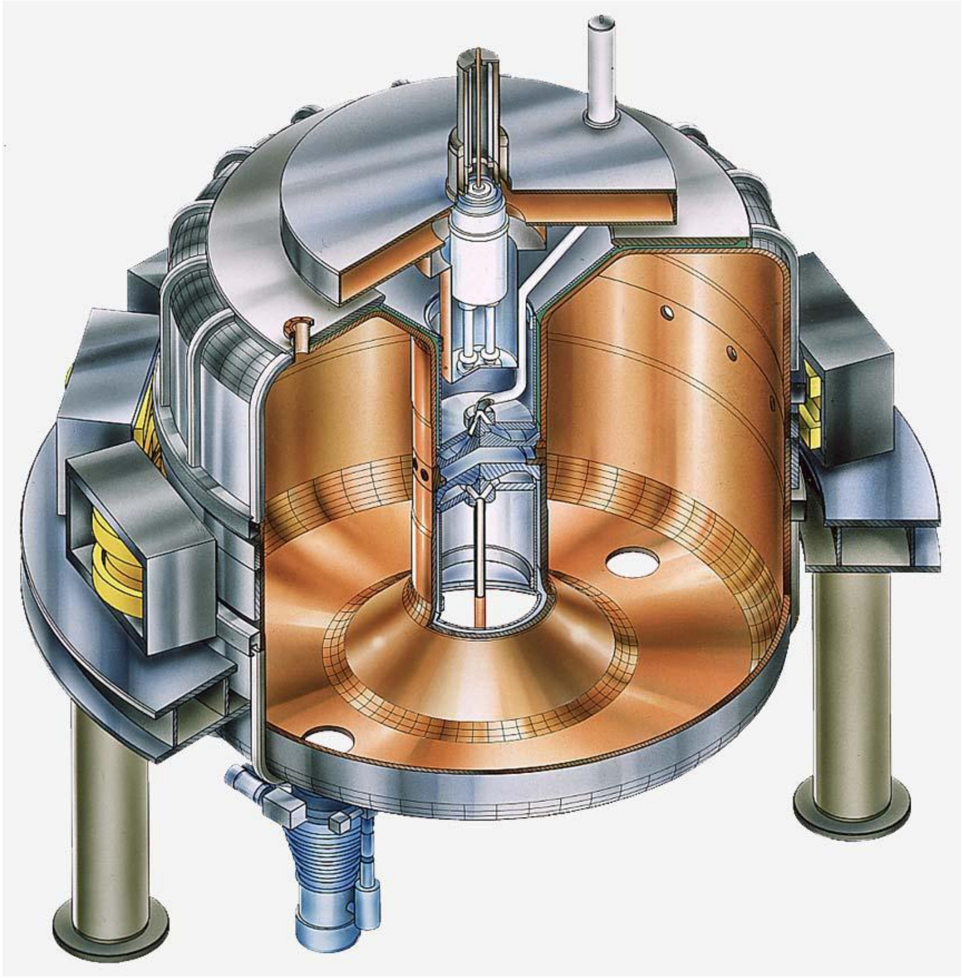
X-ray Sources and Properties

Dynamitron 5.0 MeV, 300 kW electron accelerator



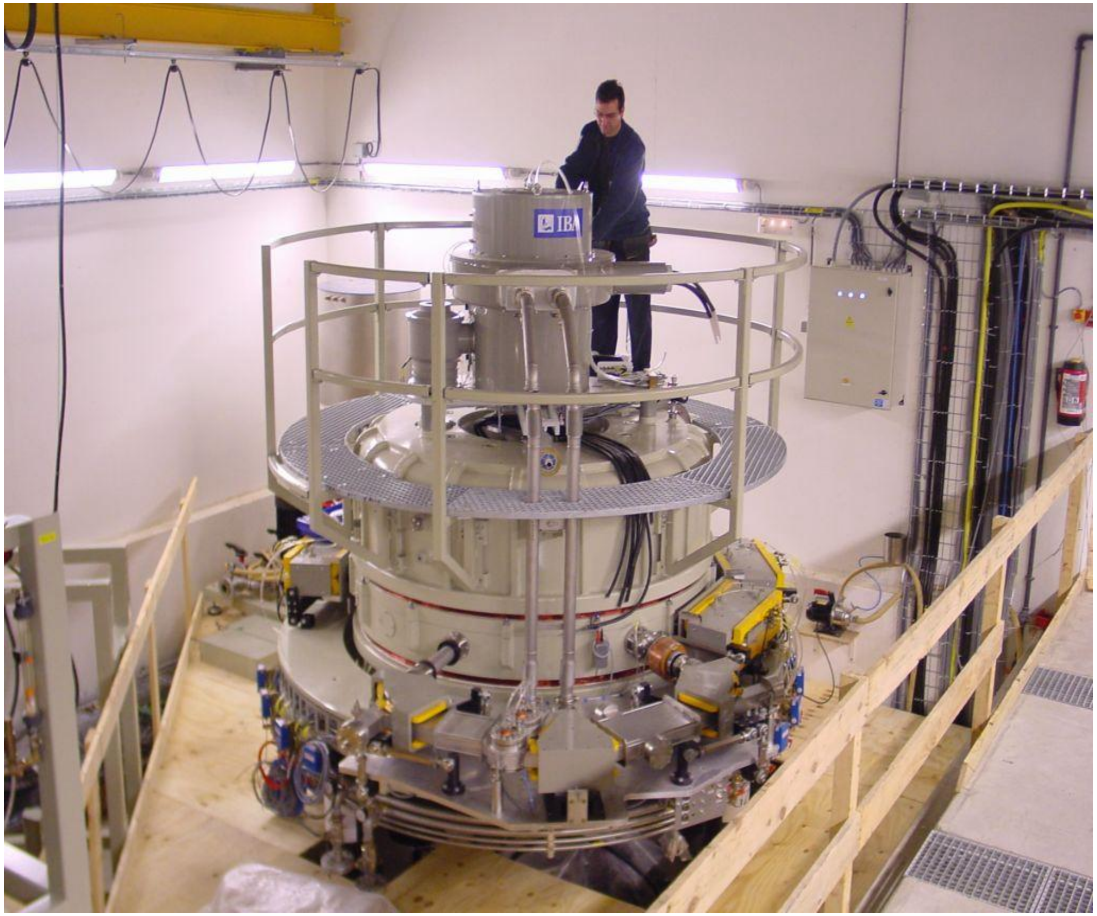
X-ray Sources and Properties

Rhodotron® 7.0 MeV, 700 kW electron accelerator



X-ray Sources and Properties

Rhodotron® 7.0 MeV, 700 kW electron accelerator

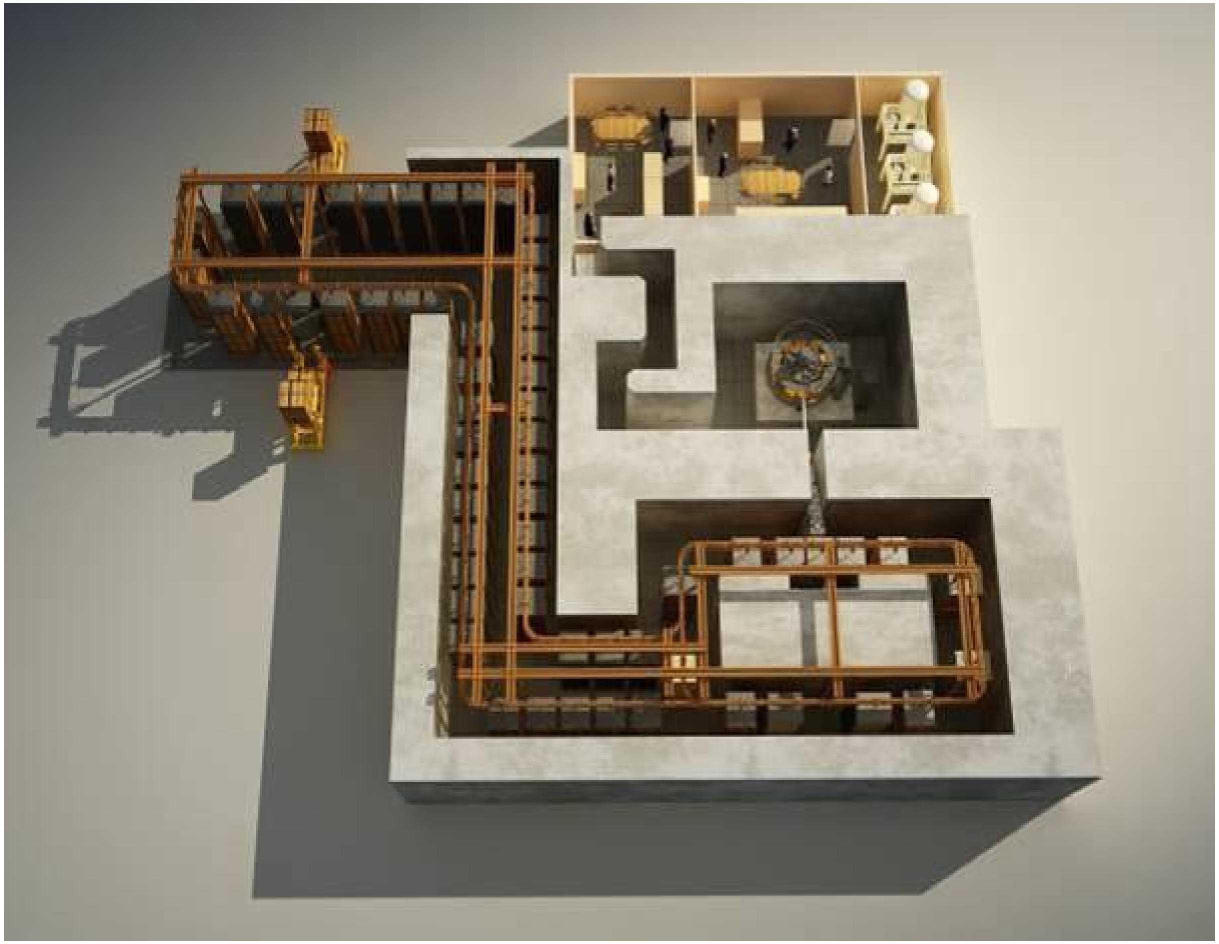


Industrial X-ray Processing Facilities

5.0 MeV and 7.0 MeV X-ray targets

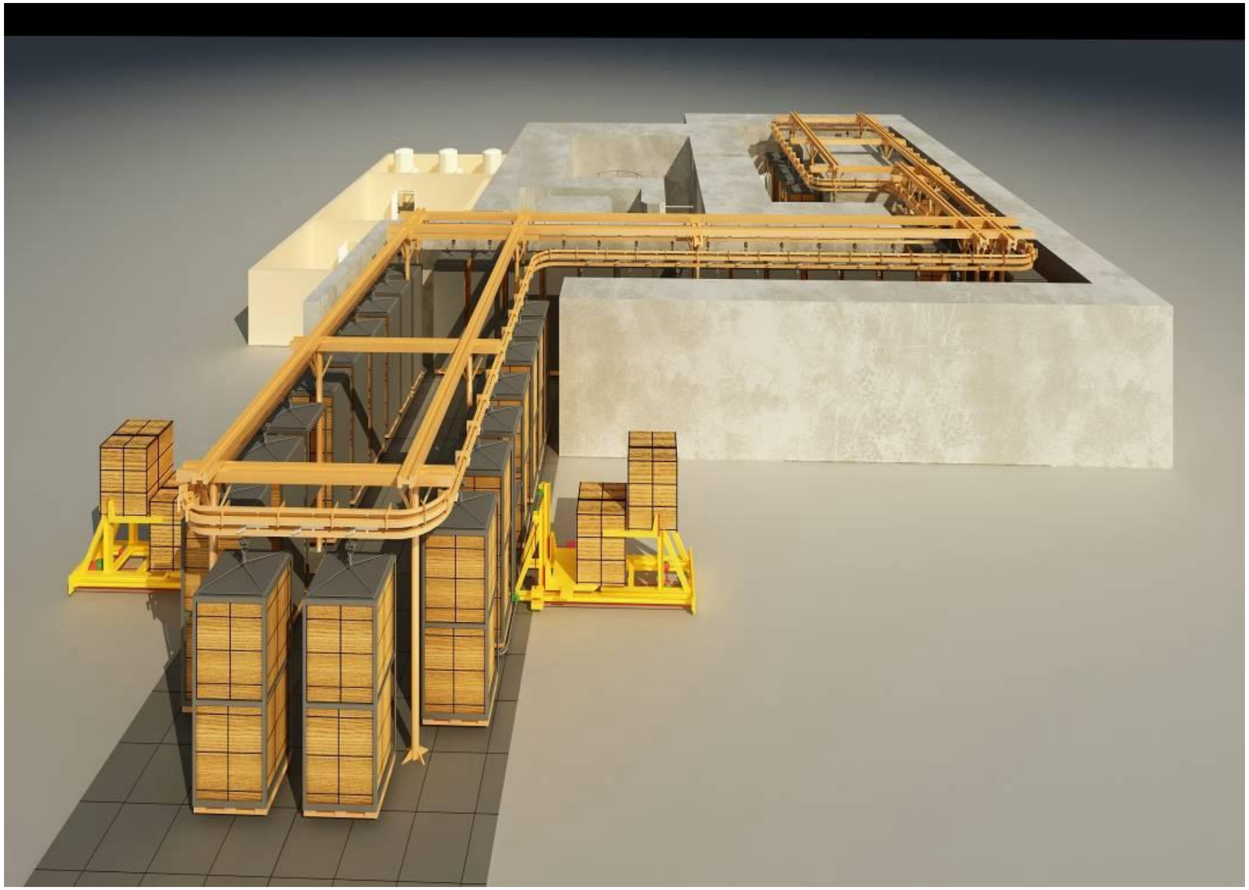
Dedicated X-ray Processing Facilities

X-ray Facility for a 7.0 MeV, 700 kW Rhodotron®



Dedicated X-ray Processing Facilities

X-ray Facility for a 7.0 MeV, 700 kW Rhodotron®



X-ray Cured Fiber Reinforced Composites

+ Cure within inexpensive, simple molds

+ Use common shelf-stable materials

+ Cure faster than thermal processes
  curing times only 2 to 3 minutes

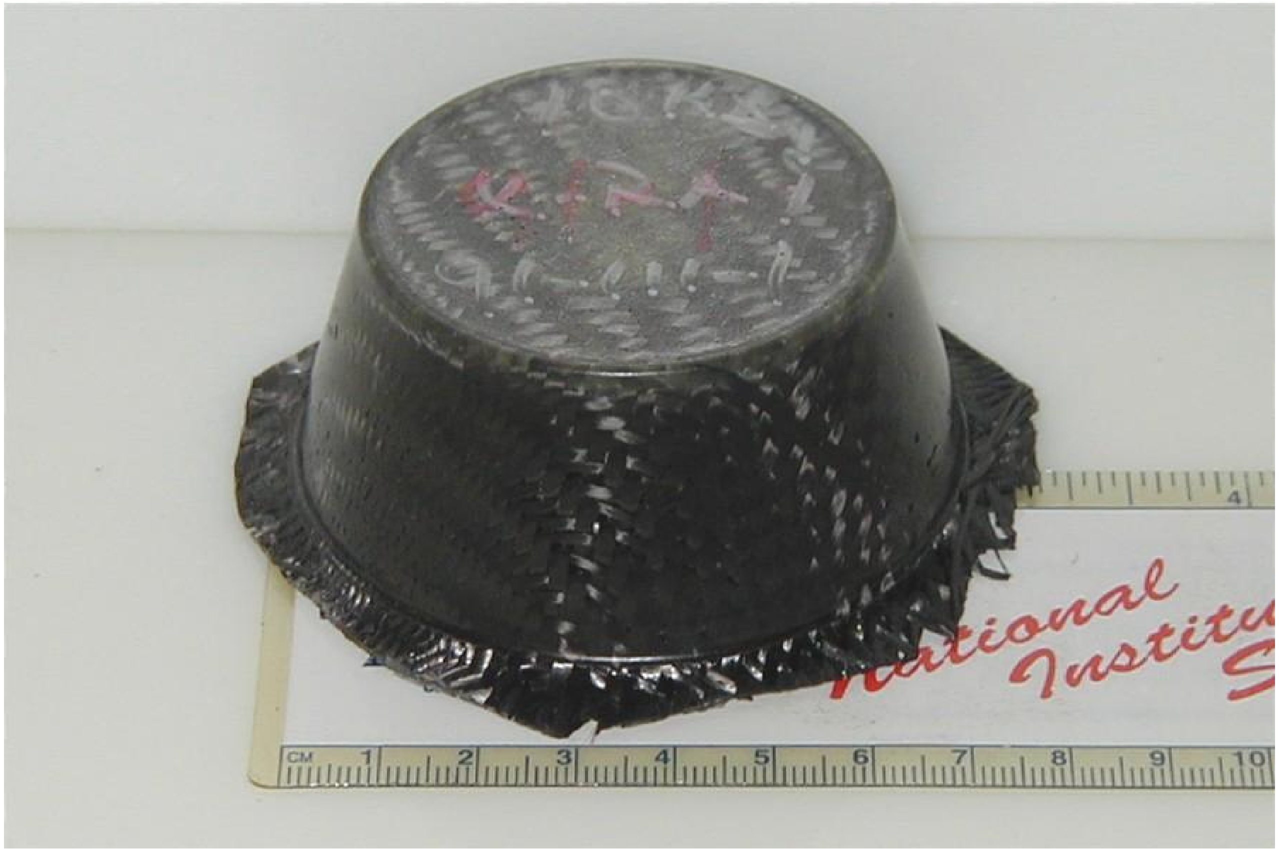
+ Encase metallic pieces for fasteners

X-ray Cured Fiber Reinforced Composites

Carbon fiber cups in a simulated mold

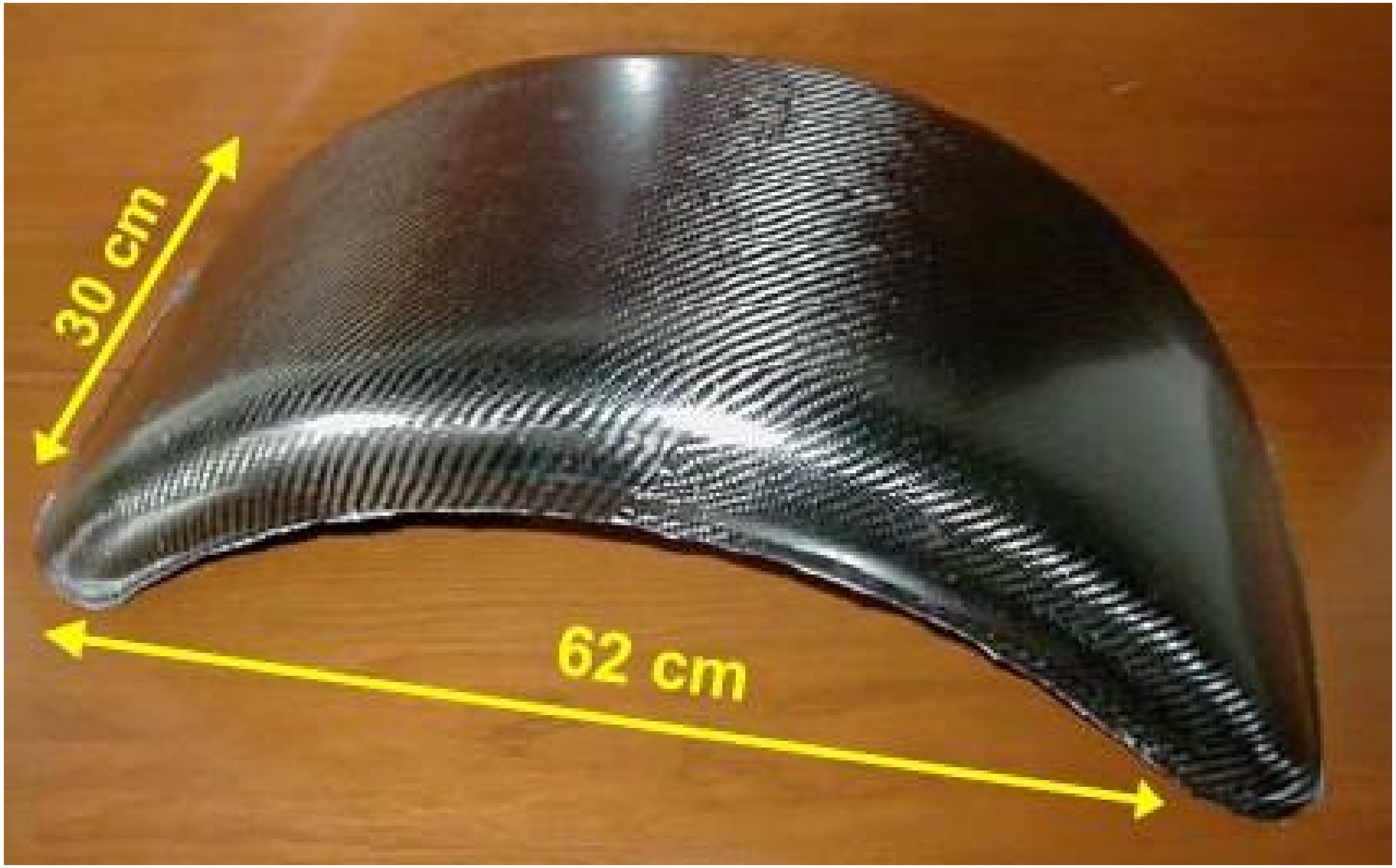
X-ray Cured Fiber Reinforced Composites

X-ray cured carbon-fiber cup



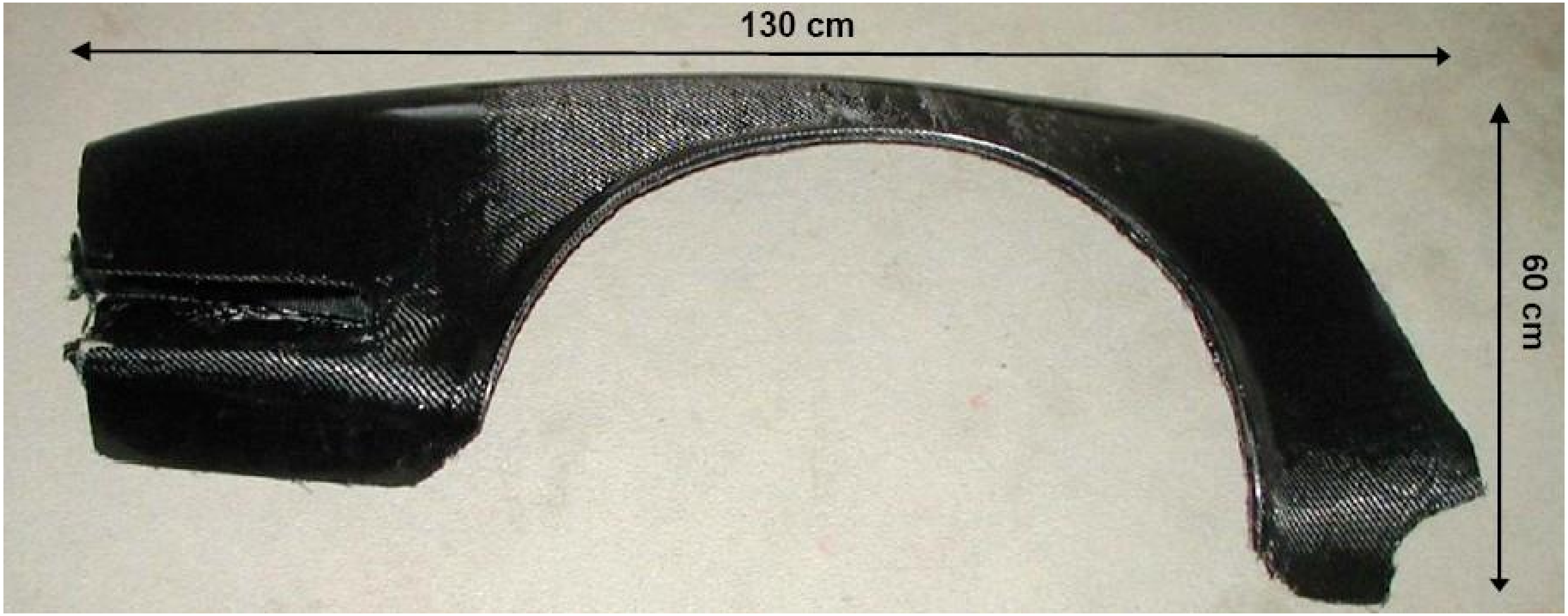
X-ray Cured Carbon Fiber Motorcycle Fender

X-ray Cured Carbon Fiber Motorcycle Fender



X-ray Cured Carbon Fiber Sports Car Fender

Class A gloss finish



Comparative Toughness Testing

Falling tup test apparatus

Comparative Toughness Testing

Four ply carbon fiber composite and aluminum panel of comparable thickness

Comparative Autobody Weights

Material	Density g/cm^3	Body weight kg
Steel	7.8	~750
Aluminum	2.7	~260
Carbon fiber composite	1.6	~155

Comparative Mechanical Properties

Material	Young's modulus GPa
Steel	~190-210
Aluminum	~70
Carbon fiber composite	~125-150

Advantages of Radiation Curing

Room temperature curing

- Makes stress-free joints
- No thermal distortion

Saves energy

- Eliminates need for autoclaves

Avoids air pollution

- No volatile organic compounds

Conclusions

X-rays penetrate through inexpensive molds made of aluminum, plastics or composites.

Composite parts can be cured with X-rays in a few minutes while still in the mold.

Common radiation curable materials can be used in formulating matrix systems.

Conclusions

X-ray cured carbon fiber composites can be used for all auto structures, including the vehicle chassis and body frame.

An 80% weight savings from carbon fiber composites versus steel could lead to more than double the fuel efficiency.

Composites completely eliminate operations such as coating for corrosion protection.

Conclusions

Cost analyses should include the added value to the consumer and societal benefits from greater fuel efficiency and less environmental emissions leaving a lower carbon footprint.