UV Equipment and Design Factors Manufacturing Market

DDU Enterprises, Inc.

www.doctoruv.com

UV CURING

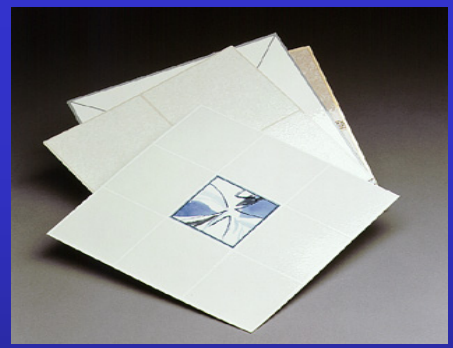
- Process to cure coatings, inks, adhesives
- Polymerization and cross-linking is initiated by UV
- Coating is converted from a liquid to a solid in a fraction of a second
- Replaces solvent-based drying processes
- Every existing method of decorating, coating or bonding has been converted to UV Curing

Converting - Siliconizing
Release liners, papers, film

Web Offset Printing
Packaging, business forms, direct mail

Converting - Coating
Flexible packaging, film

Converting - Narrow Web
Labels, flexible packaging, silicone release



Converting - Flooring
Vinyl sheets and tiles

Pressure Sensitive Adhesives
Tapes and labels

Plastic - Functional Coating, Non-Automotive
Construction materials, office furniture, and leisure craft

Wide Web Printing
Flexible packaging, wrappers

Automotive
Interior & exterior plastic, metal, and glass

Sheetfed Offset Printing
Commercial & plastic sheet printing

CD/DVD “lacquering,” printing, and bonding

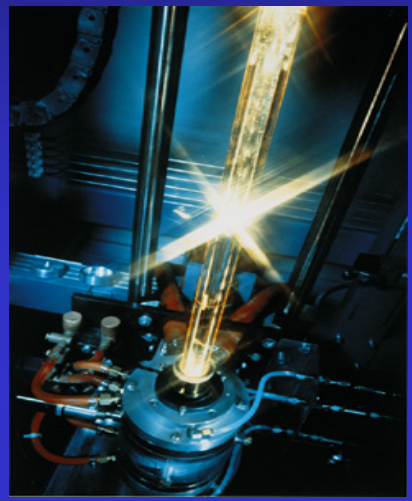
Metal-Flat Sheet Deco
Aerosol, food cans

Metal Pipe Coating
Metal tubes

Plastic Container Decoration
Cosmetic, toothpaste, food containers

Metal-2-Piece Cans
Beverage containers-decoration and rim coating

Wood Coating - Profiles
Molding, picture frames



Fiber, Ribbon & Cable
Optical fiber, coloring, ribbon, wire marking

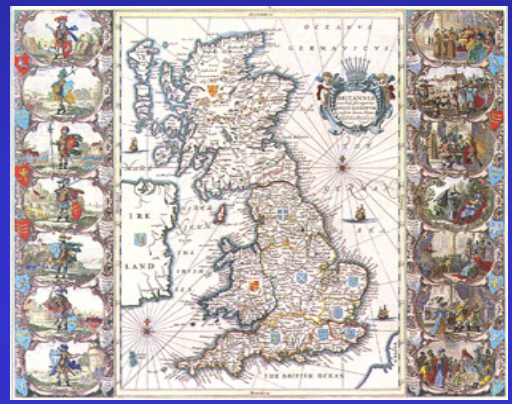
Wood Coating - Flat Sheet
Particle board, sheets, doors

Wood Coating - 3D Objects
Case goods, chairs, furniture

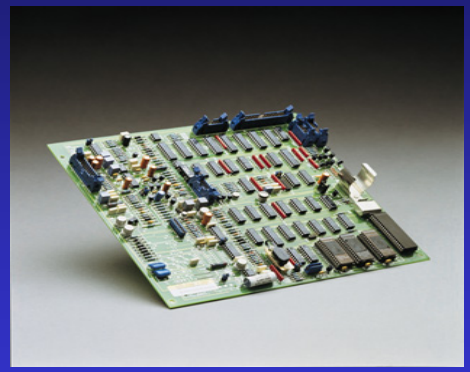
Glass Coating
Bottles, tumblers, mirrors

Consumer Products
Eyeglass lenses, pen bodies, tools, golf balls

Medical Devices
Manufacturing and assembly



Flat Sheet Screen Printing & Decorating
Posters, signs, vehicle advertising



Electronics
Marking, encapsulation, conformal coating

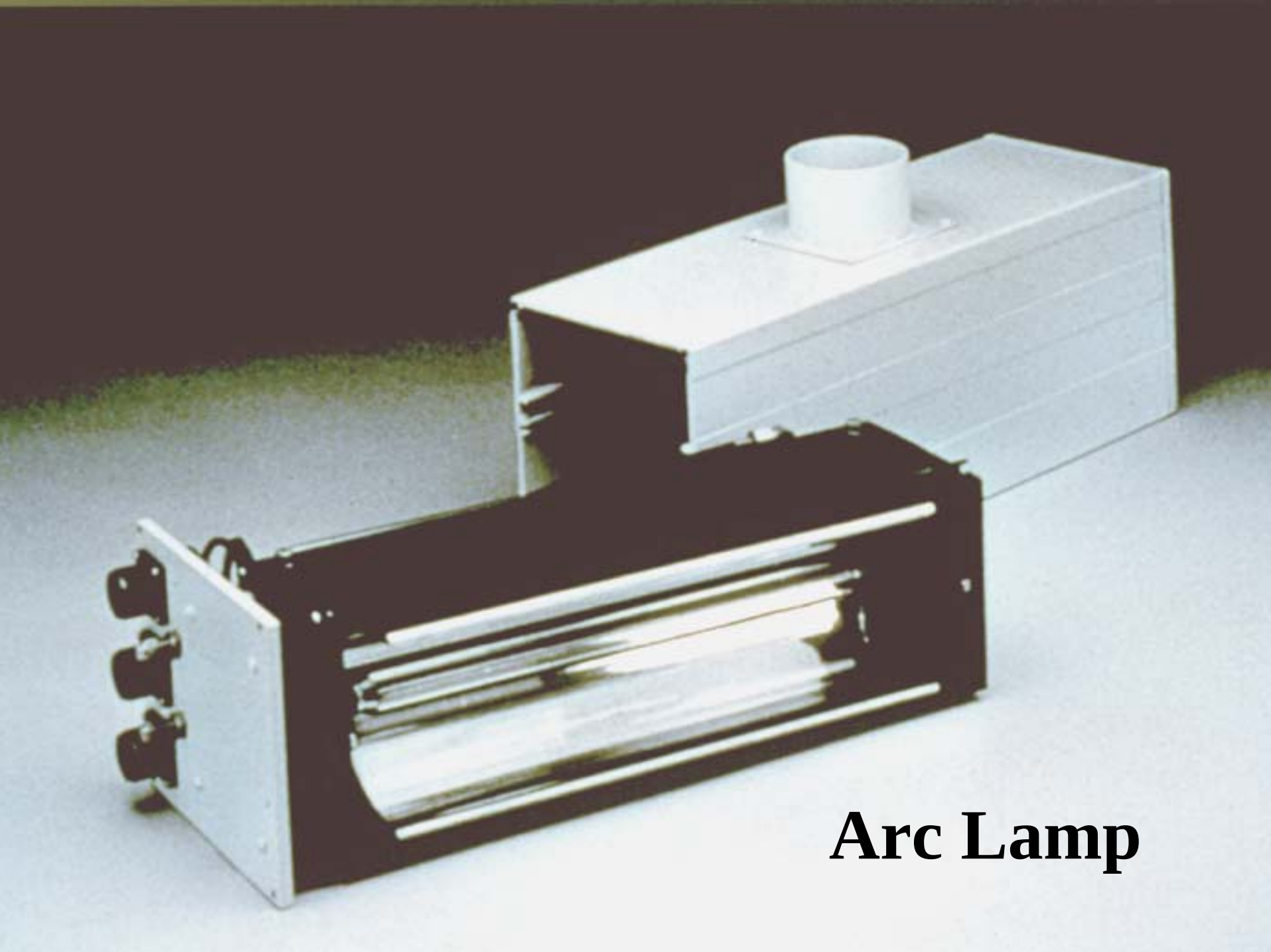
Lab/Development Units
Conveyors, static cure, process research lab equipment for coating evaluation

Categories of UV Curing

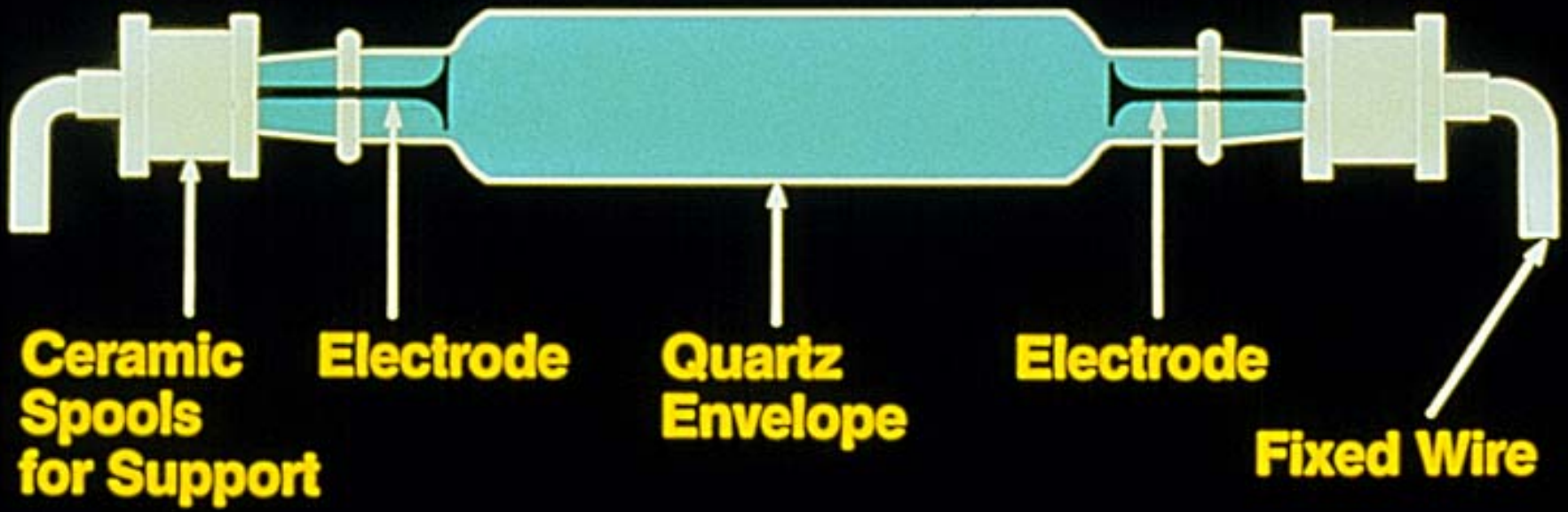
- LINEAR
  Usually Flat Surfaces
  Typically Linear Travel
  Tubular Bulbs Most Common
- FLOOD (AREA)
  Flat or Complex Surfaces
  Lower Irradiance Levels
  None to Several Degrees of Motion
  Various Configurations of Lamps
- SPOT
  High Intensity, Small Areas
  Short Projection Field, or
  Liquid Light Guides

Two types of
medium pressure mercury vapor UV lamp
are commonly used in industry:

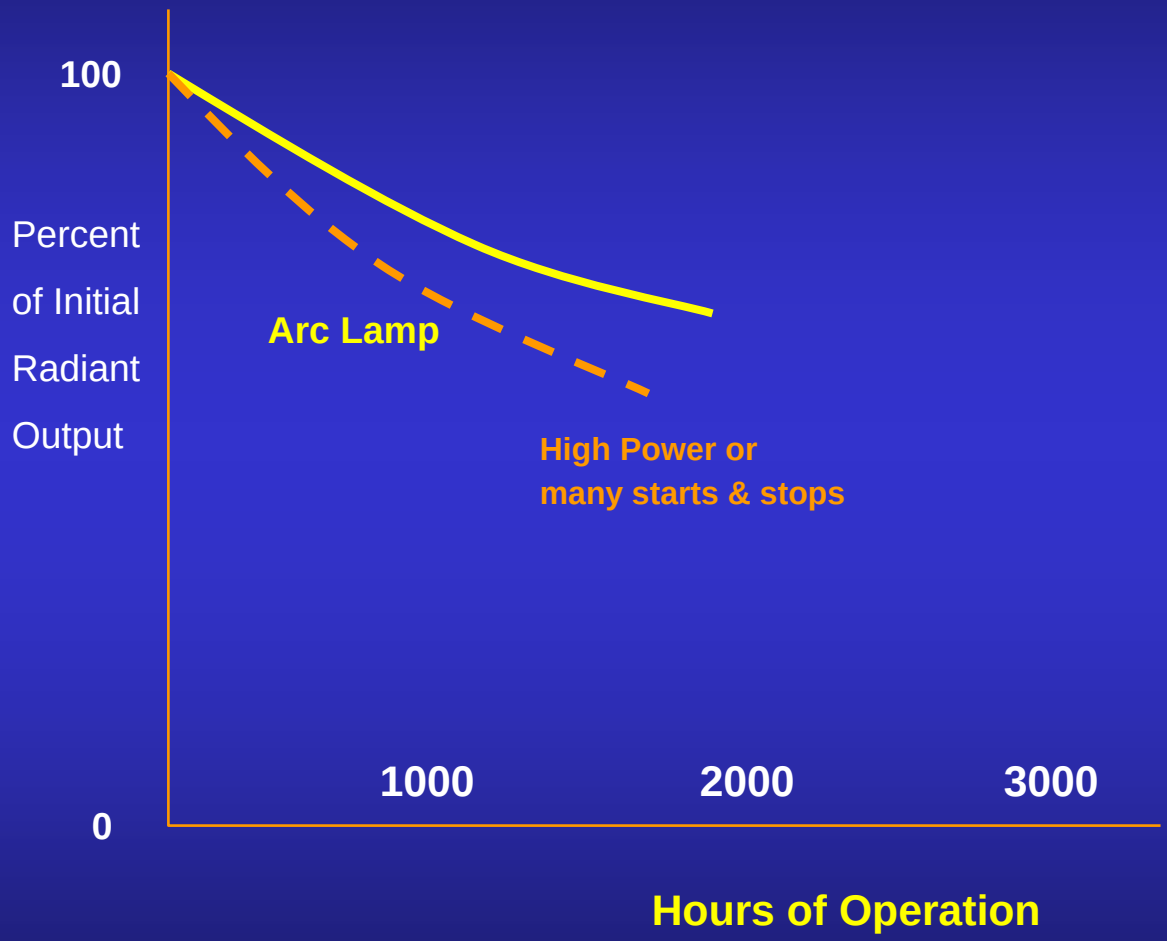
- Arc (Electrode) Lamp
- Microwave (Electrodeless) Lamp


Arc Lamp

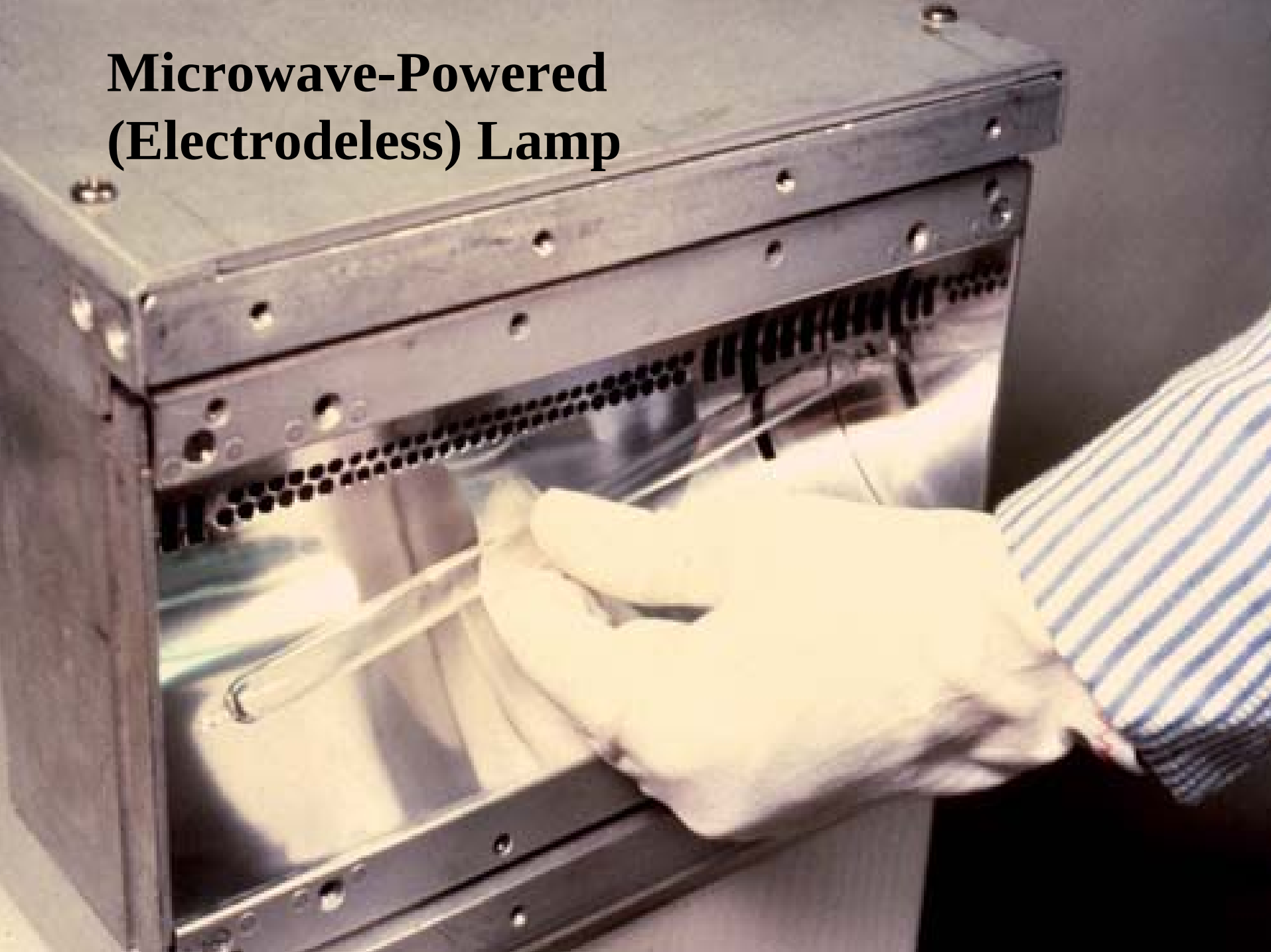
ELECTRODE LAMP

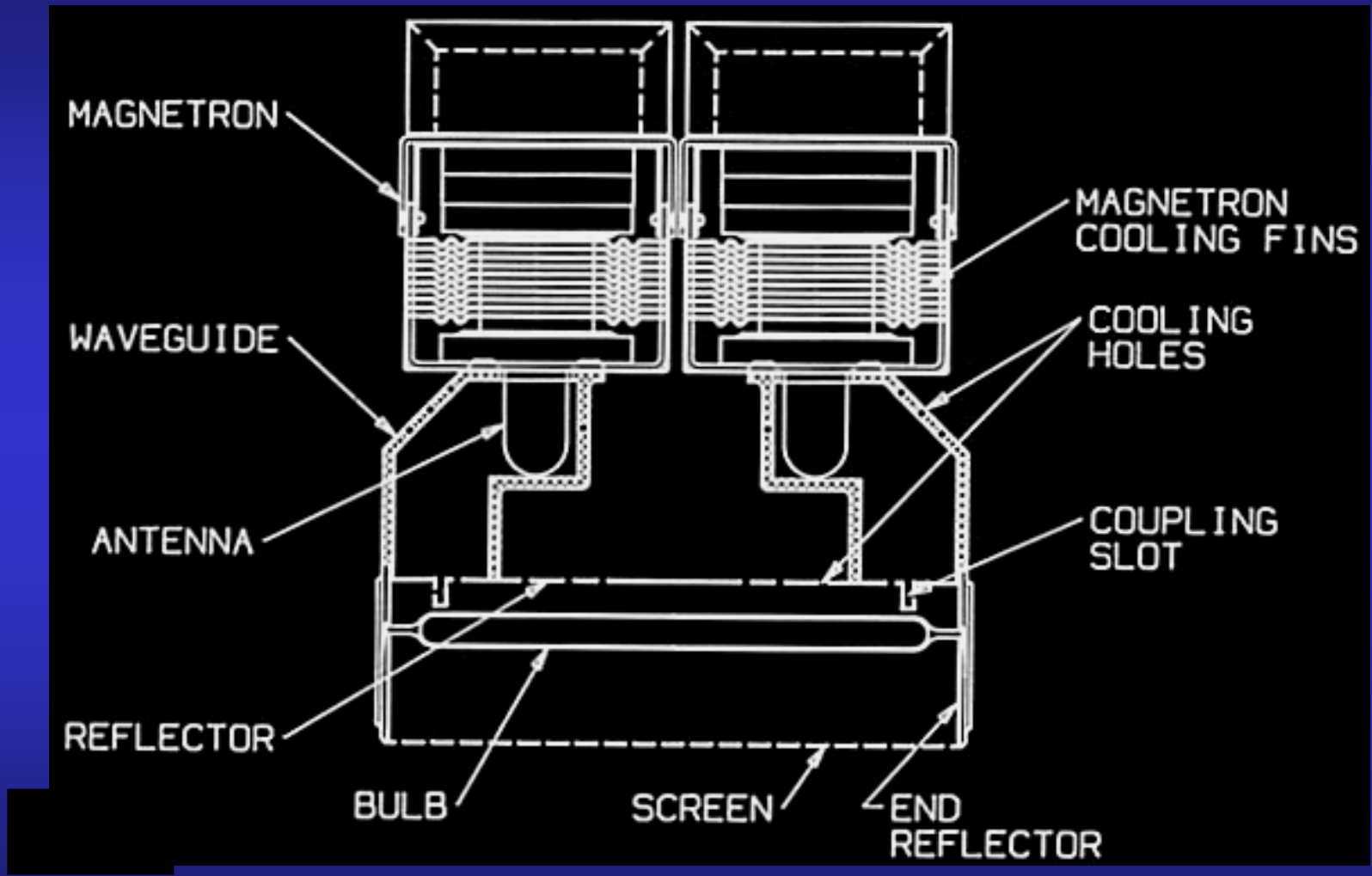


RADIANT OUTPUT STABILITY



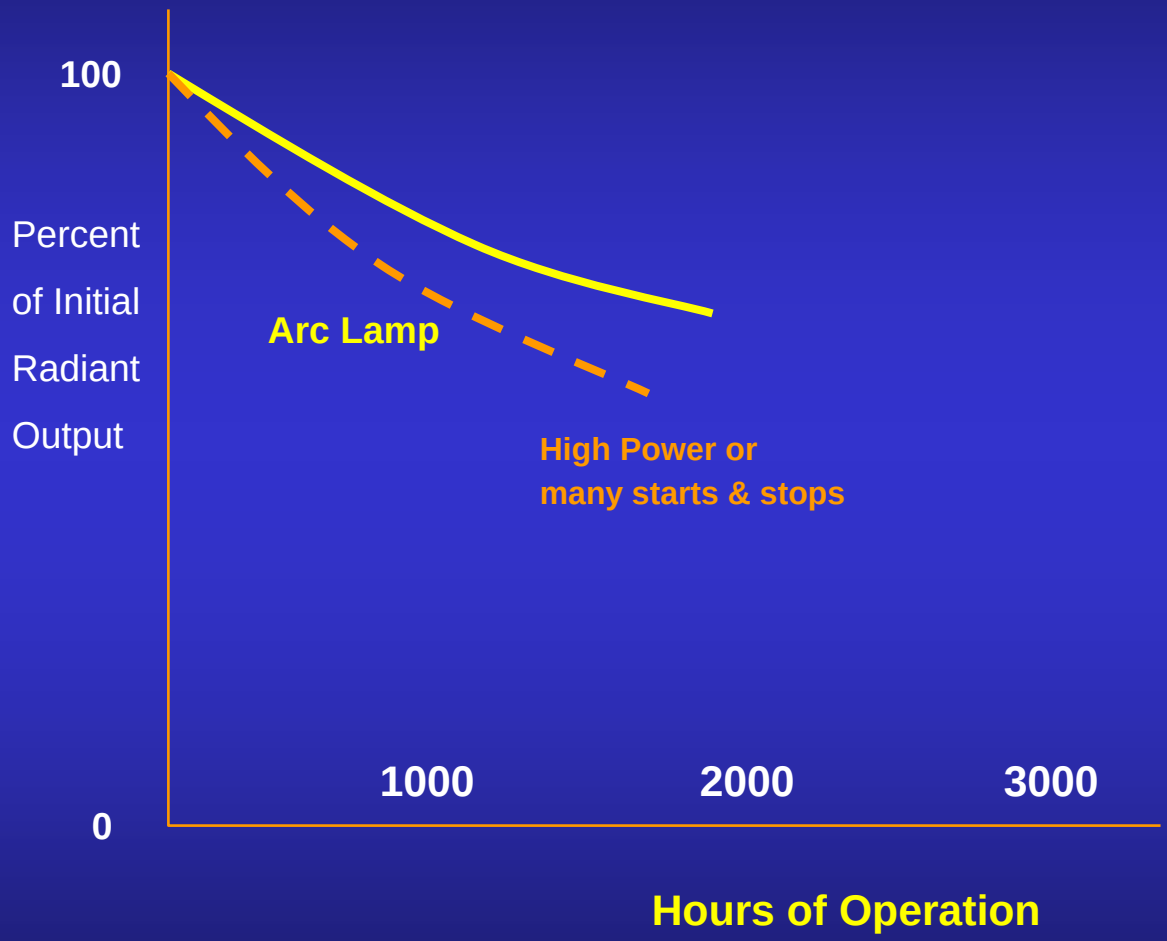
Microwave-Powered (Electrodeless) Lamp




MAGNETRON
MAGNETRON COOLING FINS
WAVEGUIDE
COOLING HOLES
ANTENNA
COUPLING SLOT
REFLECTOR
BULB
SCREEN
END REFLECTOR

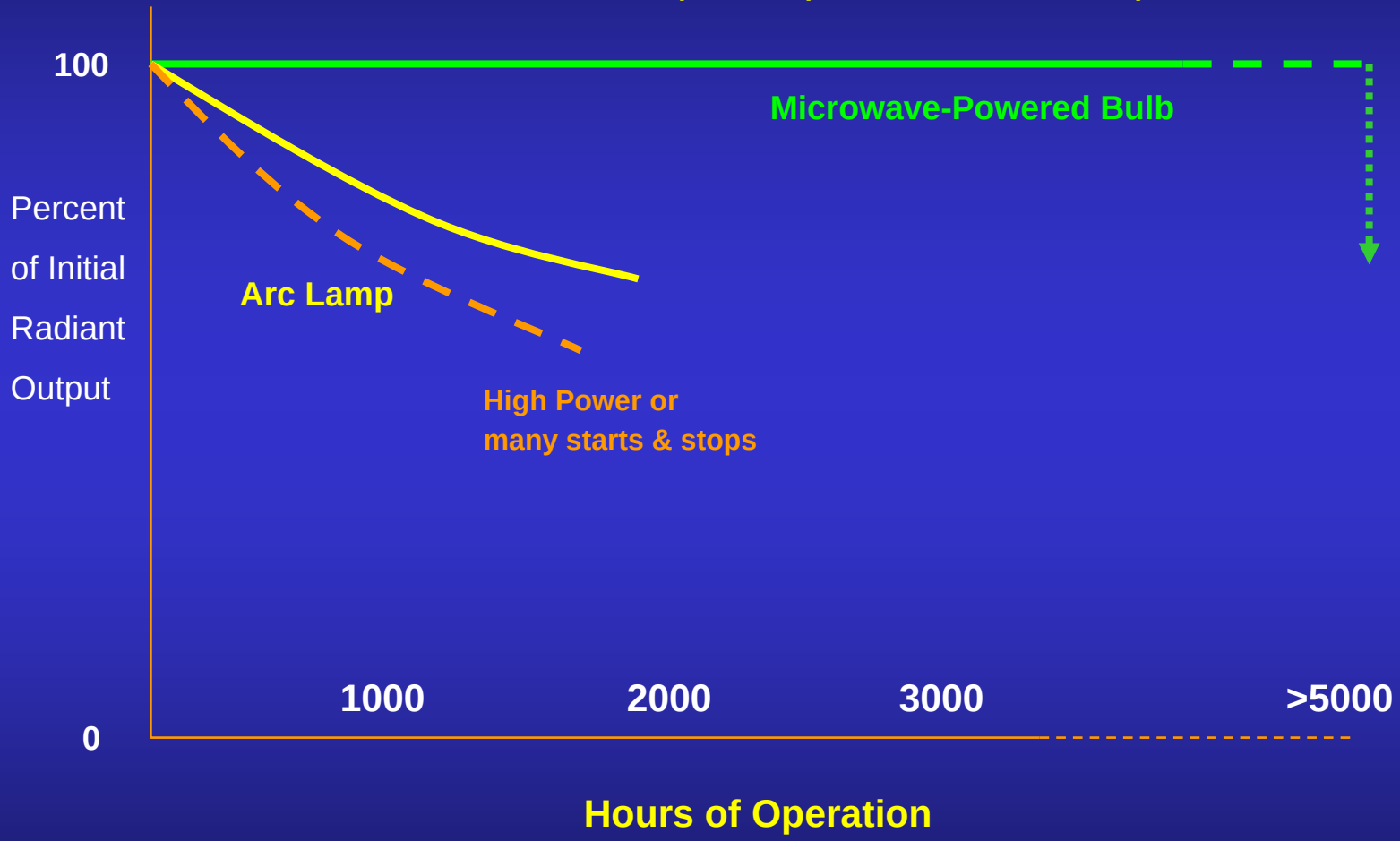
ELECTRODELESS LAMP BULB

RADIANT OUTPUT STABILITY



RADIANT OUTPUT STABILITY

Microwave Lamp Compared to Arc Lamp



UV Curing Exposure Factors "Big 4"

Factors Affecting Cure

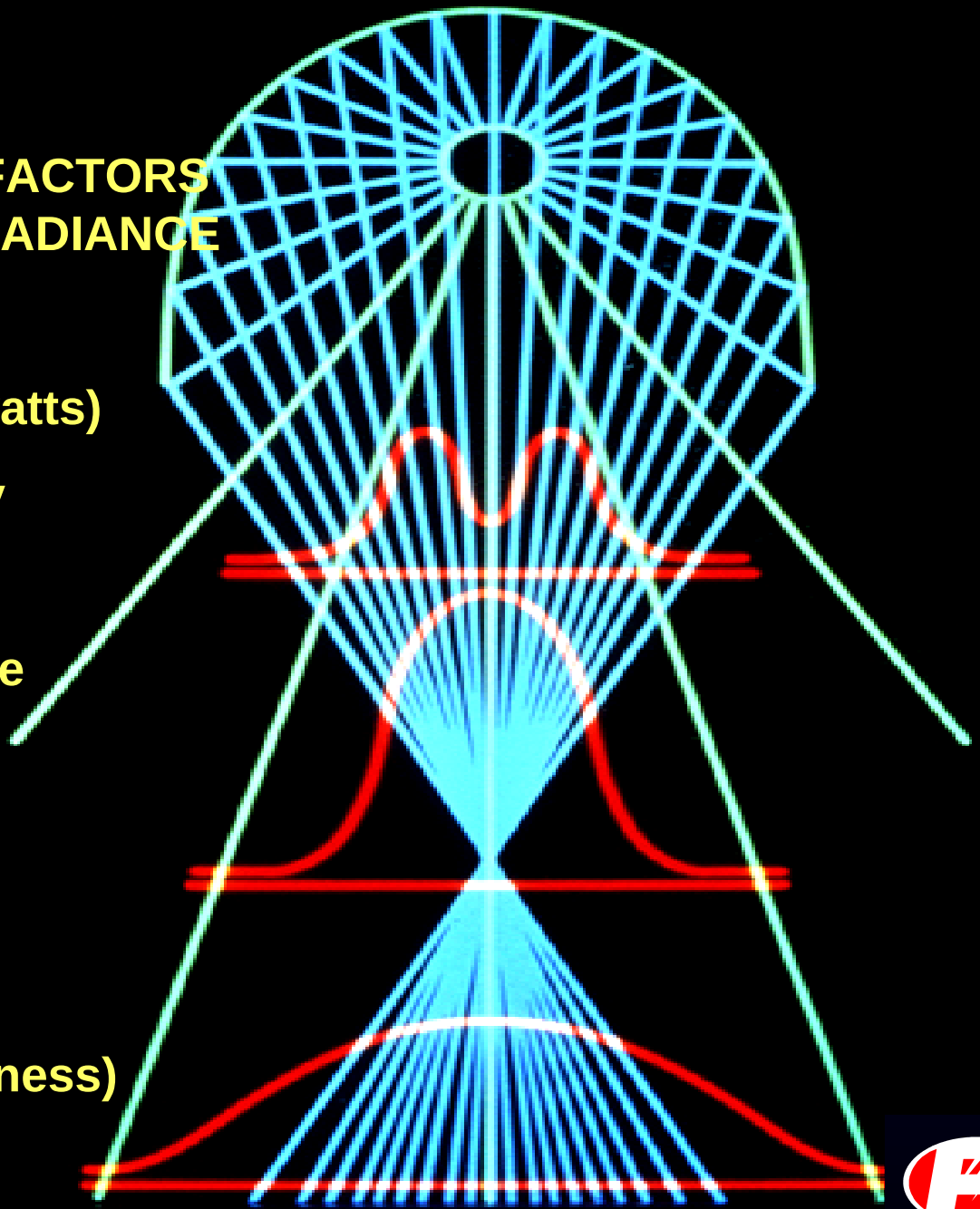
- Irradiance ("Intensity" of UV at a surface)
- Exposure Time (or speed)
- UV Spectral Output Distribution (wavelengths)
- Infrared Energy (Affects surface temperature)

LAMP DESIGN FACTORS AFFECTING IRRADIANCE

- Power Input (watts)
- Bulb Efficiency
- Bulb Diameter
- Reflector Shape
- Reflectivity

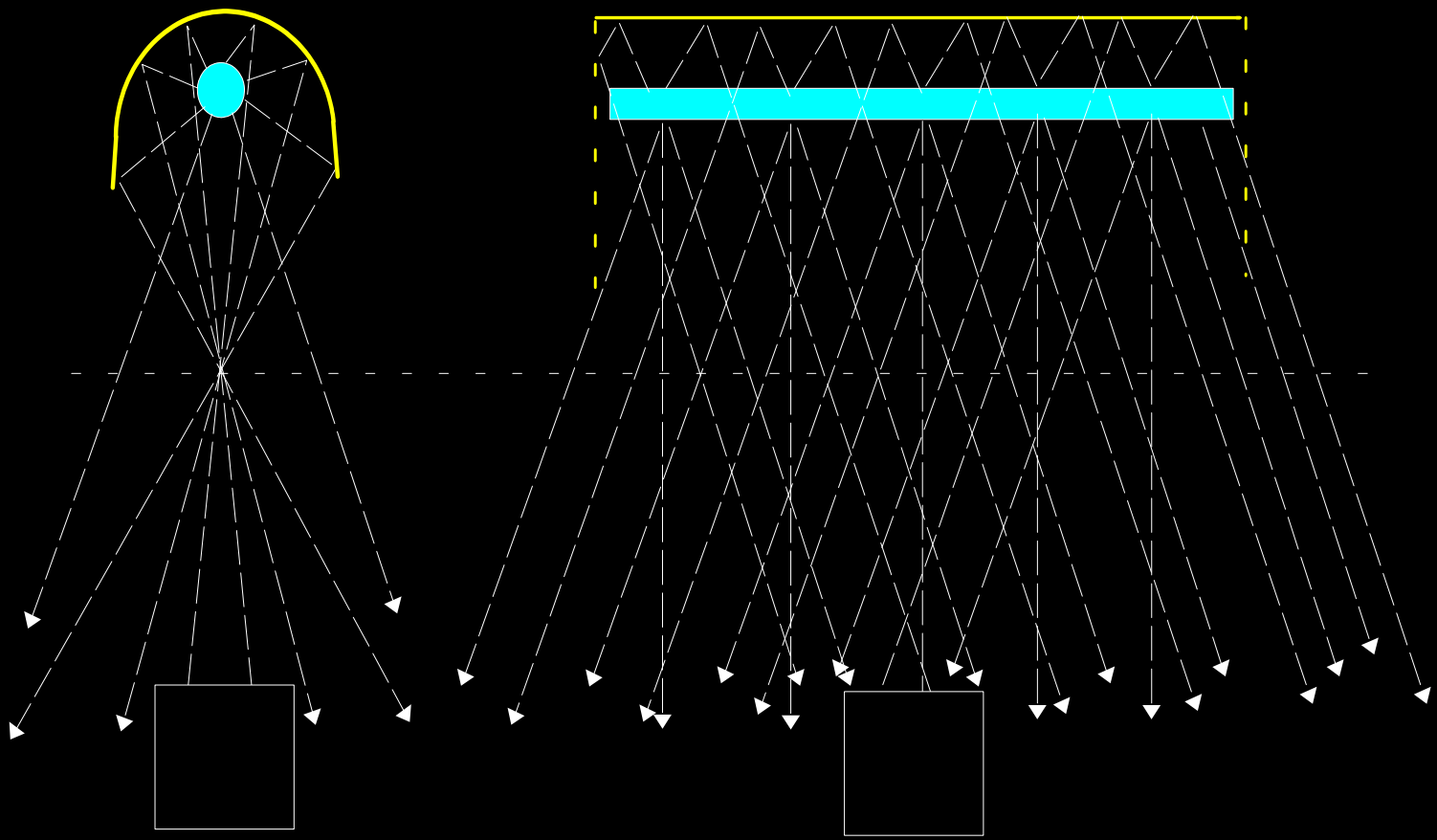
- Maintenance

(Surface Cleanliness)



FUSION SYSTEM

A Tubular Lamp Has TWO Distinct Optical Patterns



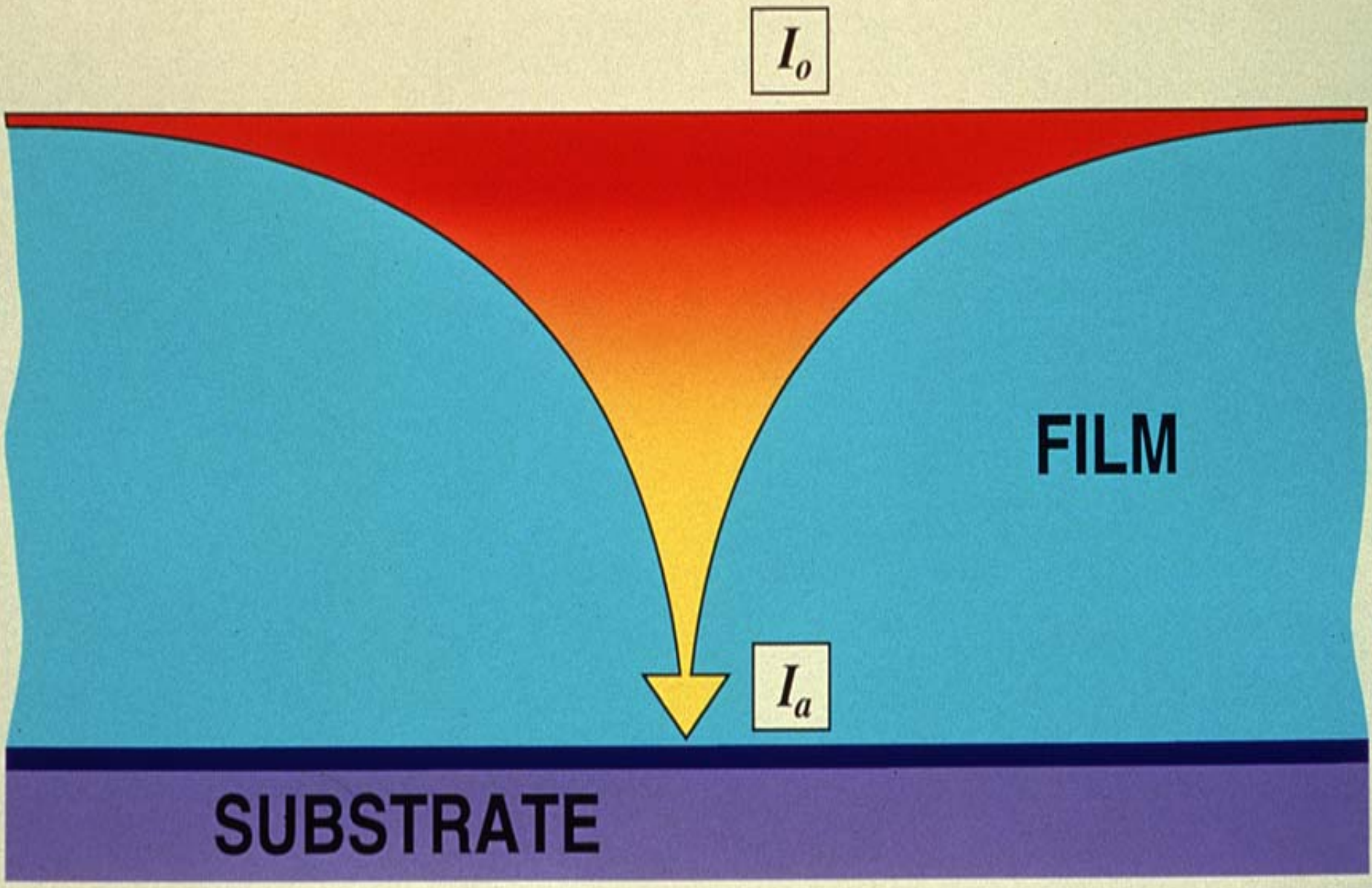
FUSION UV SYSTEMS, INC.

Why High Peak Irradiance UV?

Beer-Lambert Law

the higher the intensity at the surface, the higher the intensity at any point within the coating

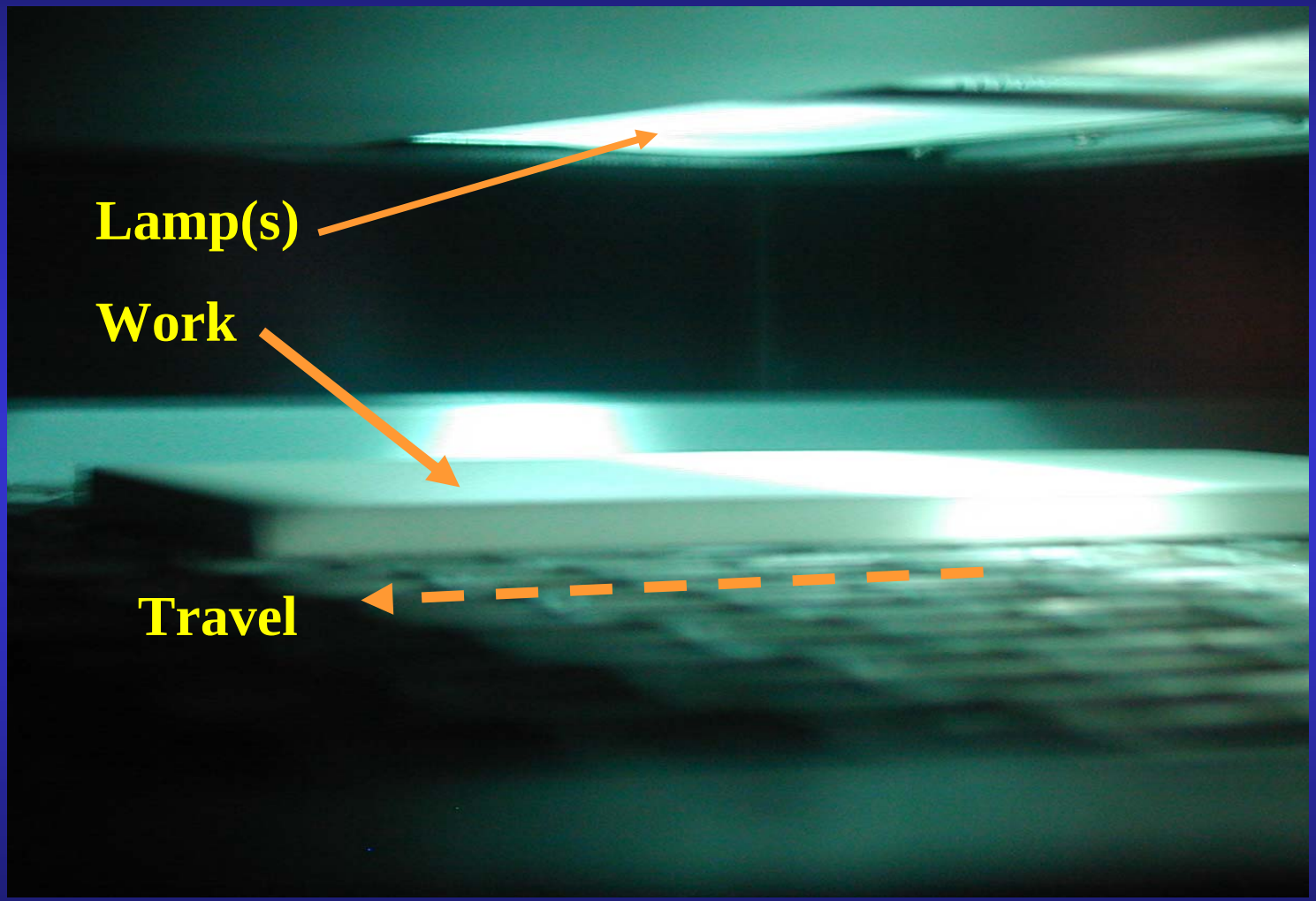
- greater depth of penetration of UV
- improved cure at the substrate / ink interface
- better adhesion to the substrate
- more uniform degree of cure throughout the film


I_o
FILM
I_a
SUBSTRATE

UV Curing Exposure Factors "Big 4"

Factors Affecting Cure

- Irradiance ("Intensity" of UV at a surface)
- Exposure Time (or speed)
- UV Spectral Output Distribution (wavelengths)
- Infrared Energy (Affects surface temperature)


Lamp(s)
Work
Travel

UV Curing Exposure Factors "Big 4"

Factors Affecting Cure

- Irradiance ("Intensity" of UV at a surface)
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- UV Spectral Output Distribution (wavelengths)
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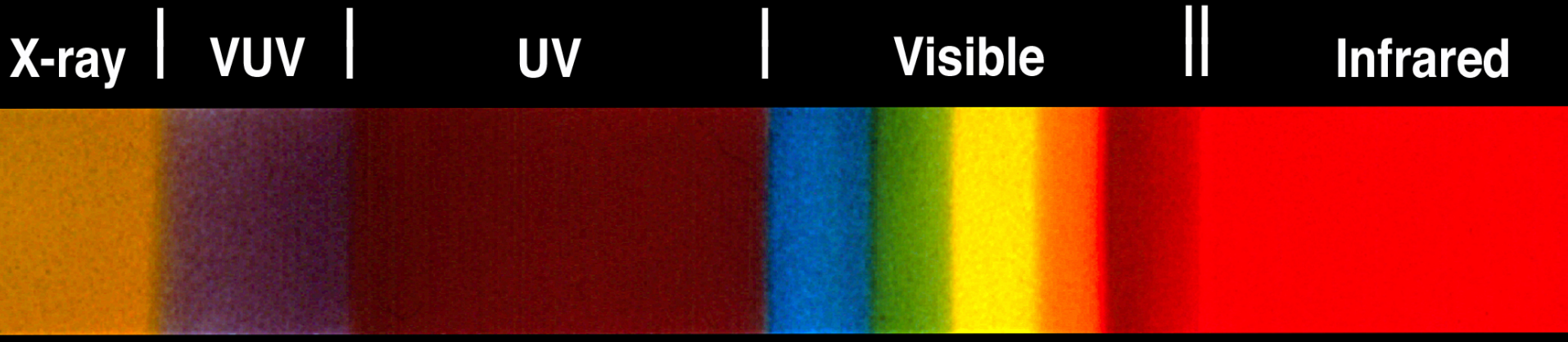


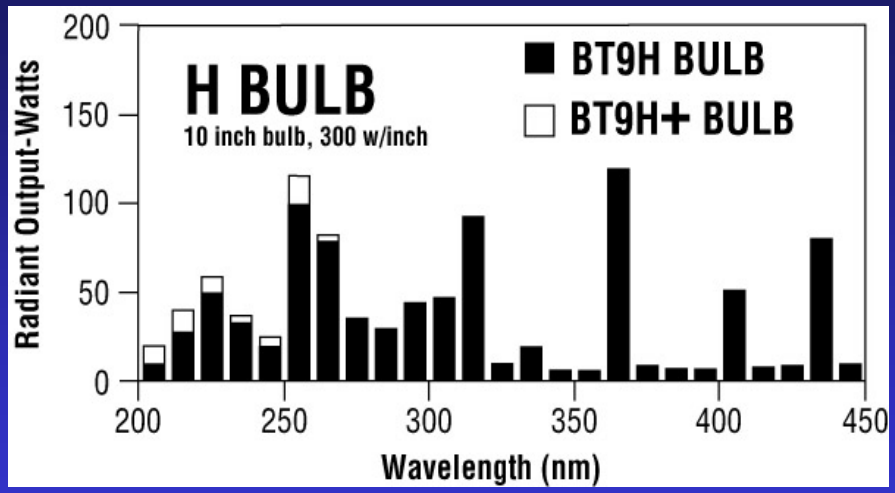
UVC UVB UVA

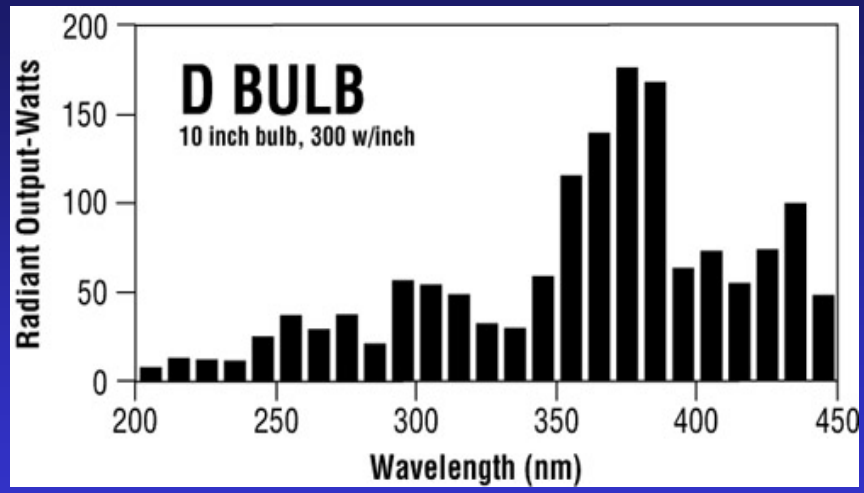
100nm 200nm 425nm 750nm .75 microns 10 μ 10 microns

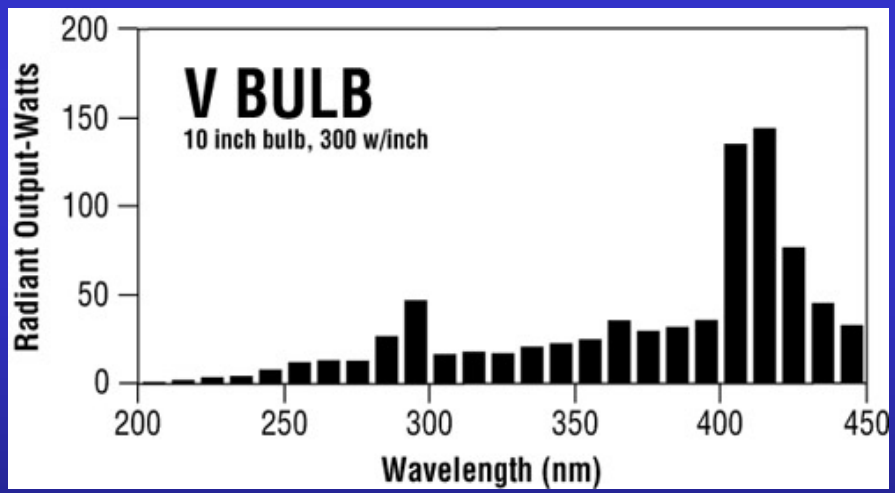
1nm = 10^{-9} meter. nm

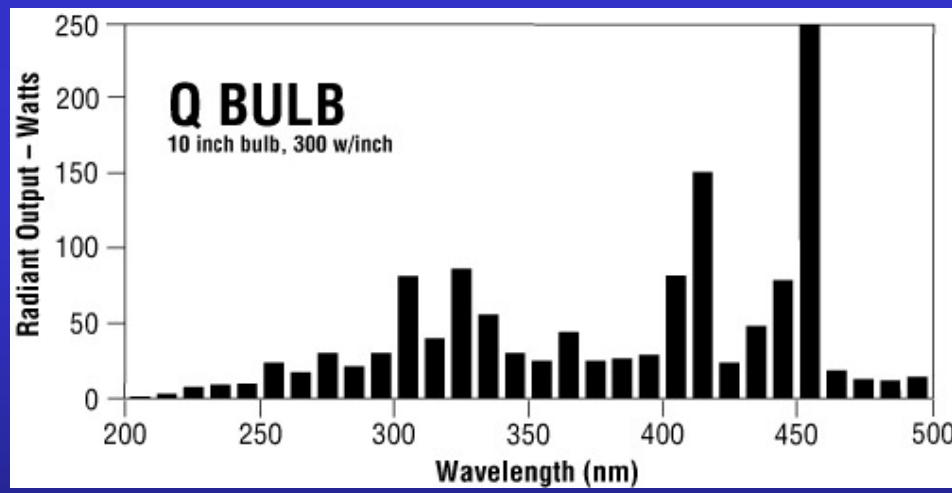
1micron = 10^{-6} meter. μ

1angstrom = 10^{-10} meter. A°



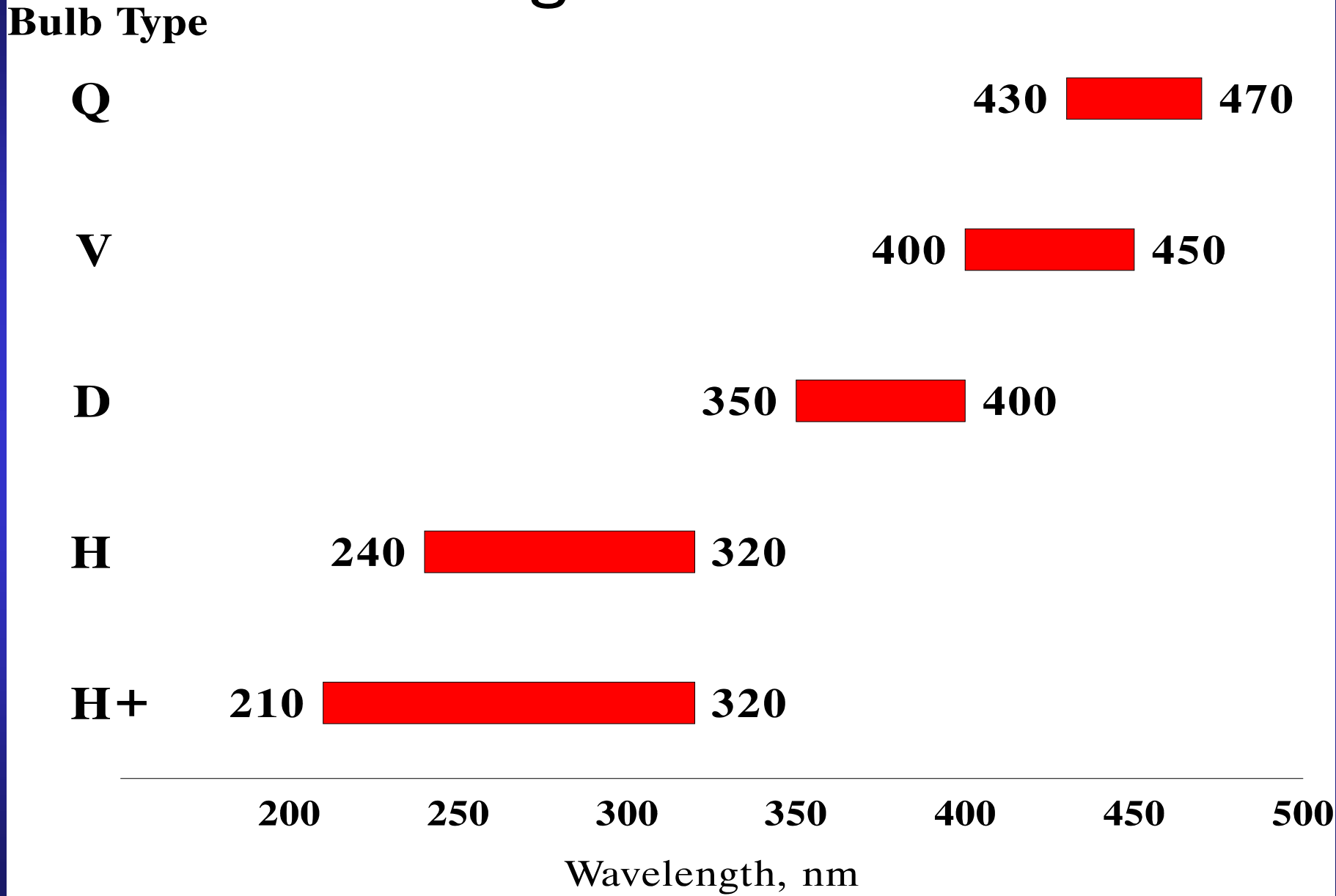






The spectral output of UV lamps can be expressed in 10-nanometer bands – this integrates the effects of line and continuous spectral emission. It makes calculation easy by reducing the UV lamp spectra to 25 data points.

Strongest Radiance



UV Bulb Spectra & Optimal Processes

H-bulb

Clear lacquers, adhesives, silicone release coatings

D-bulb(90% of all Medical applications)

Inks and pigmented systems, industrial bonding adhesives

V-bulb

White / Black pigmented coatings, visible light curing systems, gloss control

Q-bulb

Systems using camphor-quinone photoinitiators

M-bulb

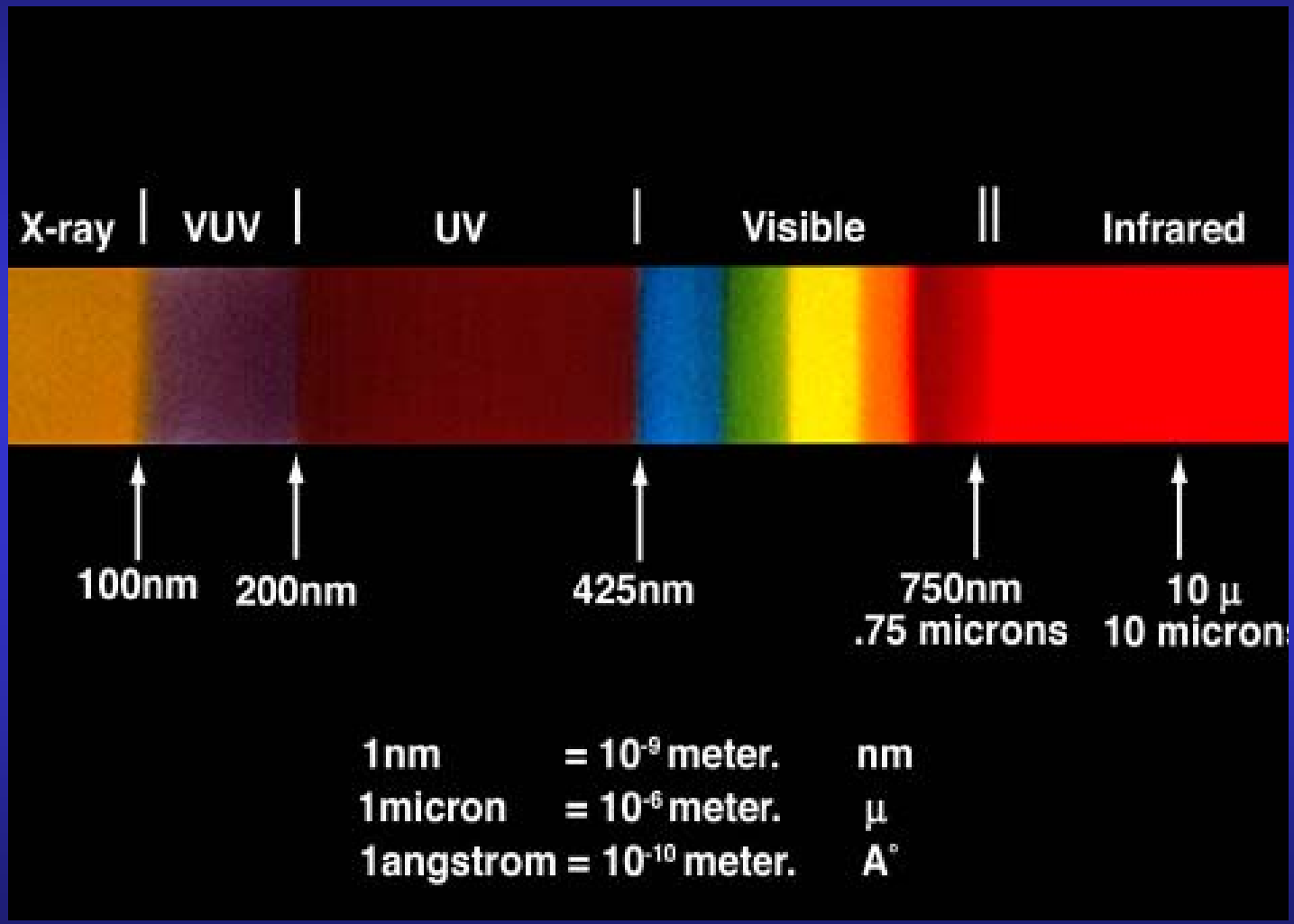
Special bulb for coatings containing UV absorbers

UV Curing Exposure Factors "Big 4"

Factors Affecting Cure

- Irradiance ("Intensity" of UV at a surface)
- Exposure Time (or speed)
- UV Spectral Output Distribution (wavelengths)
- Infrared Energy (Affects surface temperature)

Optimize Spectral Output for Maximum

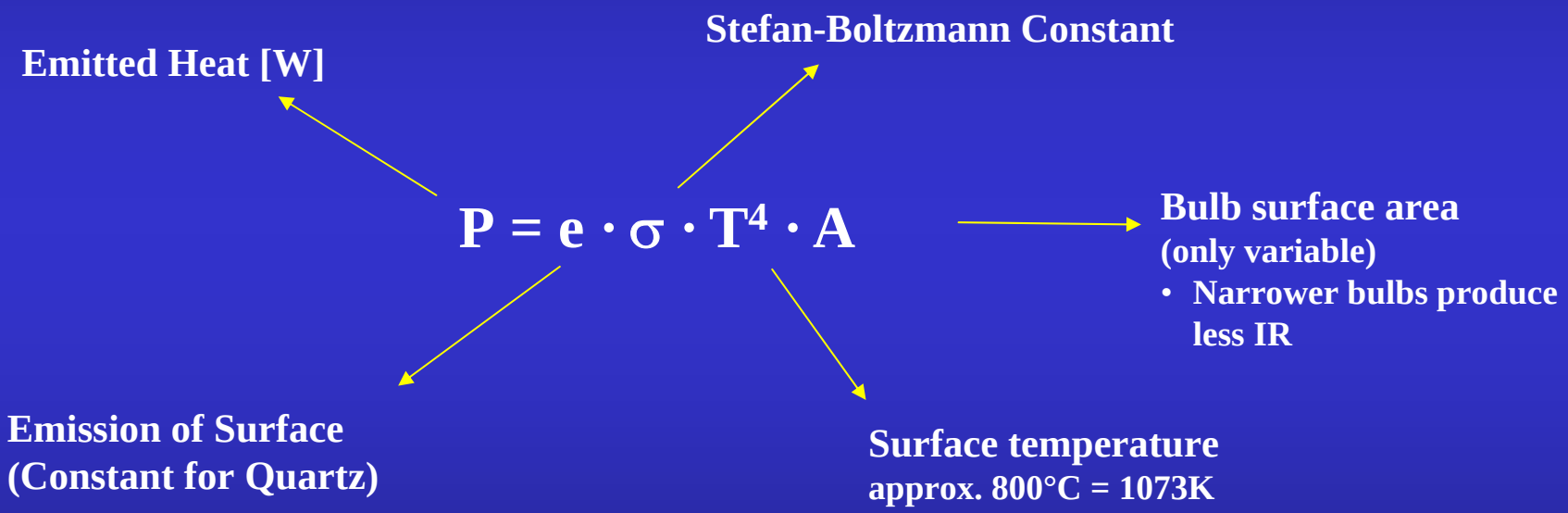


Managing Heat

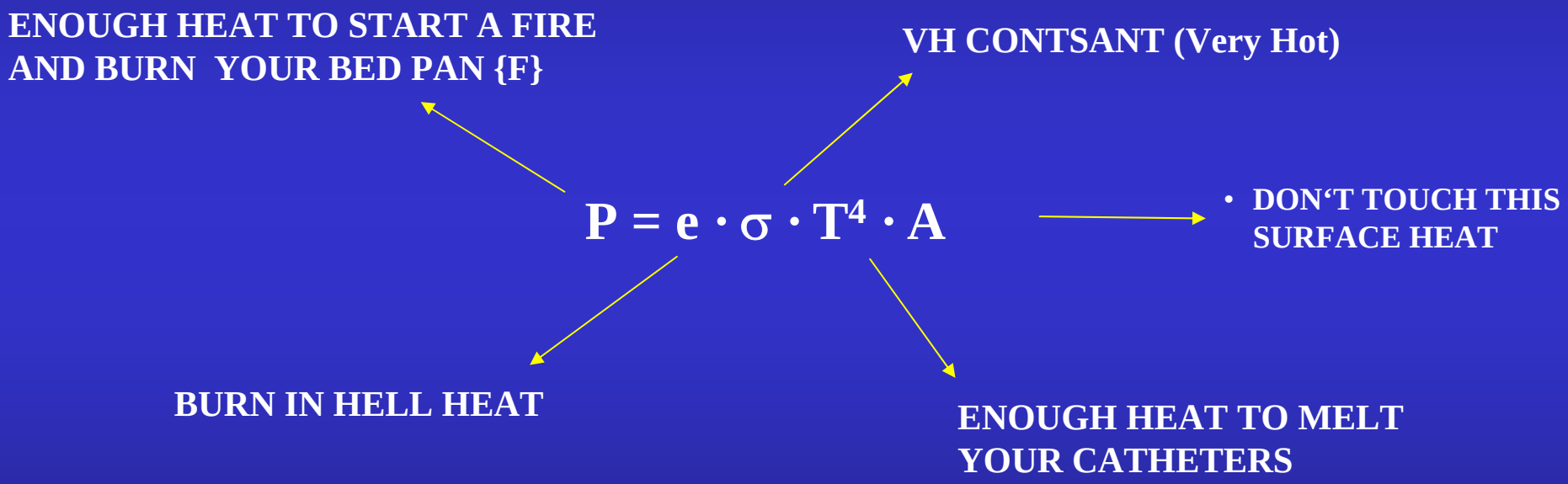
Infrared radiation from the UV bulb has the greatest heating effect on the surface

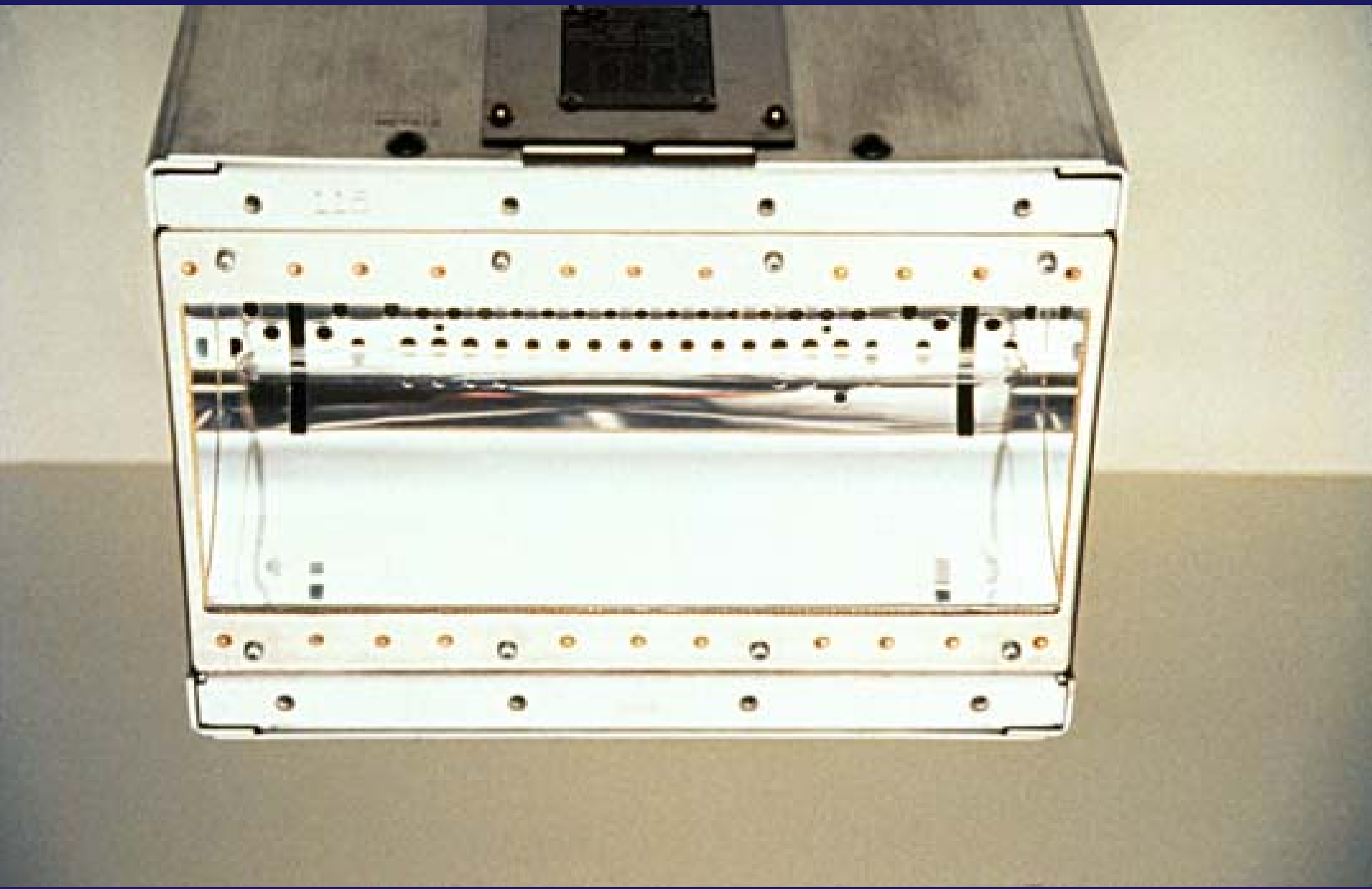
Exotherm and cooling air temperature have less effect

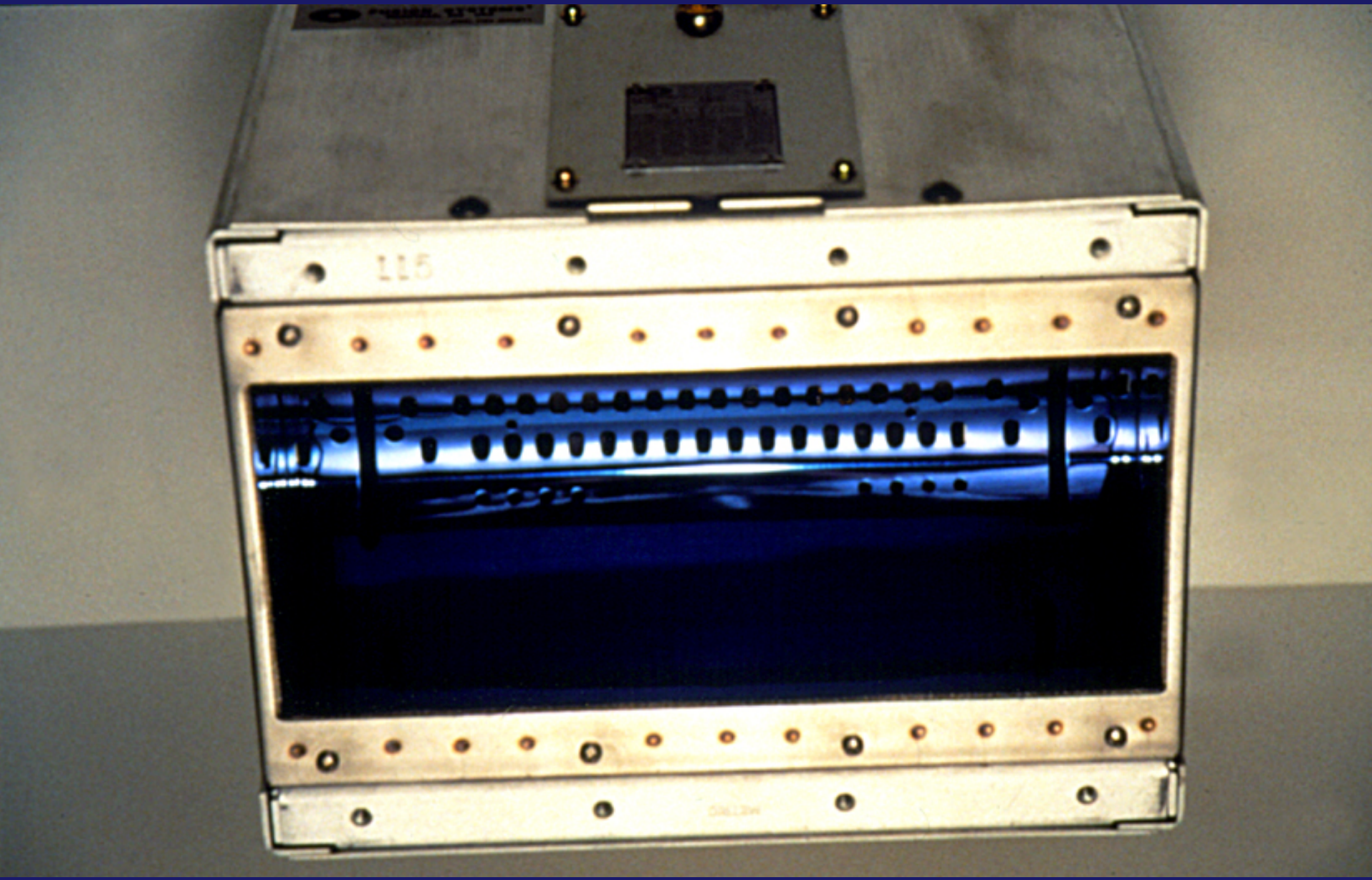
IR Production and the Stefan-Boltzmann Law



IR Production and the Stupid Novice Heat Law

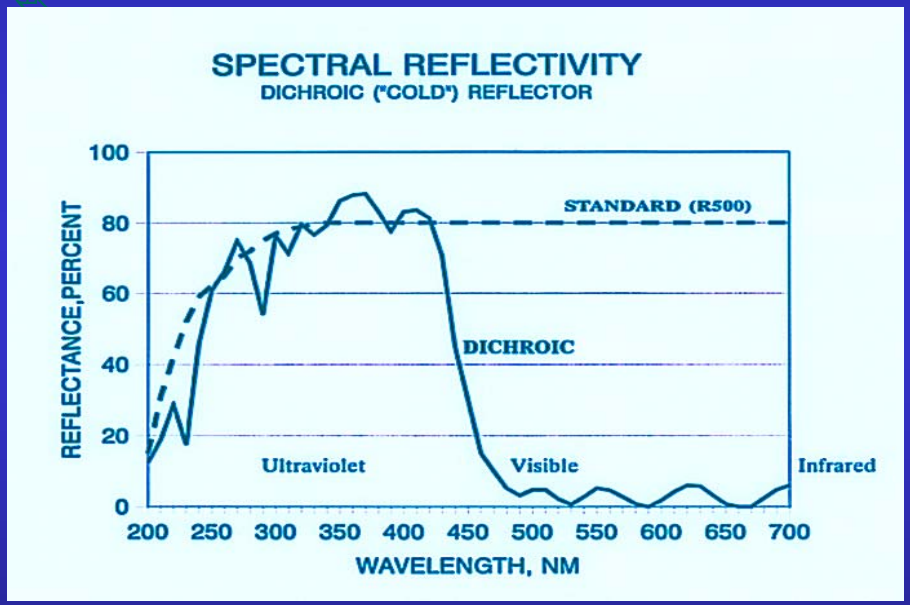


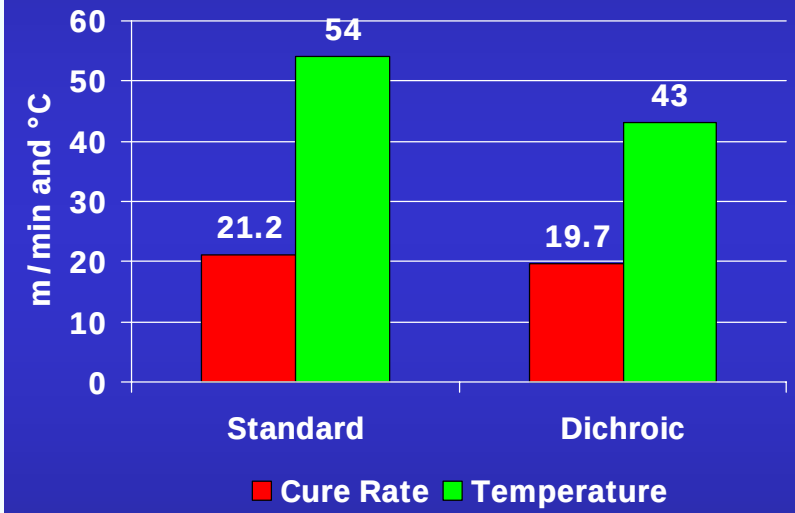




Dichroic Reflector

- Reflects UV
- Does Not Reflect Visible & IR (> 450nm)





In this example, significant reduction in peak temperature is accompanied by a slight reduction in speed.

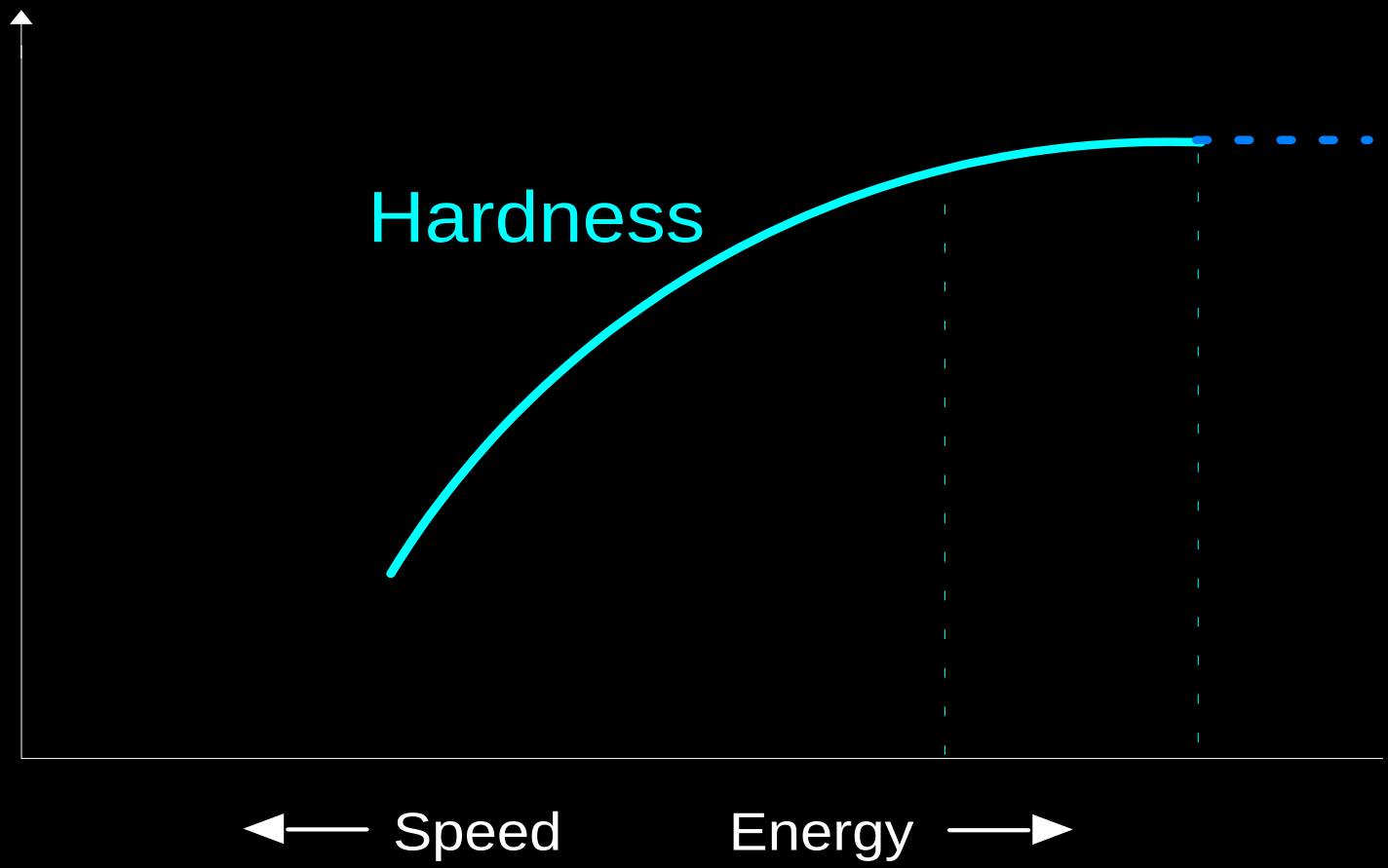
A METHOD FOR IMPROVING UV CURING PERFORMANCE AND EFFECTIVE USE OF UV LAMPS:

THE PROCESS “WINDOW”

Process "Window"

The range of a
measurable production variable
within which
"cure" meets an acceptance requirement.

DEVELOPMENT WINDOW

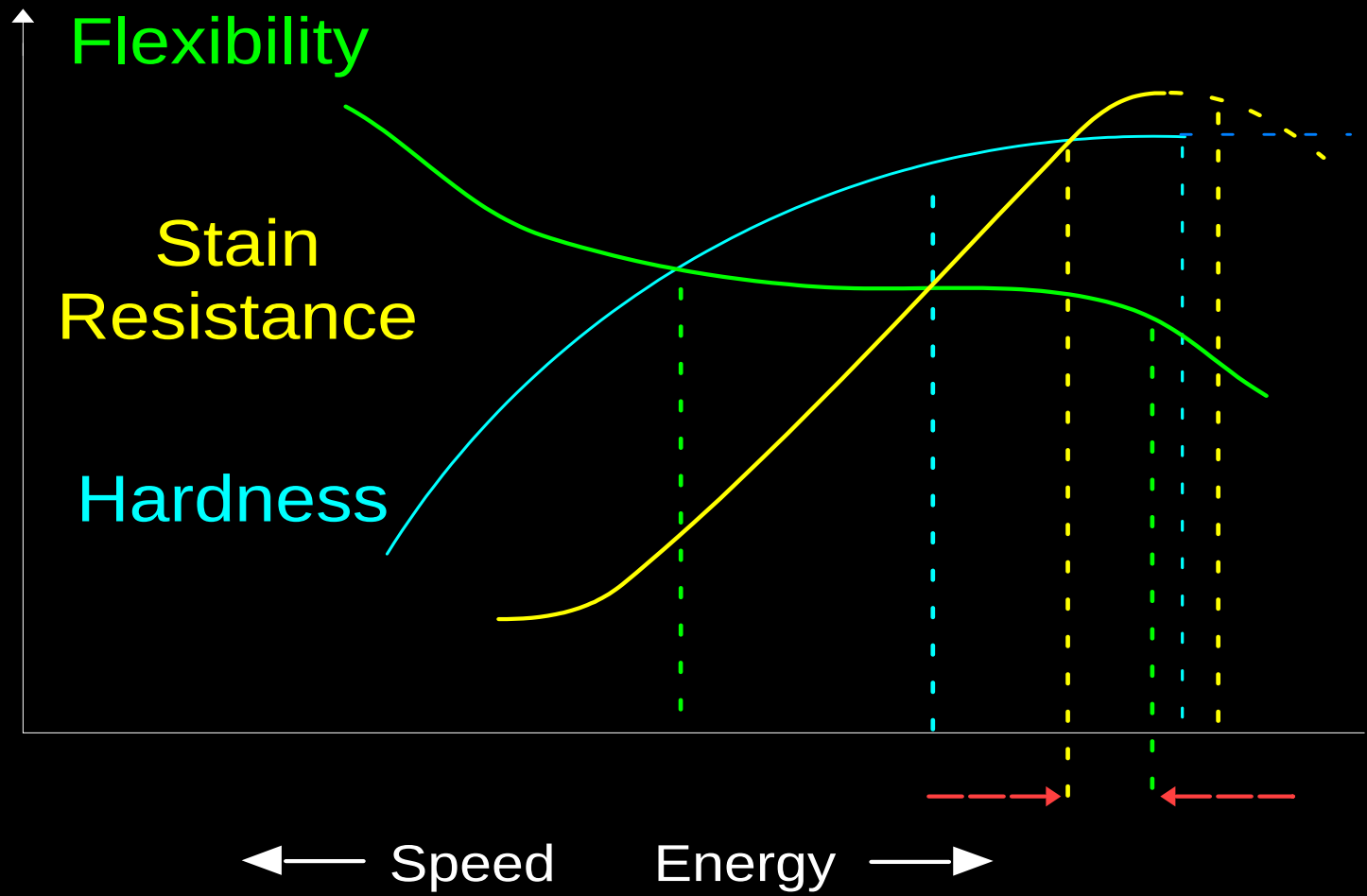


1. Using a cure ladder, determine the upper *and* lower limits of achievement of target properties

2. Find the upper and lower limits of all properties critical to success

3. Plot these limits on the energy diagram

PROCESS WINDOW

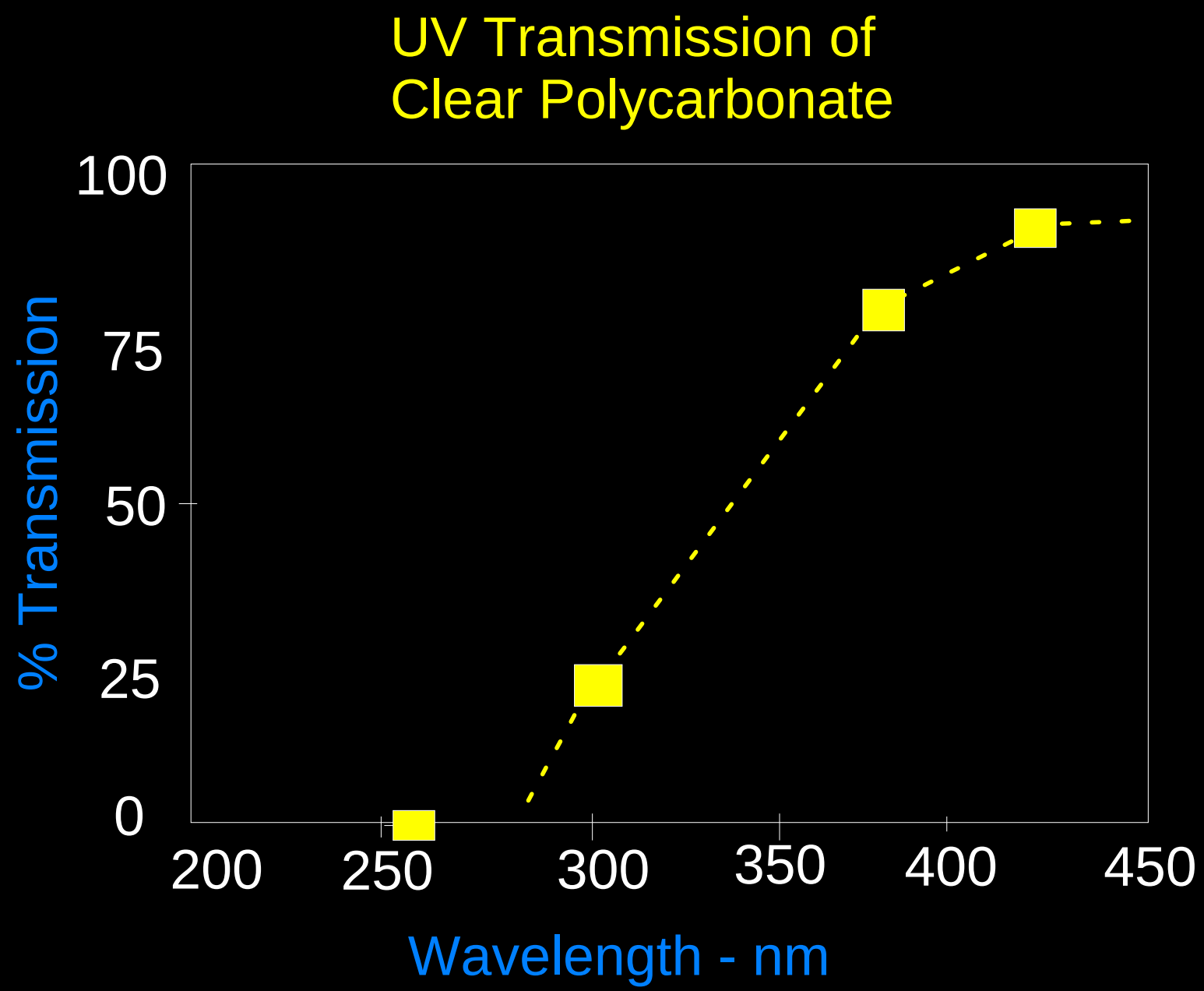


4. Identify the limiting properties and evaluate how they are affected by changes in:
UV Wavelength, Irradiance, IR, or formulation.

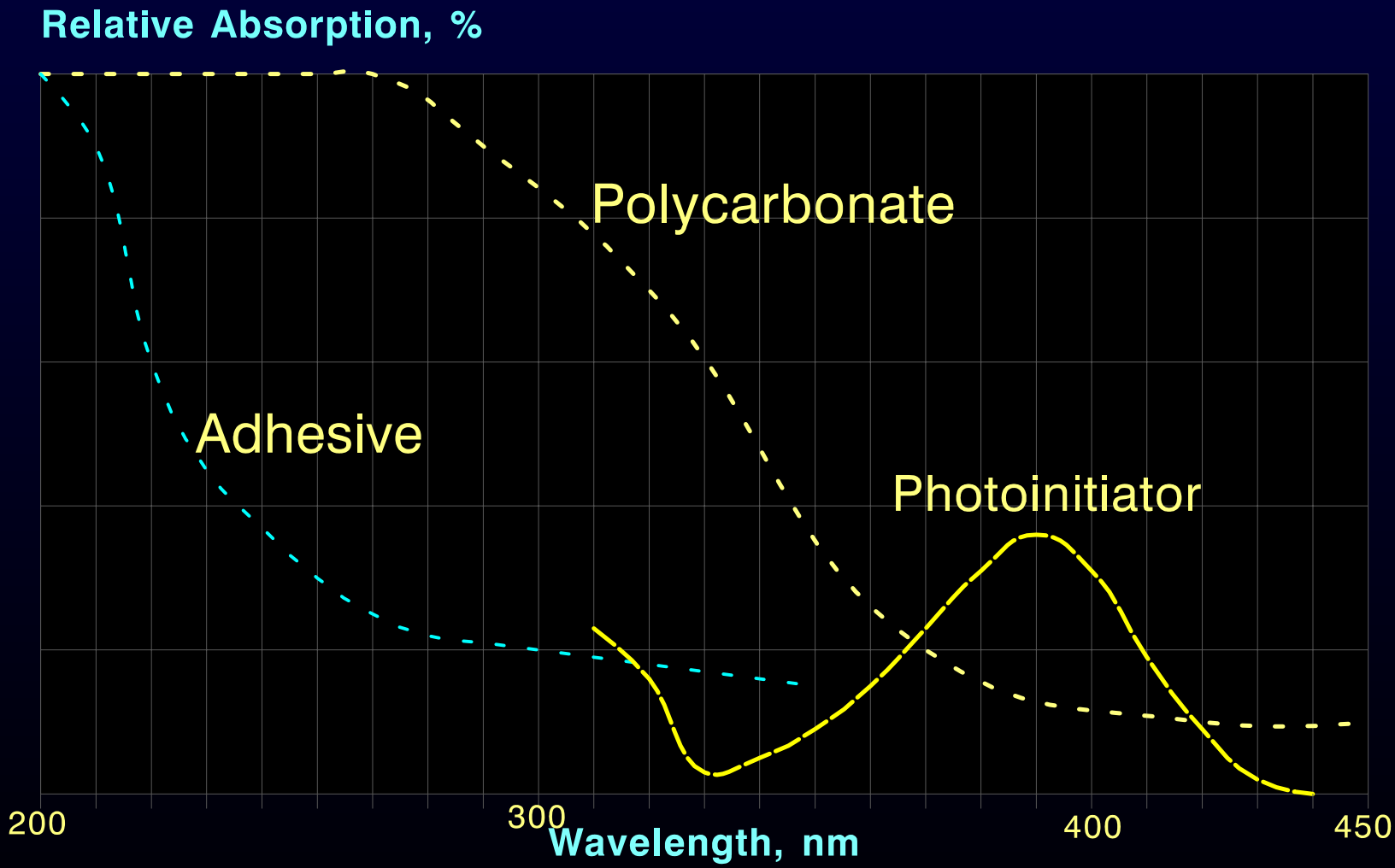
Peak irradiance affects depth of cure and efficiency;
Short wavelengths affect surface properties;
Long wavelengths affect deeper and bulk properties

This method can be used to improve any UV curing process, but requires a set of versatile UV lab tools

Curing Through Plastics

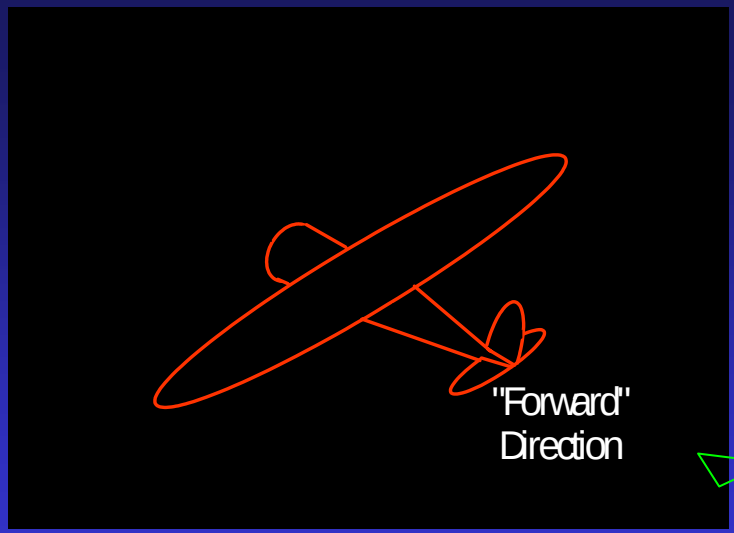

UV Transmission of
Clear Polycarbonate
100
75
50
25
0
% Transmission
200
250
300
350
400
450
Wavelength - nm

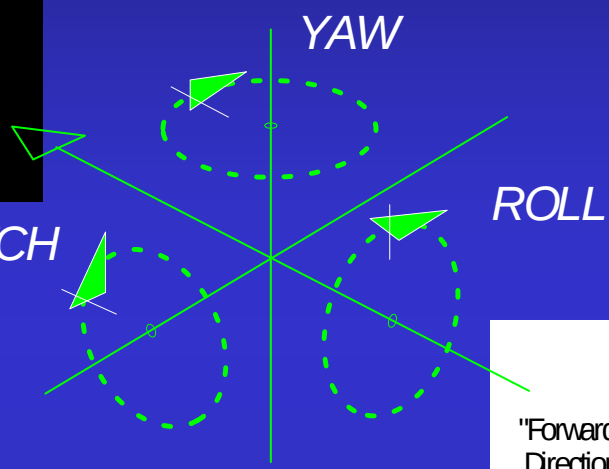
UV ABSORPTION of COMPONENT MATERIALS

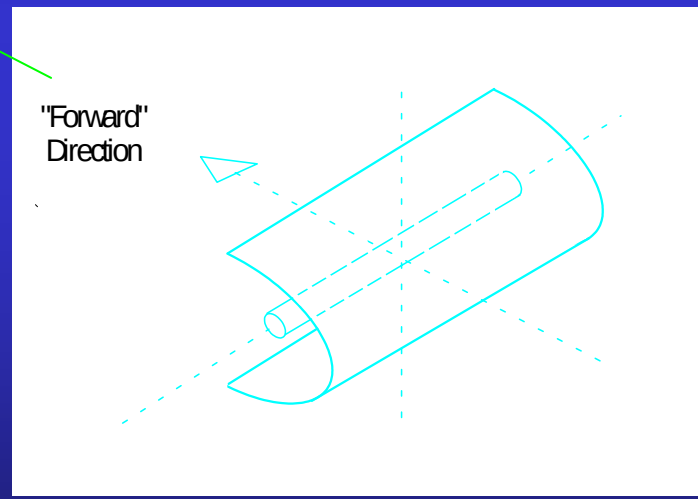


3D Cure is limited by the least-illuminated surface.

All other surfaces receive excess energy

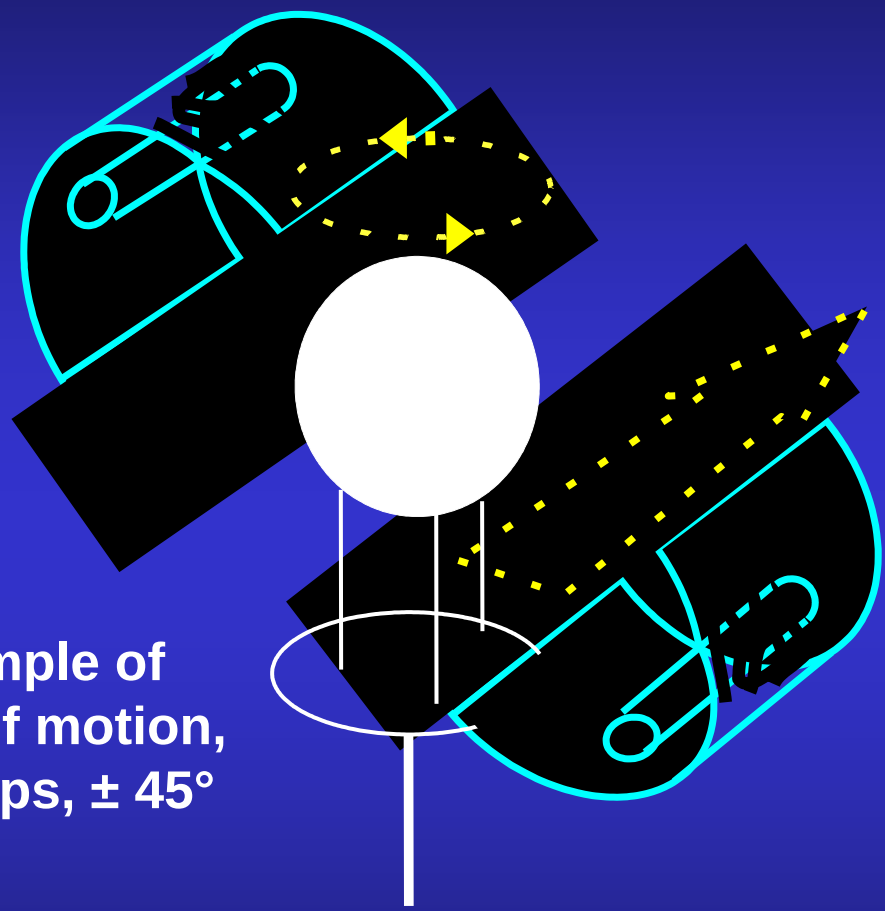






A Useful “language” for describing the “attitude” of a UV lamp in space

FUSION UV SYSTEMS, INC.

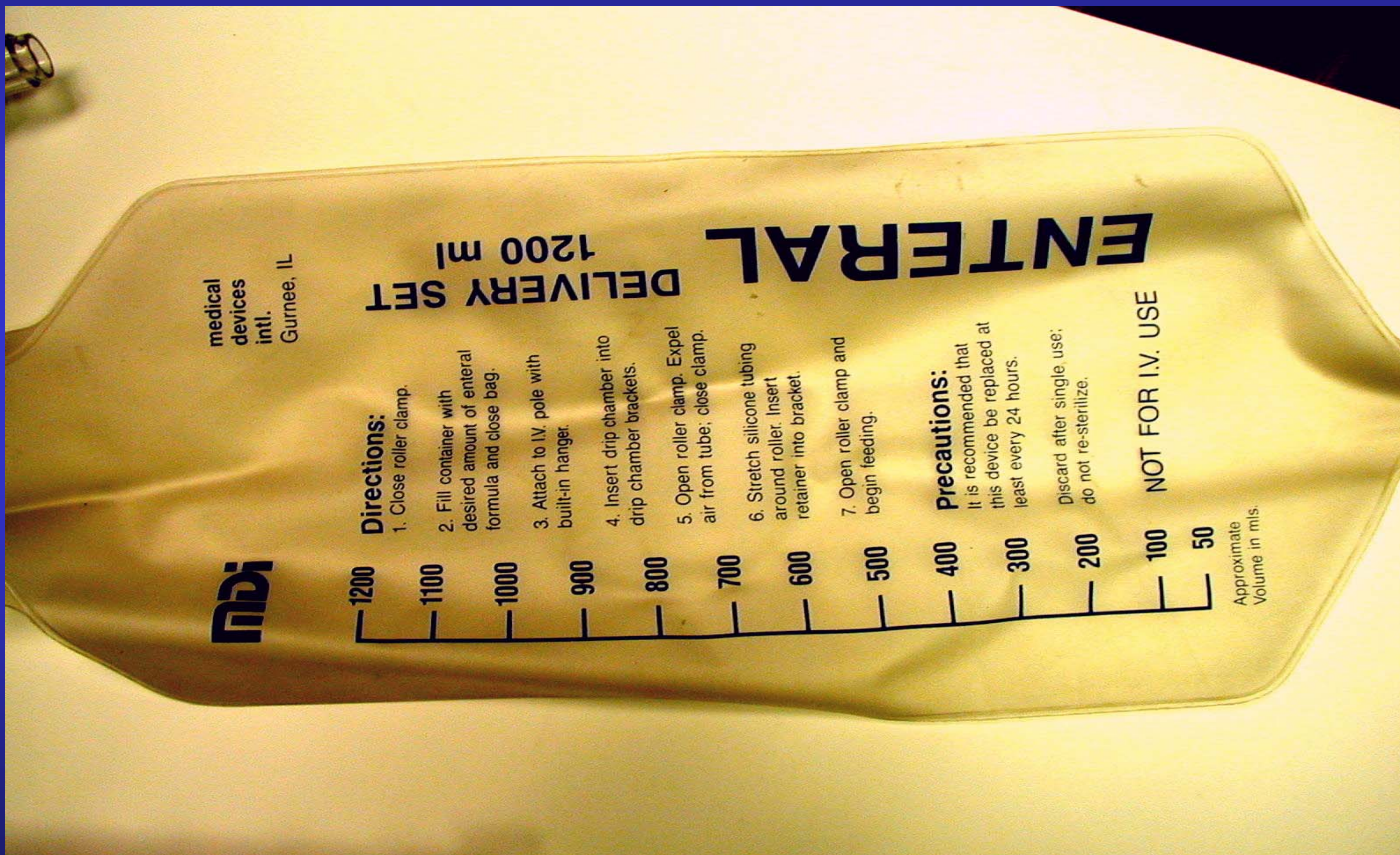


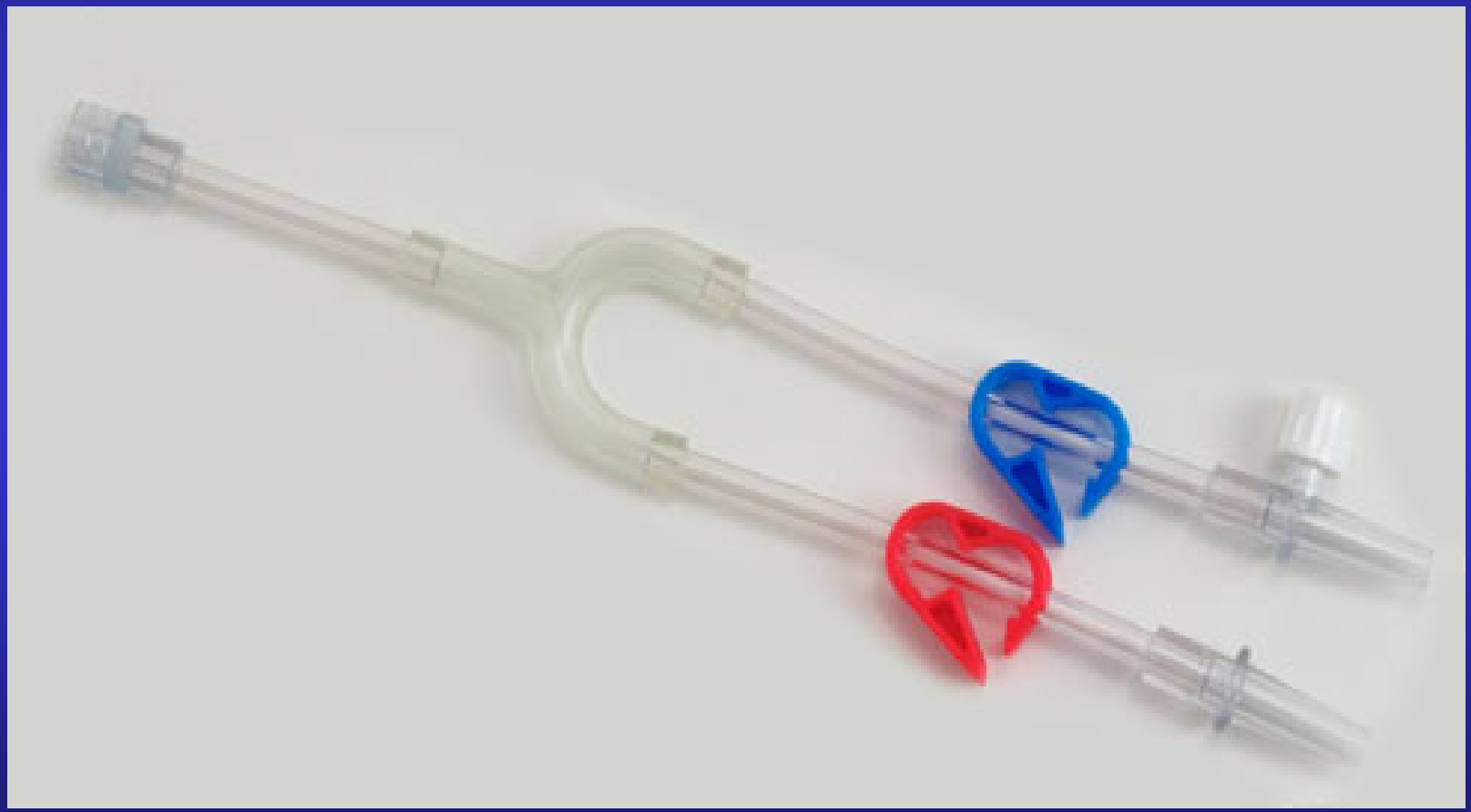
Golf Ball

A Simple example of two degrees of motion, using two lamps, ± 45° pitch.

Medical Device Examples

Medical Fluid Bags





CalMed
LABORATORIES

Photo courtesy of
Cal Med Corp.


Photo courtesy of
Cal Med Corp.

A Successful UV Process….