1. UV Light and UV Curing

- Why Cure with UV?
- Electromagnetic Spectrum and the Wavelengths DYMAX Utilizes
- Advantages of Curing with UV AND Visible Light
- Wavelengths, Intensity, and Energy
- Shortwave, Longwave, and Visible Light
- Four Types of UV Curing Systems
- The UV Curing Process
Why Cure with UV?

- Each customer will perceive and realize a unique set of benefits from UV curing, but there are three that customers consistently cite:
  - Fast Cures
  - One Component
  - Environmentally and Worker Friendly
Electromagnetic Spectrum

Shorter wavelengths contain higher energy.
Advantages of Curing with Both UV AND Visible Light

- Faster
  - UV + Visible results in 50-100% faster cures
- Deeper
  - \( \frac{1}{4}'' \) to \( \frac{1}{2}'' \) is typical with UV + Visible
- Through UV-blocking substrates
  - We can now cure through UV blocked, but visibly transparent substrates like some polycarbonates and acrylics, for example.
Wavelengths - Intensity - Energy

- **Wavelengths**
  - Defined as the distance between crests of a wave. In the UV region, these wavelengths are typically measured in nanometers (one billionth of a meter).

- **Intensity**
  - Energy reaching an area per time. Often measured in mW/cm² or W/cm².

- **Energy**
  - Total energy reaching a area over a period of time. Often measured in mJ/cm² or J/cm².
# Shortwave – Longwave - Visible

<table>
<thead>
<tr>
<th></th>
<th>Contains</th>
<th>Primary Emission Spectra</th>
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<tbody>
<tr>
<td><strong>Shortwave (H)</strong></td>
<td>Mercury</td>
<td>210-315 nm</td>
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<tr>
<td><strong>Longwave (D)</strong></td>
<td>Mercury and Metal Halide</td>
<td>350-400 nm</td>
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<tr>
<td><strong>Visible (V)</strong></td>
<td>Mercury and Gallium</td>
<td>400-450 nm</td>
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DYMAX UV Curing Equipment

- **UV Spot Lamps**
  - Highest intensity, small area (up to 0.5” diameter)

- **UV Flood Lamps**
  - Moderate Intensity, large area (5” x 5” or 8” x 8”)

- **UV Conveyors**
  - Moderate to High Intensity

- **Radiometers**
  - Measure UV Intensity
The UV Curing Process

- Typical Cure Speeds
  - 1 to 30 second UV cures are typical

- Intensity
  - Higher Intensity = Faster Cures

- Substrates and Distance
  - Substrates and Distance Affect Intensity

- Depth of Cure
  - Maximum depth of cure of ¼” to ½” is typical
The UV Curing Process

- **Shadow Curing**
  - Curing will not propagate into “shadowed” areas. Secondary cure mechanisms are available for curing in these areas.

- **Cure after exposure?**
  - Acrylates stop curing immediately after exposure.
  - Cationics continue to cure for 24 hours after exposure.
The UV Curing Process (Cont.)

- **Oxygen Inhibition**
  - The surfaces of some UV materials will remain tacky after exposure to UV light. Often this tackiness can be minimized or eliminated by using a …
    - Higher intensity
    - Longer cure
    - Inert gas blanket (like nitrogen)
    - Another UV curing material
The UV Curing Process (Cont.)

- **Overexposure**
  - UV curing resins can typically tolerate over-exposure from 100% to 500% without any degradation.

- **Operating Intensity versus Validation Intensity**
  - A UV curing process should be operated at a higher intensity/energy than the validation intensity/energy to allow for intensity degradation.
The UV Curing Process (Cont.)

- **Multiple Parts**
  - Sometimes a flood lamp, although slower curing, cures more efficiently than a faster curing spot lamp. For example, which is more efficient:
    - 10 parts cured together for 30 seconds with a flood
    - 10 parts cured 5 seconds each with a spot

- **Multiple Exposures**
  - Multiple in-line curing stations can be used. For example:
    - Two 5 second exposures are essentially as effective as one 10 second exposure.