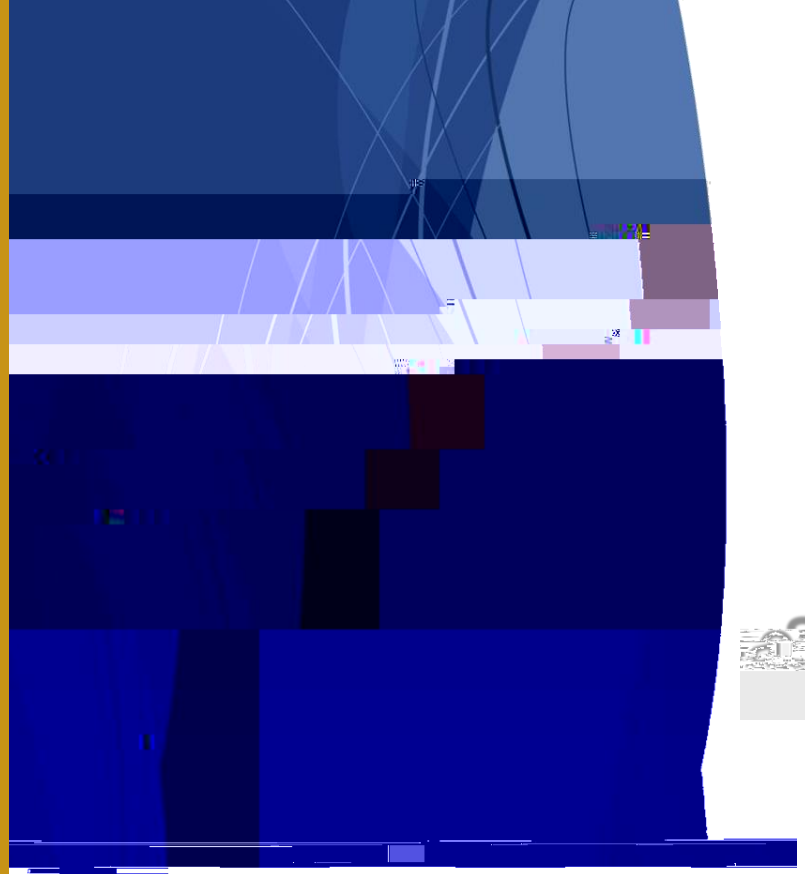
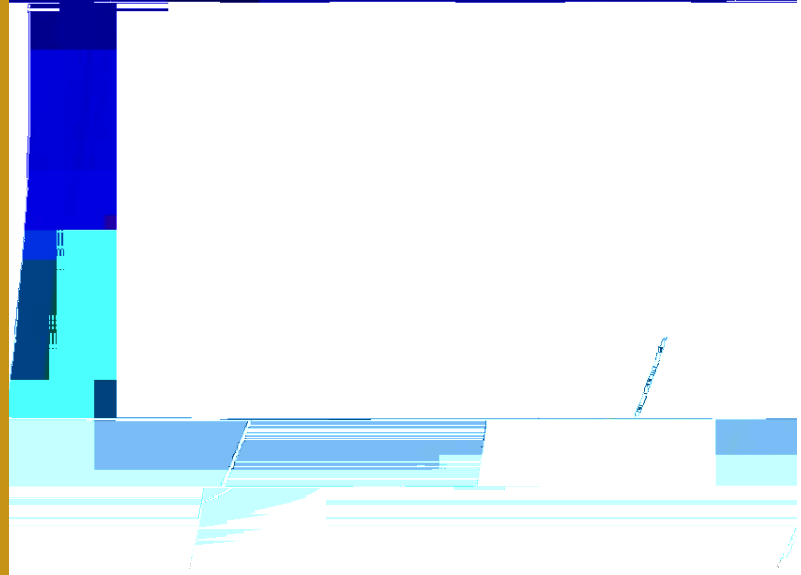




JAMS 2018 Technical Review
May 23-24, 2016

Standardization of Incandescent Ignition Source Detection Methodology for Composite Structure Lightning Testing

Motivation and Key Issues

Incandescent particles, hot spots, and edge glow produced by carbon fiber composites have not yet been characterized by their ability to ignite fuel, causing unnecessary failure with current test method.

Objective

Development of a new detection methodology for incandescent ignition sources to reduce the number of edge glow failures that occur with current photographic method.

Approach

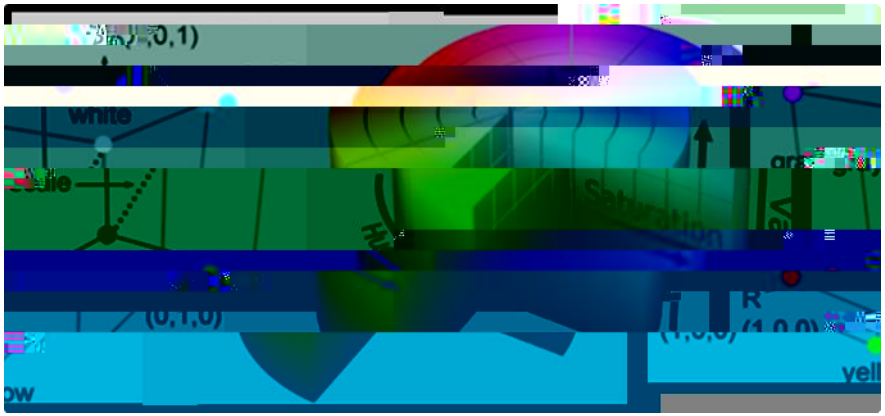
Utilize an augmented photographic method to predict ignition conditions of the flammable gas mixture imposed by an incandescent heat source.

Digital Color Imaging

CMOS sensor filters light through red, green, and blue (RGB) filters.

Each individual pixel measures light intensity through ONE of the color filters.

An internal camera-specific demosaicing algorithm interpolates individual R, G, and B values for each pixel into a full color image.



Transformation from RGB color to HSB (Hue, Saturation, Brightness) color space.

HSB space is a cylindrical-coordinate representation of colors in the rectangular RGB color model.

The hue component is most important for this analysis.

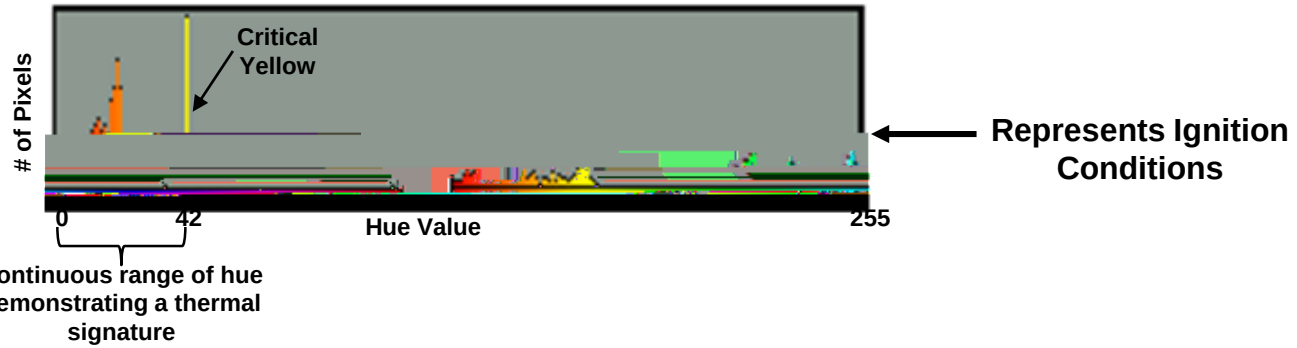
Hue histograms are used to determine the hue signature present in the image.

Incandescent Signature of Ignition

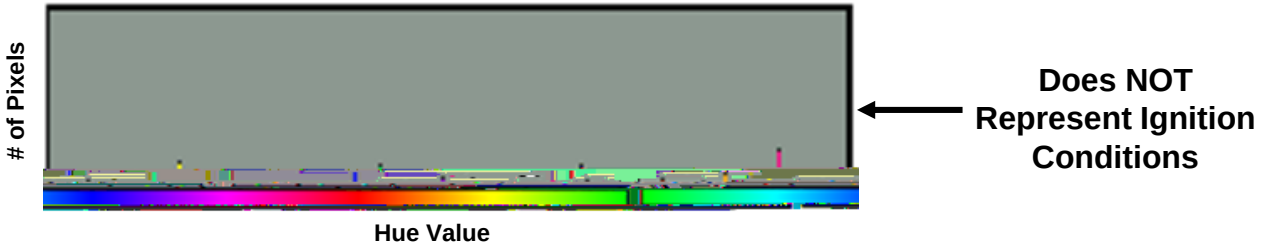
1. Continuous range of hue between red-orange-yellow

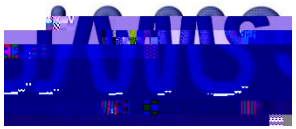
2. Signals that the material has reached temperature of ignition

The "continuous range" and "critical yellow" must BOTH be present to signal ignition



Edge glow: No continuous range is present, signaling an absence of a thermal source. The hue spikes can be loosely tied to the emission lines to ionization of air. Does not ignite gas



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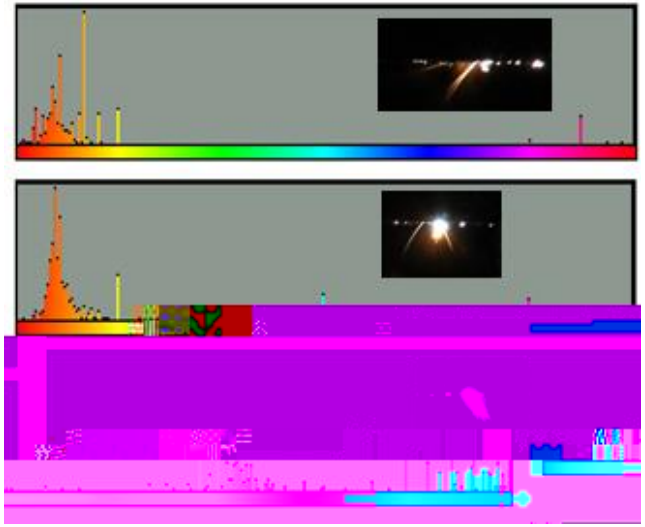
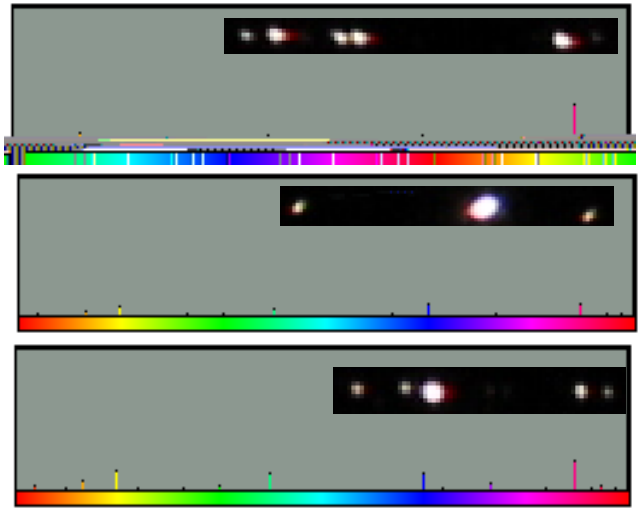
CFRP Edge Glow

Incandescent Hot Spots (Ignition)



Edge Glow (No Ignition)



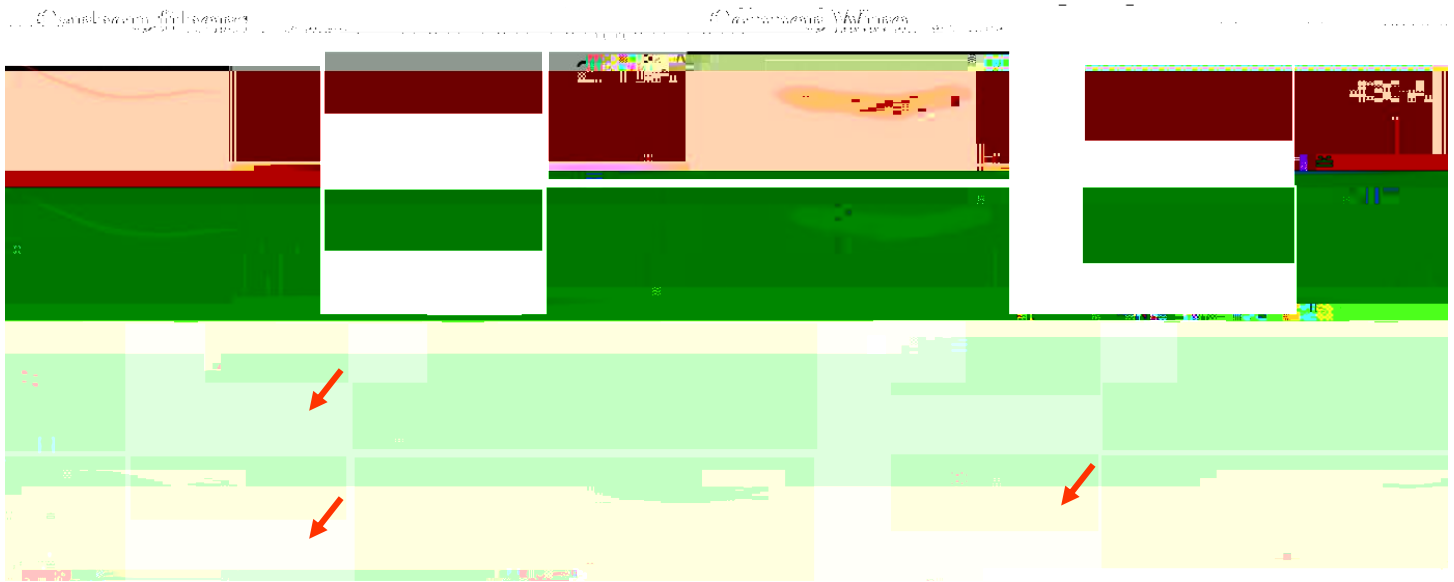
Verification of incandescent/thermal signature

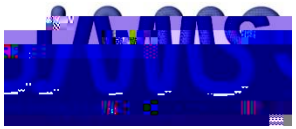
Gas ignition coincides with the appearance of the incandescent signature for all investigated materials:

Tinned copper wire

Nickel titanium wire

Steel wire





Detailed list of investigated materials

Incandescence

Copper wire, 30 AWG (0.25 mm), 60 mm long (AlphaWire & Arcor).
Tinned copper wire, 24 AWG (0.51 mm), 60 mm long (Belden)
High carbon spring tempered steel wire

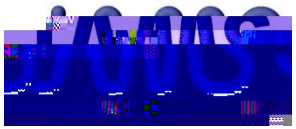
Origin of Yellow Hue – Testing in Air

Presence of incandescent signature is not a result of hydrogen combustion.

Examples of tests performed in air (no flammable gas) with hue histograms displaying the incandescent signature.

Combustion of lean H2 and O2 produces faintly visible flames primarily in UV and blue range which does not introduce incandescent hue to test images.

Ref: http://iopscience.iop.org/article/10.1088/0031-9120/48/1/22

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Round Robin Procedure

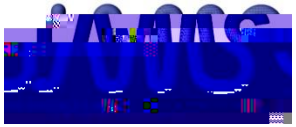
Test articles were developed to produce incandescence, edge glow, or both.

- NIAR provided test articles to the round robin participants.
  - CFRP test coupons, loose carbon fibers, copper wire.

Use the flammable gas and digital color emission spectroscopy detection methods simultaneously to allow color emitted by ignition source to be directly compared with ignition/no ignition of gas.

- Testing must be conducted in hydrogen mixture (hydrogen flame is nearly invisible, other fuel gases may burn with a yellow color which will interfere with the photographic technique).
- Waveform 5A will be used to generate edge glow.
- Use cameras calibrated

Planned Progress



Questions?