Progress in Developing a Software Based Arc Damage Modeling Tool

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Outline

- Introduction to the tool
- Description of the three modules of the tool
  - Modeling the arc
  - Partition of the arc energy
  - Damage to the target
- Examples
  - Temperature in a metallic tube
  - Damage to insulation at a distance
- Conclusion

What is the Goal for the Tool

- An easy to use software tool that can predict the damage cause by an arc based on circuit and material parameters.
  - Provide a fundamental understanding how damage occurs.
  - Used to supplement and extend test data throughout the range of test parameters.
  - Provide insight to how variation in test parameters will affect levels of damage.
  - Show how mitigation techniques will affect arcing damage

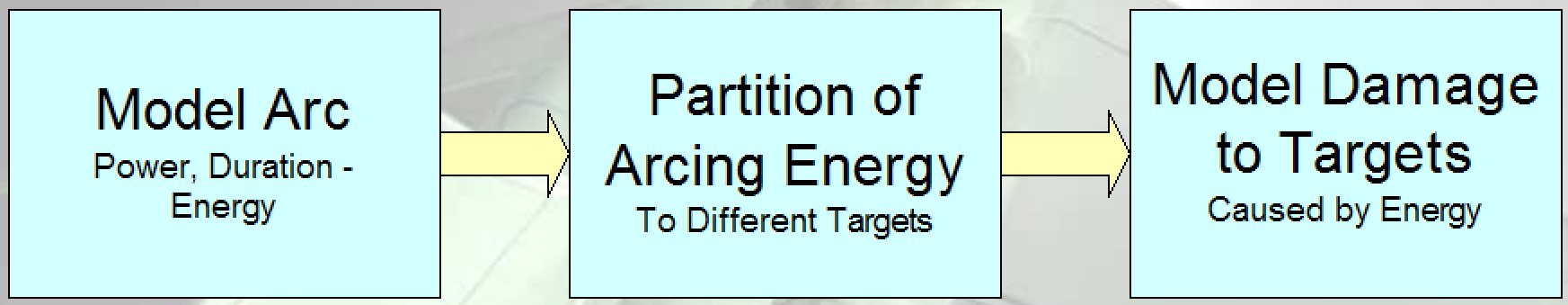
What Types of Damage are modeled

- Primary arcing target: grounded structure and hardware
  - Metallic lines: hydraulic, pneumatic, oxygen
  - Flight control cables
  - Spars and other structural members
- Arcing wire: Conductor damage
- Other wires in the bundle
- Wires and other material at a distance

Based on Laboratory Data

- Testing done at Lectromec and the FAA
  - Over 700 arcing tests done at Lectromec and more done at the FAA Tech Center
- Test Parameters
  - Source voltage
  - Fault current
  - Circuit protection
  - Target material & geometry
  - Wire specification
  - Separation distance and segregation material

3 Modules of the Tool



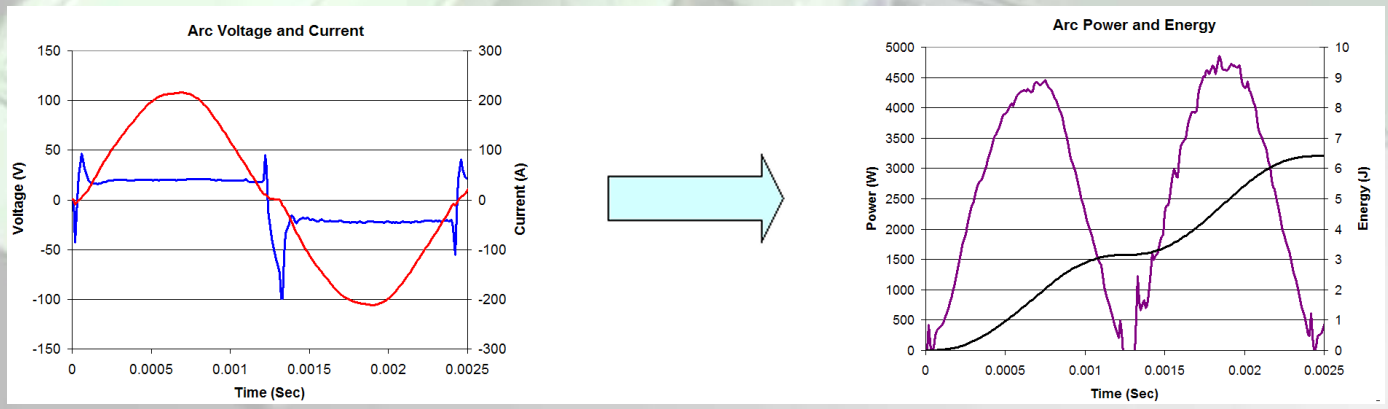
Modeling of the Arc

Power and Energy

$$P_{arc} = I_{arc} \times V_{arc}$$

$$E_{arc} = \int P_{arc} dt$$

For AC Arcs a convenient unit of measure is energy in an arcing ½ cycle



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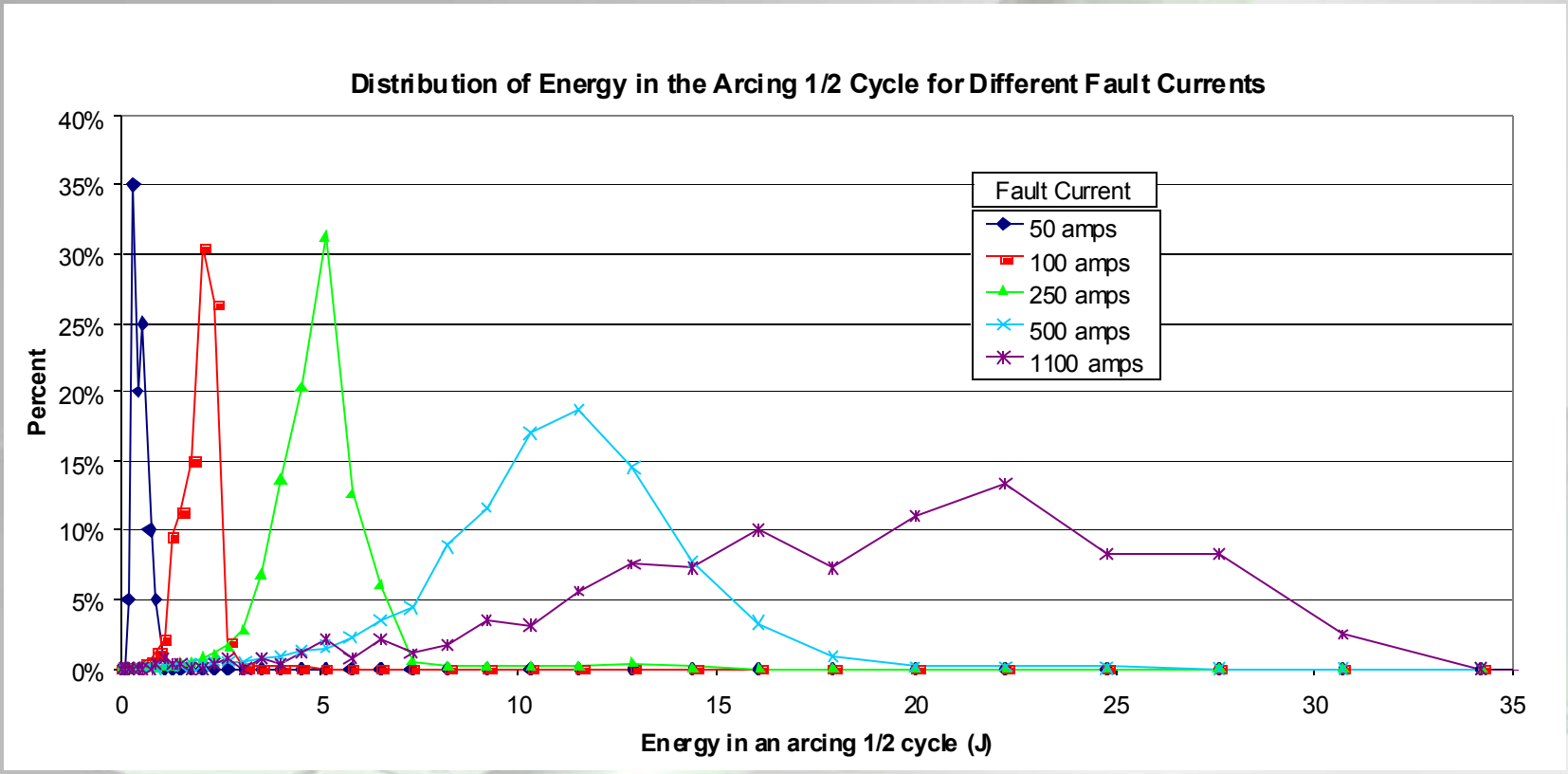
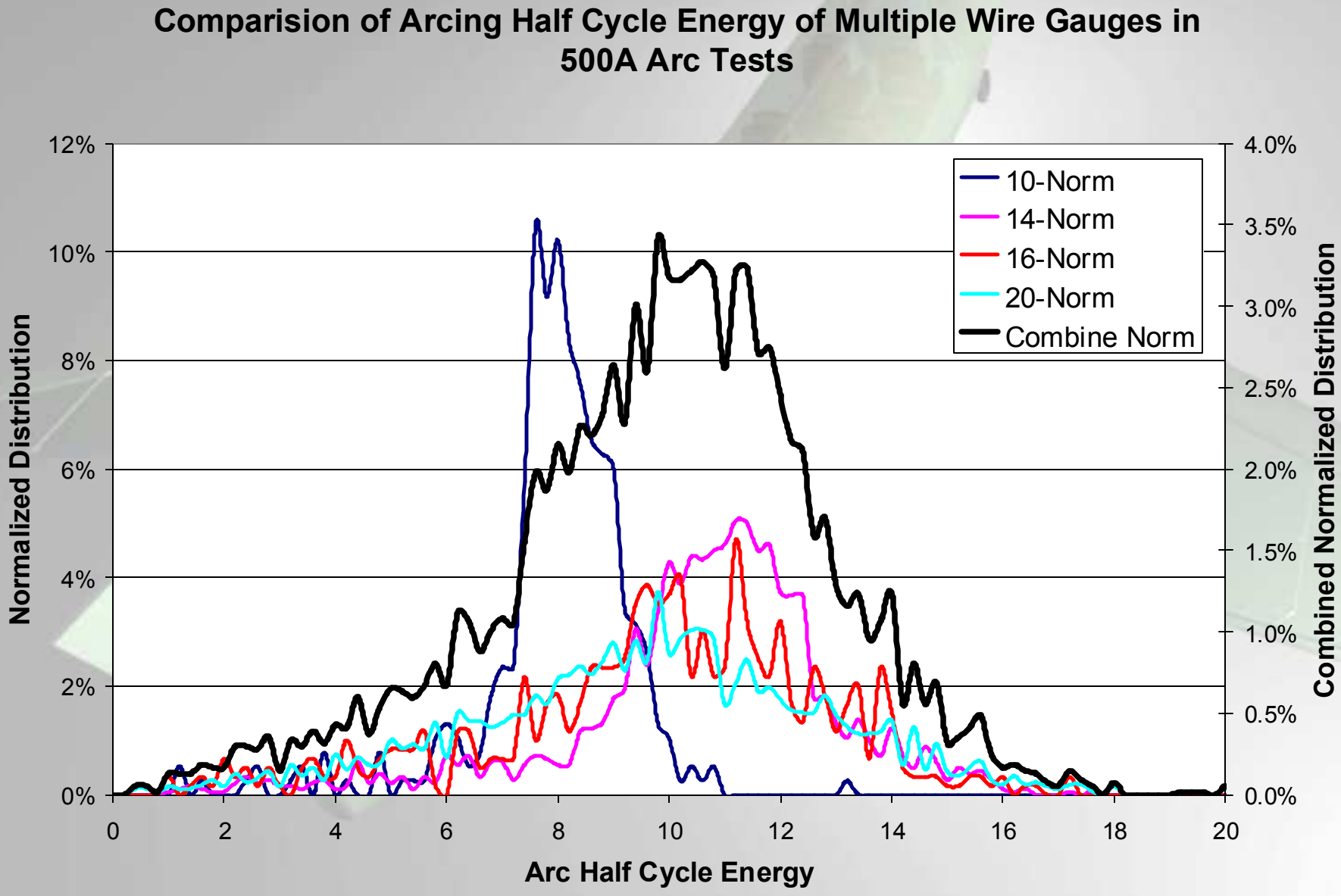


- Based on the Evaluation of over 35,000 arc ½ cycles

Modeling of the Arc



Modeling of the Arc

Duration

- Circuit Protection: Thermal and Arc Fault
  - Thermal Circuit Protection
    - Evaluation of RMS current of arcing and shorting ½ cycles.
    - Trip Curve Data
  - Arc Fault
    - Allowed number of arcing ½ cycles
- Damage to conductor

Modeling Damage to the Target

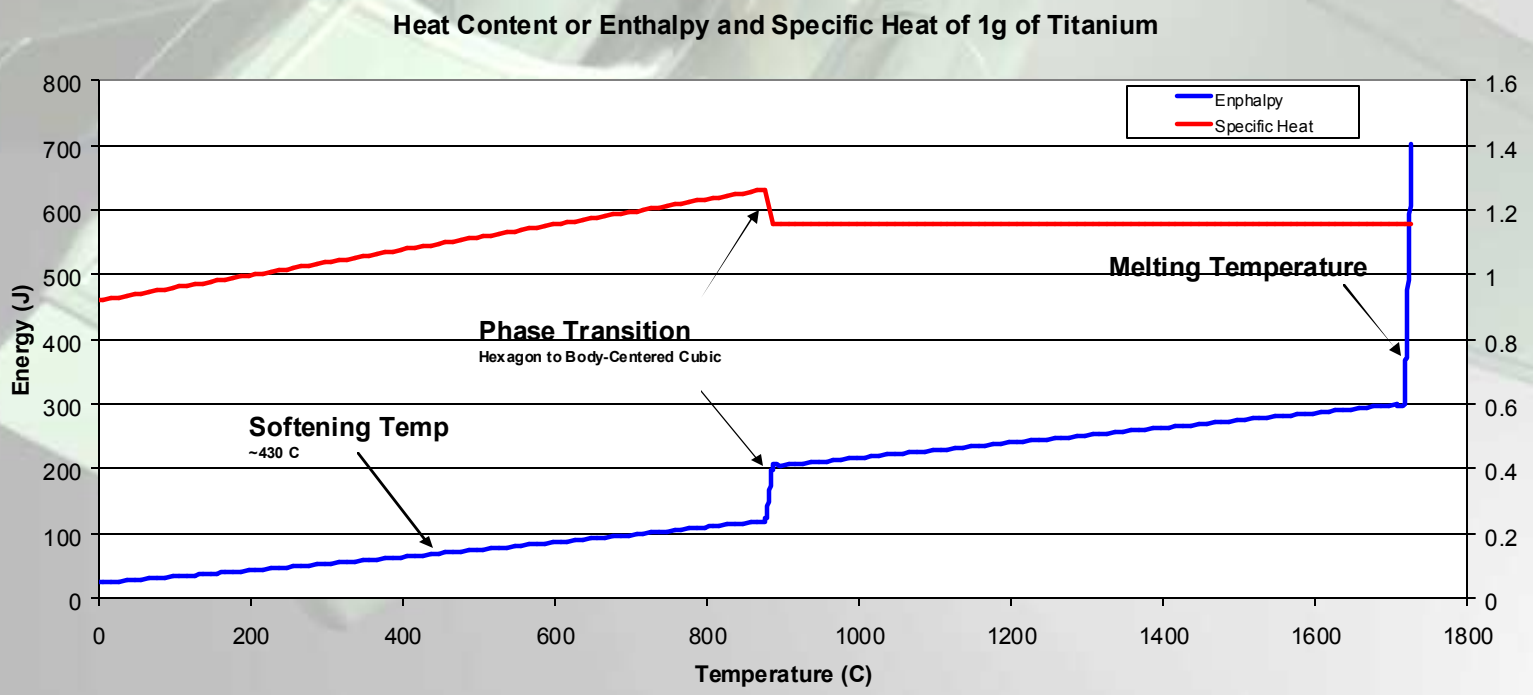
Heat Transfer within the Target is modeled using a Finite Difference with Controlled Volume Method.

1. Target is represented by mesh of cells
2. Arc Energy is incident onto surface of target (changing internal energy of cells
3. Temperature of Cells is calculated and state of cell determined (melted cells removed)
4. Internal energies of the cell allowed to redistribute according to heat equation.
5. Loop to 2.

Modeling Damage to the Target

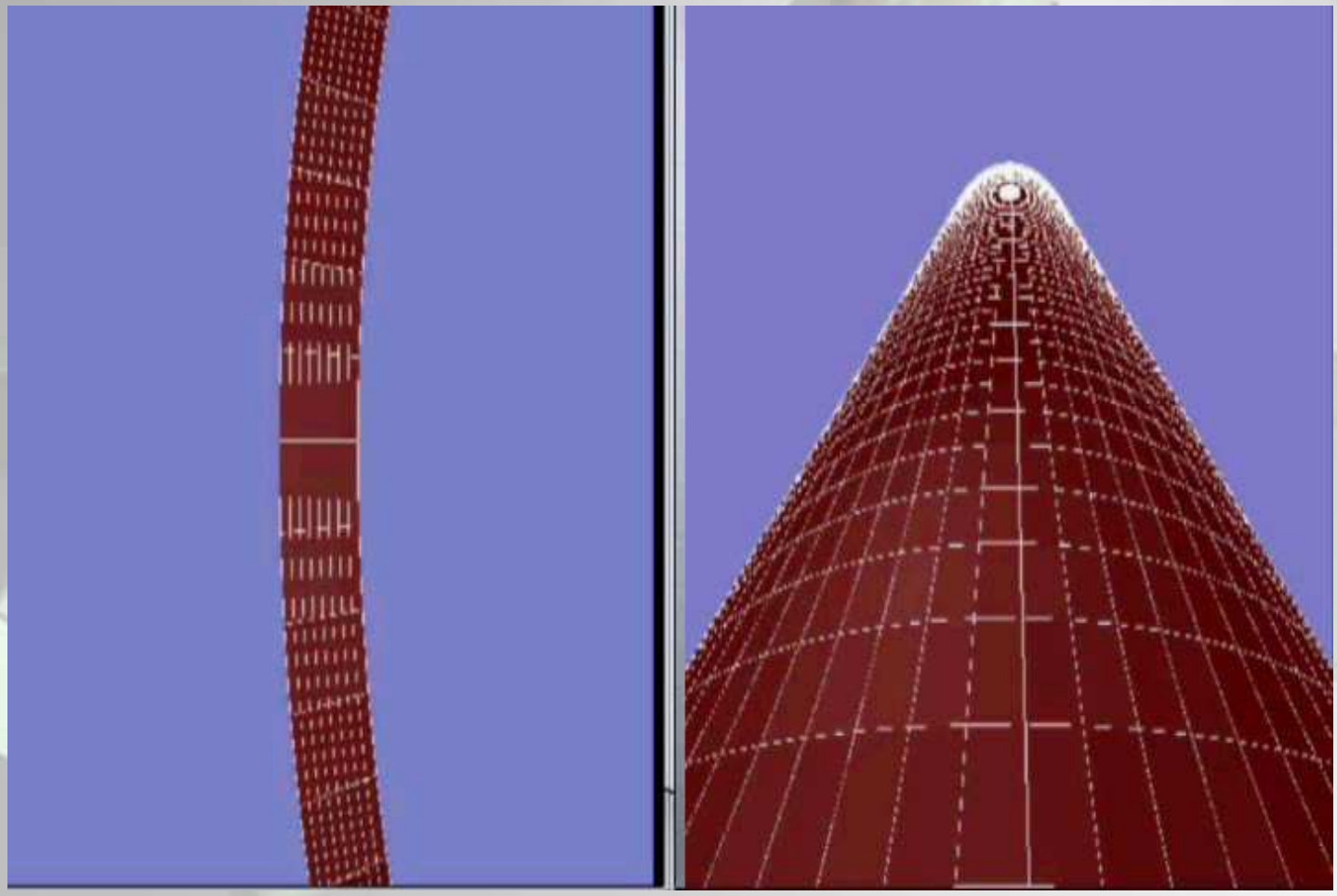
Thermal Parameters of the Target

1. Specific heat and heat of fusion etc.
2. Thermal conductivity
3. Phase Transition and Melting Temperature



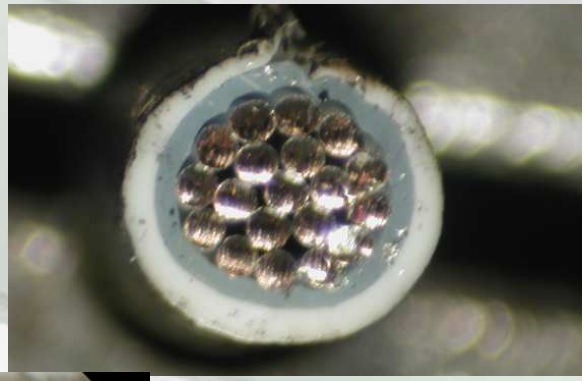
Modeling Damage to the Target

Example: Hydraulic line



Partition of Arcing Energy

Where does the arc energy go?

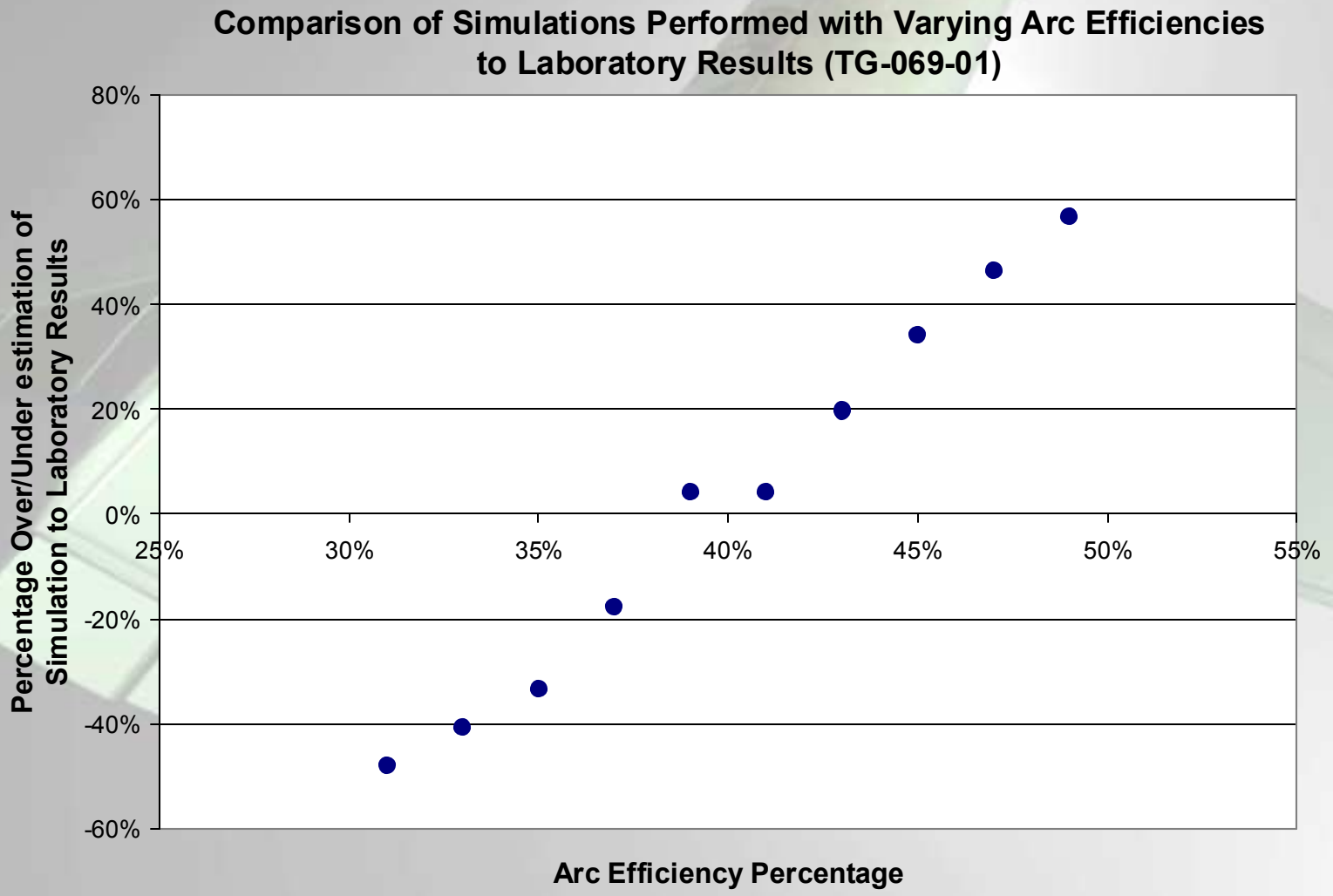


Partition of Arcing Energy

- Need to determine the proper fraction of arc energy (arcing efficiency) that is incident on the different targets. Compare experiment damage to simulated damage:
  - Use experimental power waveform as input to simulation
  - Run multiple simulations using a range of arcing efficiency
  - Chose arc efficiency in which simulated damage best match experimental damage
  - Develop database of arcing efficiency for different parameters

Partition of Arcing Energy

Chart of Arc Efficiency for Arcing to Hydraulic Tube



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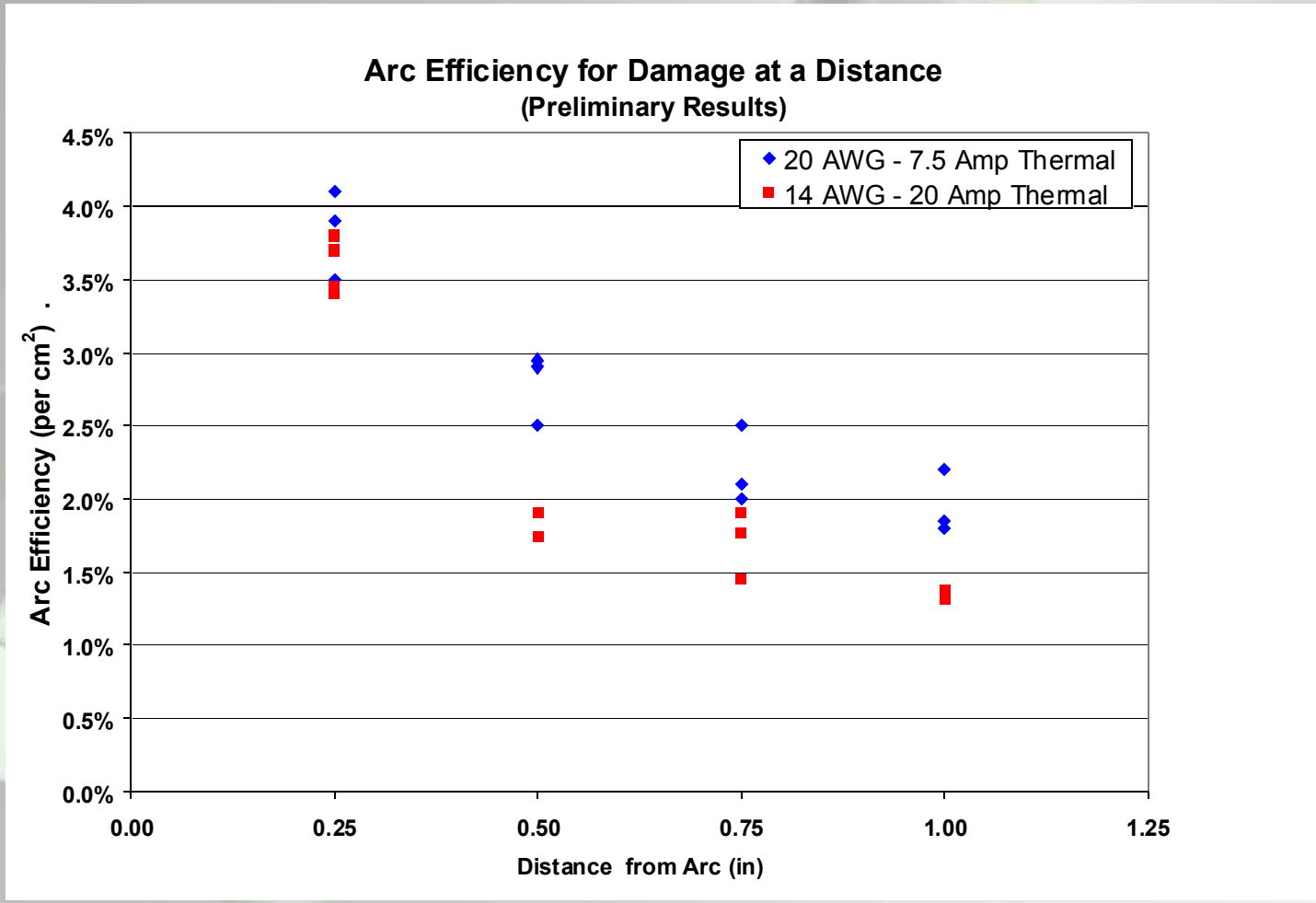
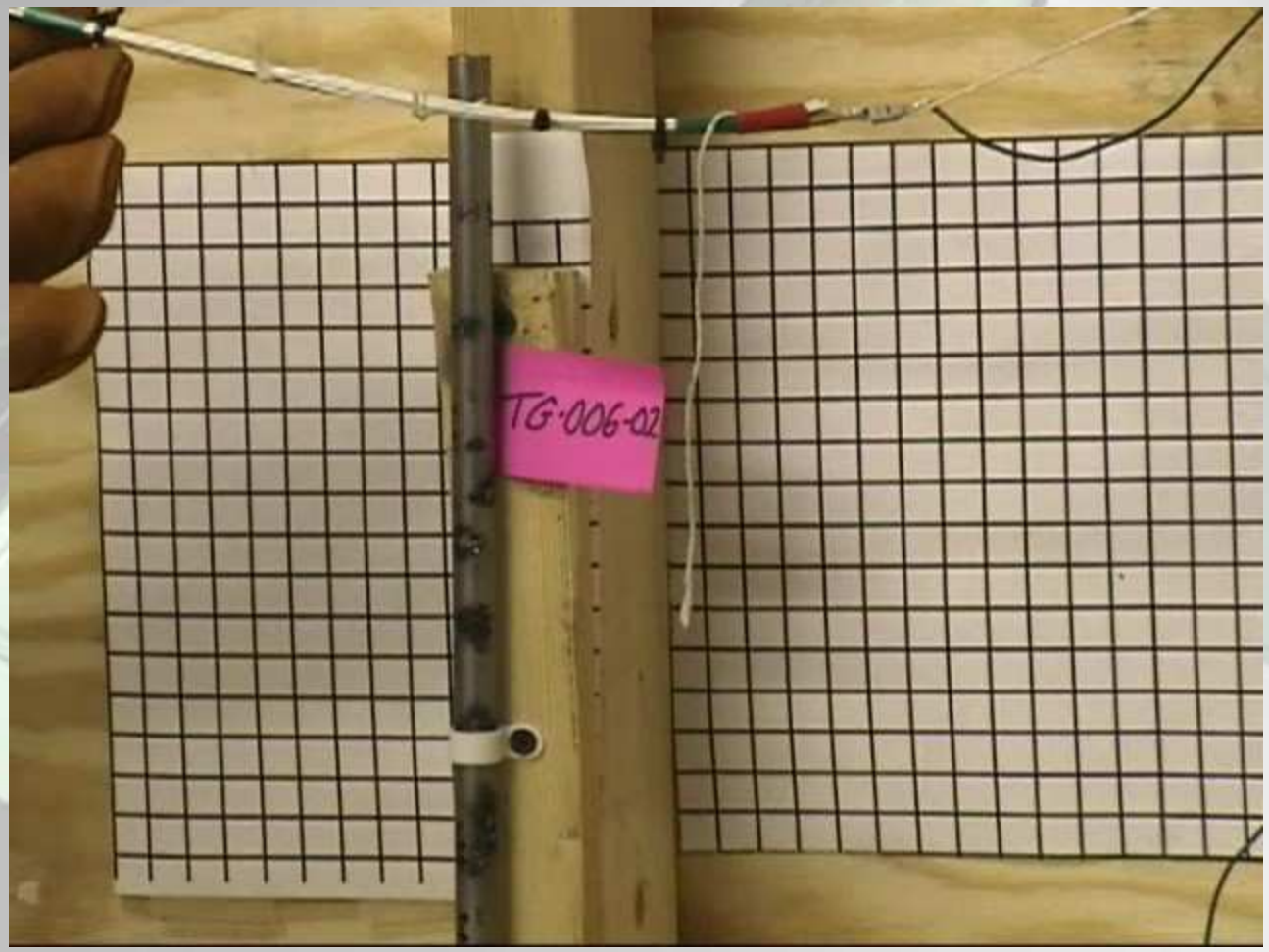


Example 1: Damage and Temperature Distribution within a Titanium Tube



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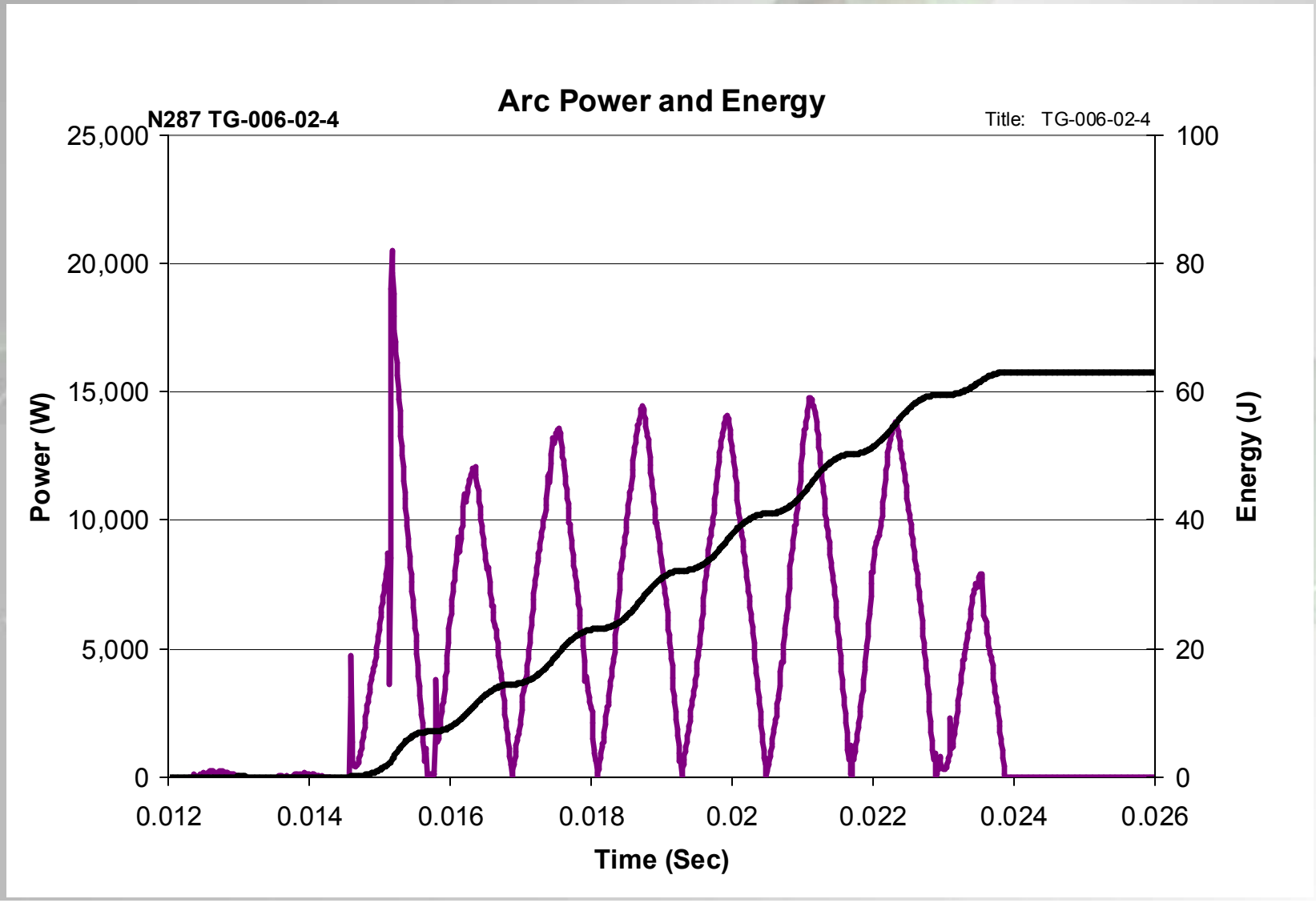

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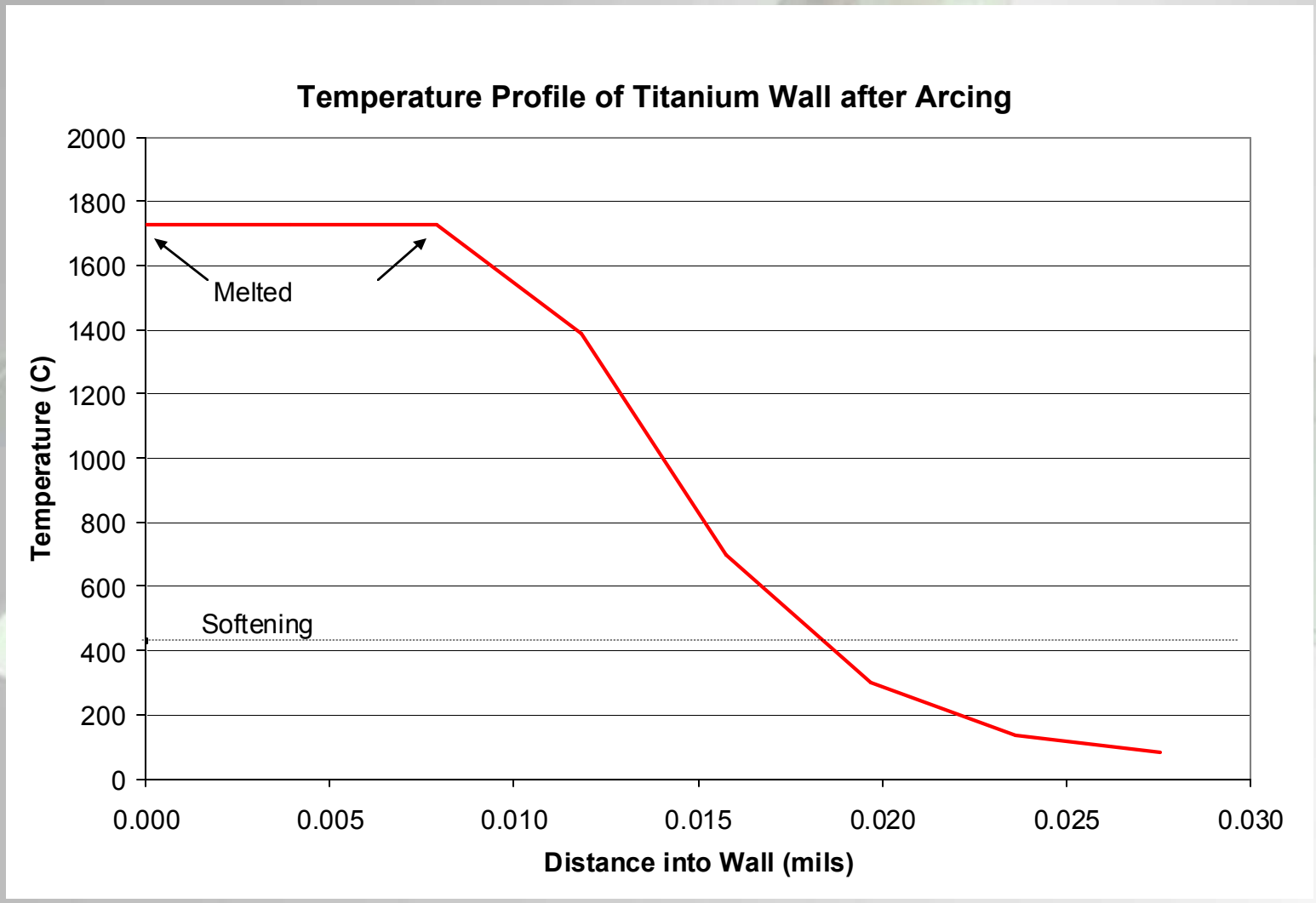

Example 2: Insulation Damage at a Distance

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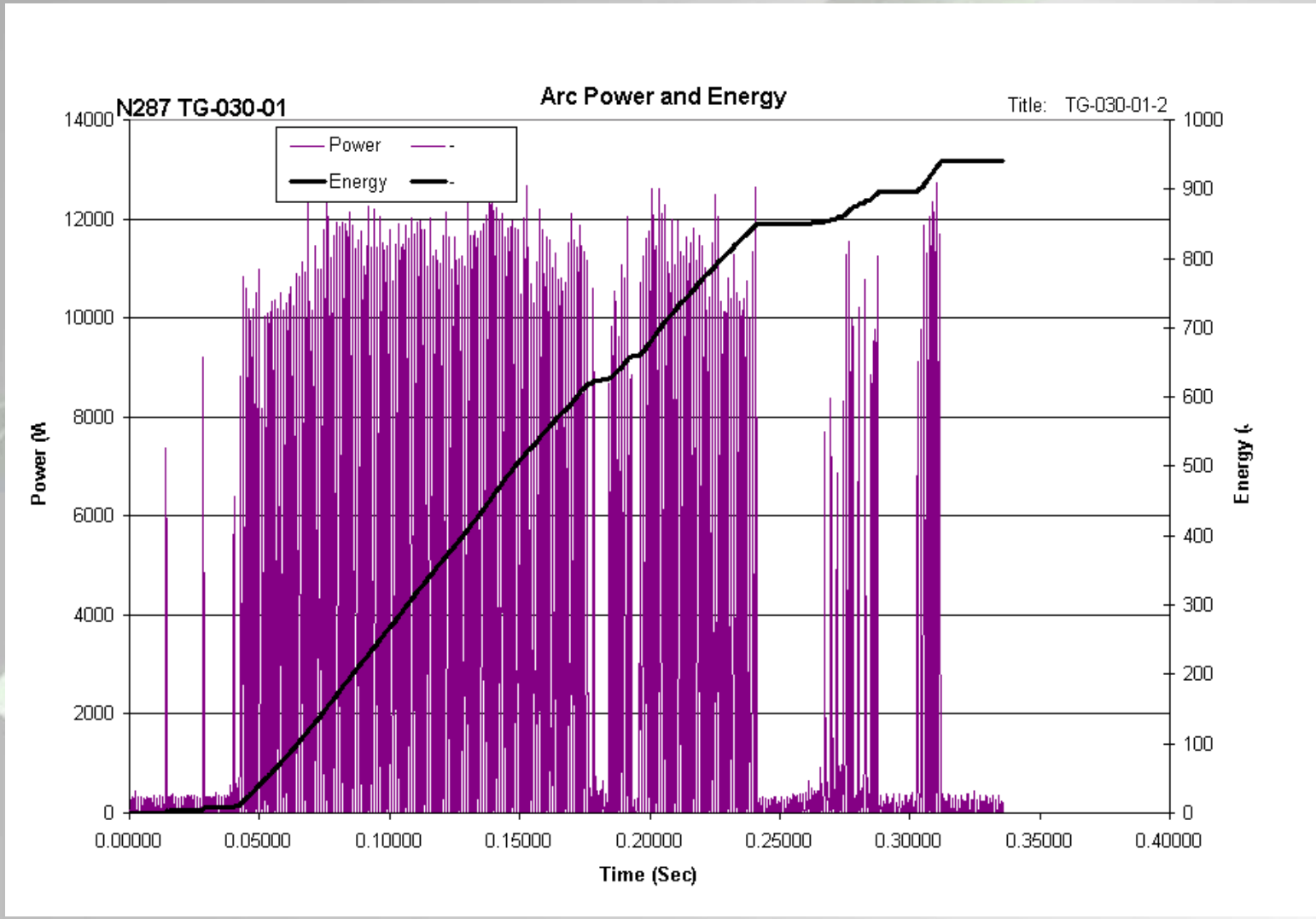

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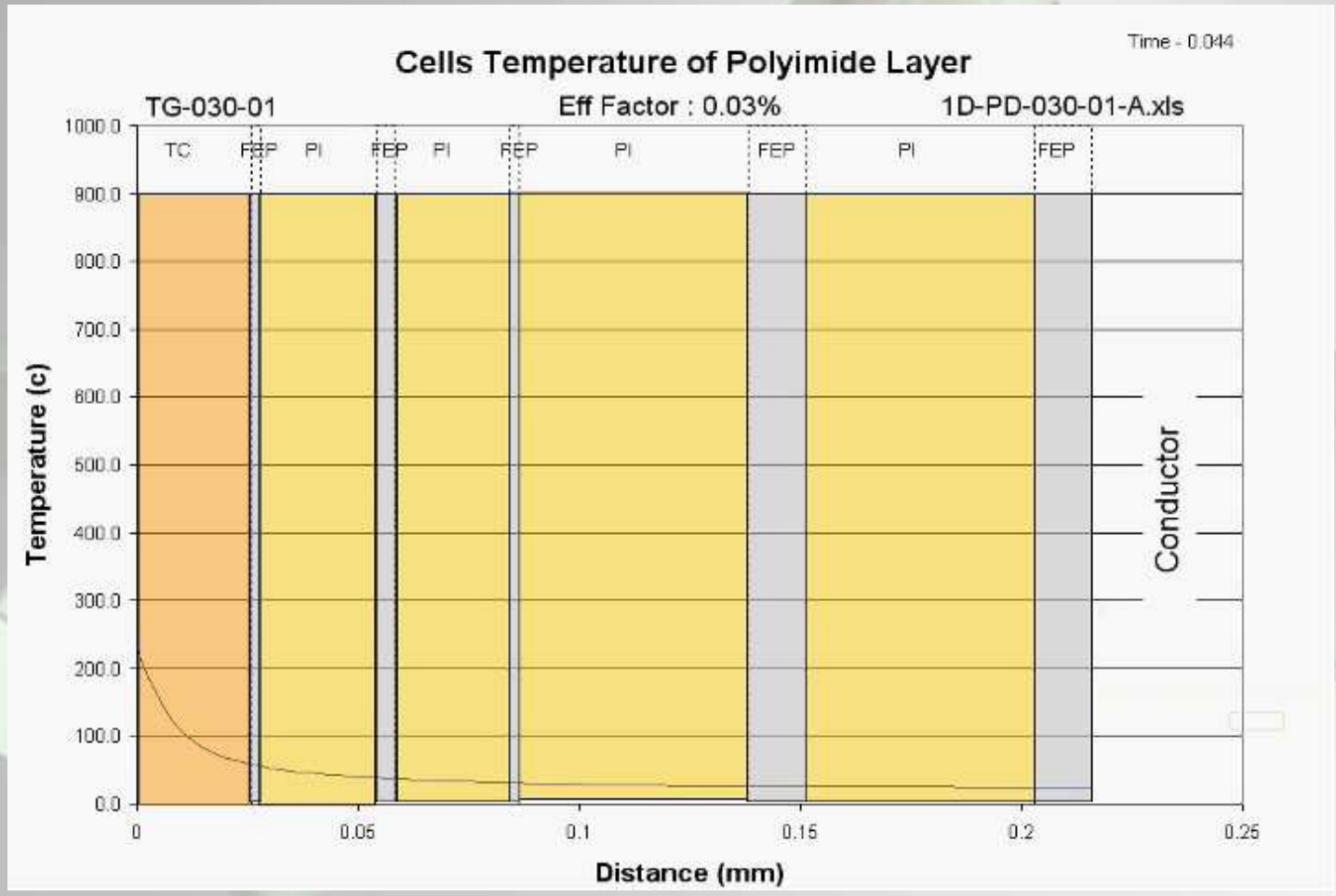

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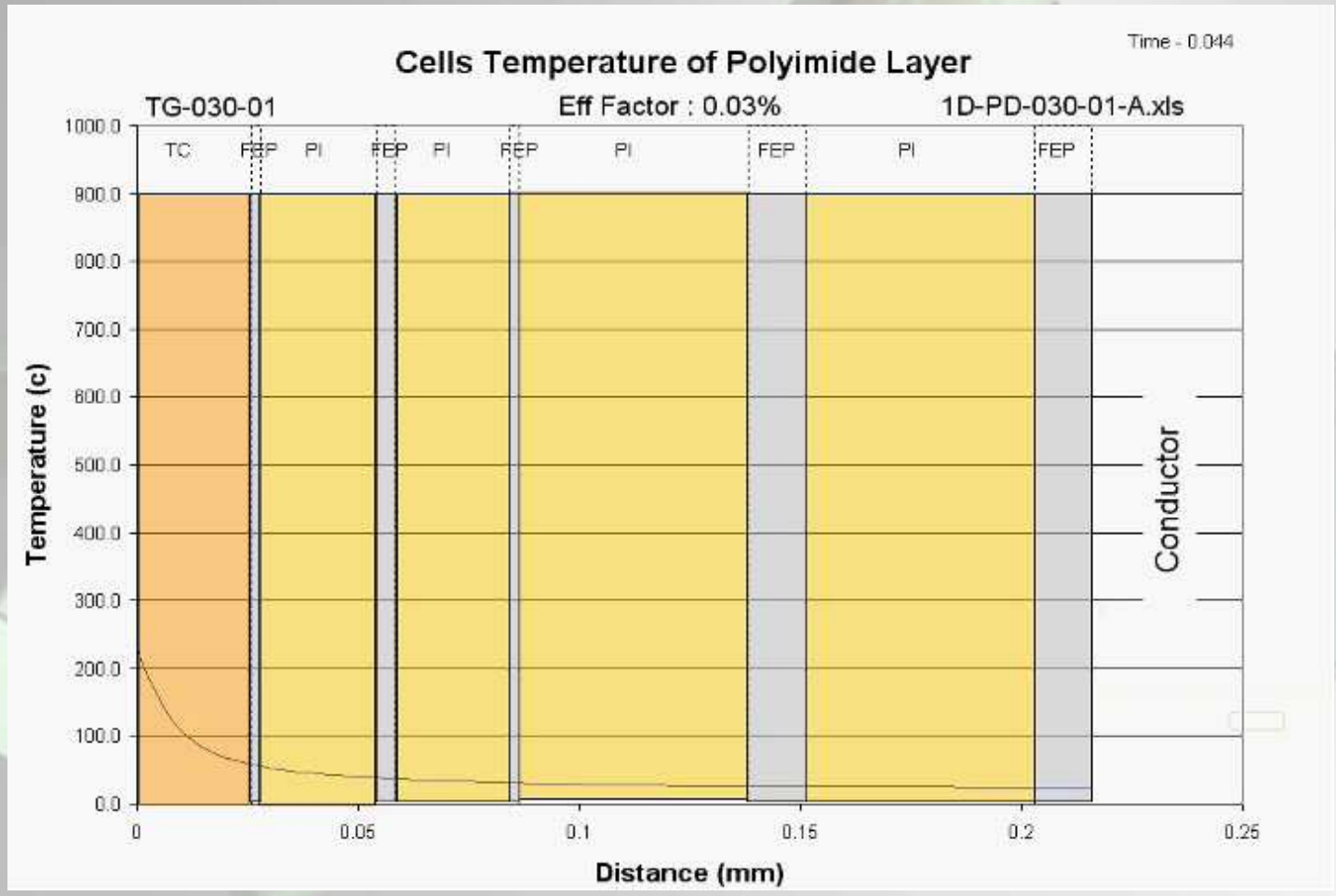

Conclusion

- A user-friendly software tool that can model arc damage is being developed.
- It is based on analytical and empirical data.
- Preliminary result show good correlation between experimental and predicted damage.
- The tool can be a stand alone tool or be part of an integrated EWIS risk analysis using the EWIS RAT.
- Expected completion December 2008.

Questions?

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