Examination of EWIS and Pressurized Hydraulic Lines

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Examination of EWIS and Pressurized Hydraulic Lines

- Research focused on arc damage at a distance to pressurized hydraulic lines
- Goals:
  - Understanding the factors that affect separation requirements
  - Determine the level of damage that sustained by a pressurized hydraulic tube
  - Determine the yield temperature of aluminum under pressure.
  - Provide seed data for arc damage simulations.

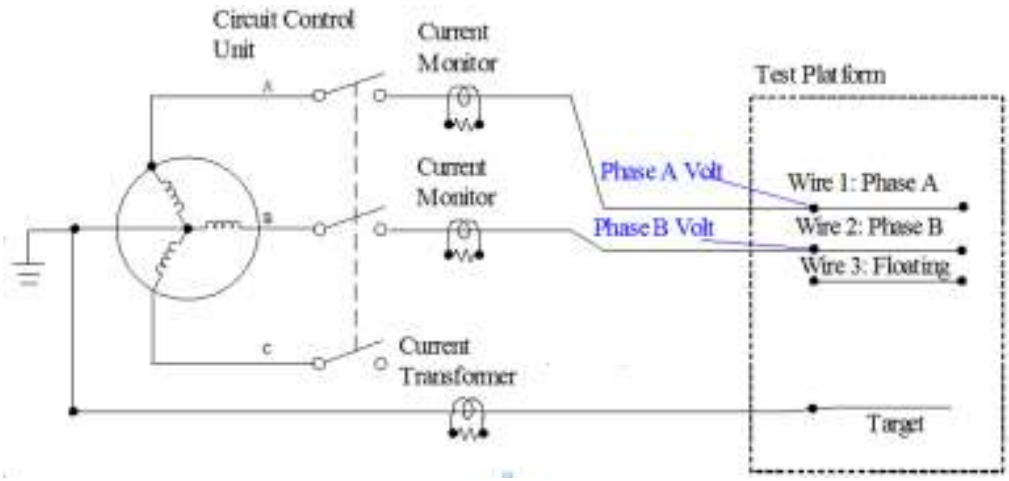
Background to Electrical Arcing

- The damage caused by electrical arcing from wires has been well documented.
- Chafing of a power wire against a grounded hydraulic line and the subsequent damage have previously been examined.
- Limited research has been done on arc damage at a distance.
- All arcing events generate localized hot, ionized gas. This ‘arc plume’ can cause damage to objects inches away from the arcing event.
- The ionized arc plume makes it possible for air to conduct electricity and therefore to arc directly from the power wire to a grounded target.

Example of arc damage to unpressurized tube

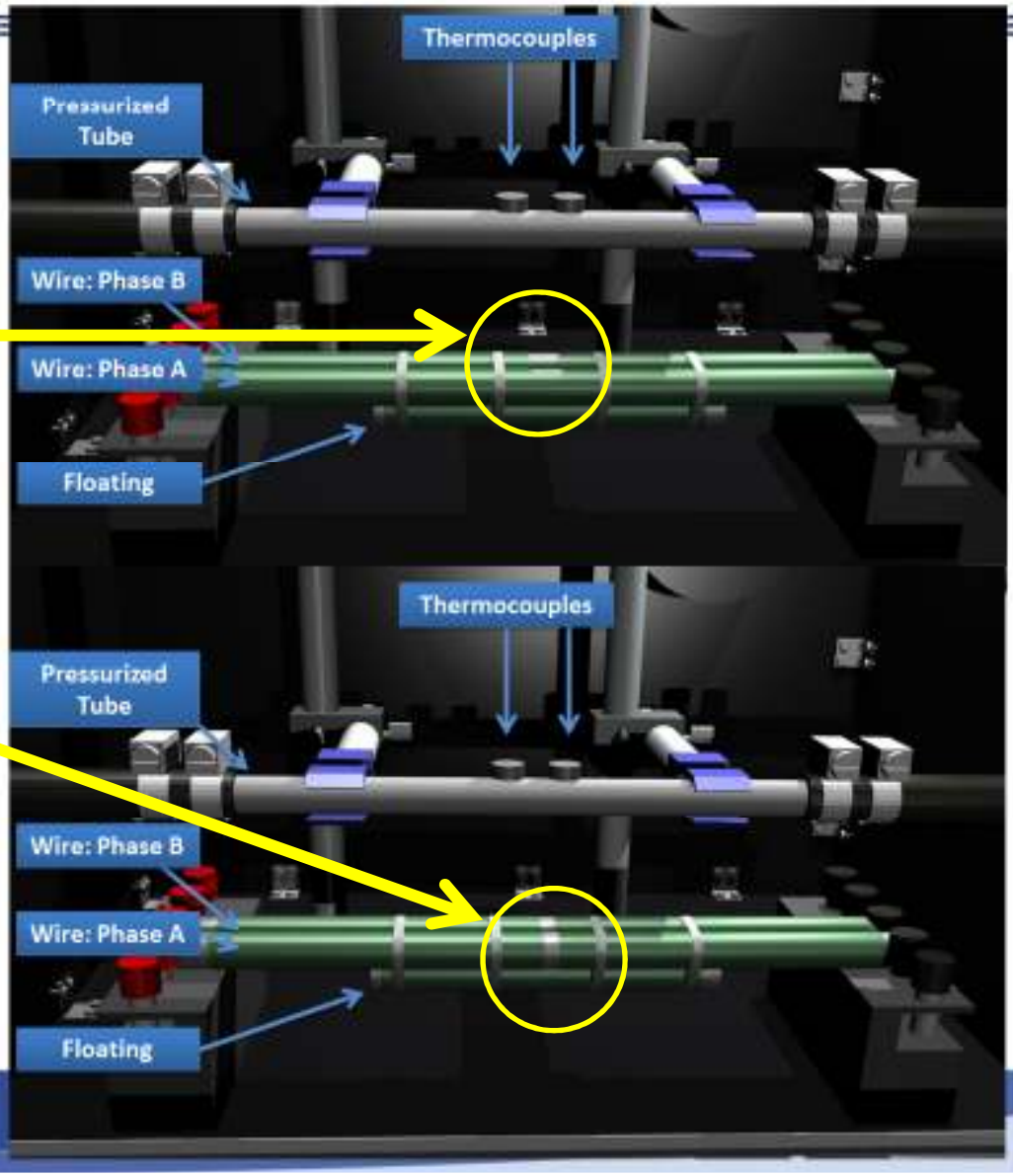
Test Circuit

- **Power Source**: 20kVA, 400Hz, 3 phase generator
- **Wire Configuration**: 3 Wires (one floating, two on different phases)
- **Circuit Protection**: No circuit protection except for a circuit control unit able to cut power to the system after a predetermined time.
- **Target**: Aluminum Tube Alloy 6061

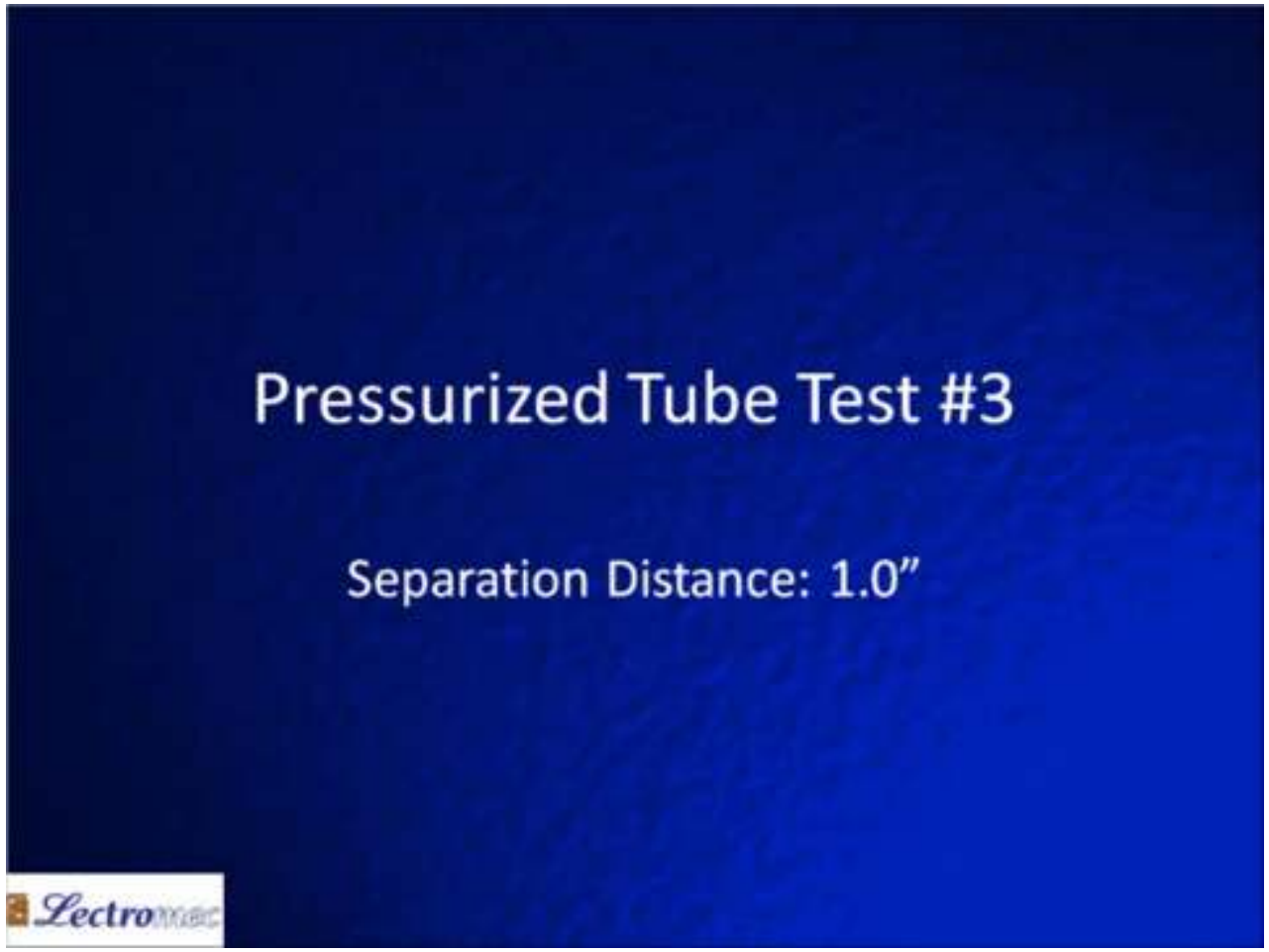


Test Configuration

- Testing was performed with the wire bundles prepared in two different configurations
- One set of tests were performed with a sliver cut
- One set of tests were performed with a standard ring cut
- Thermocouples were affixed to inside wall of tube facing arcing event.

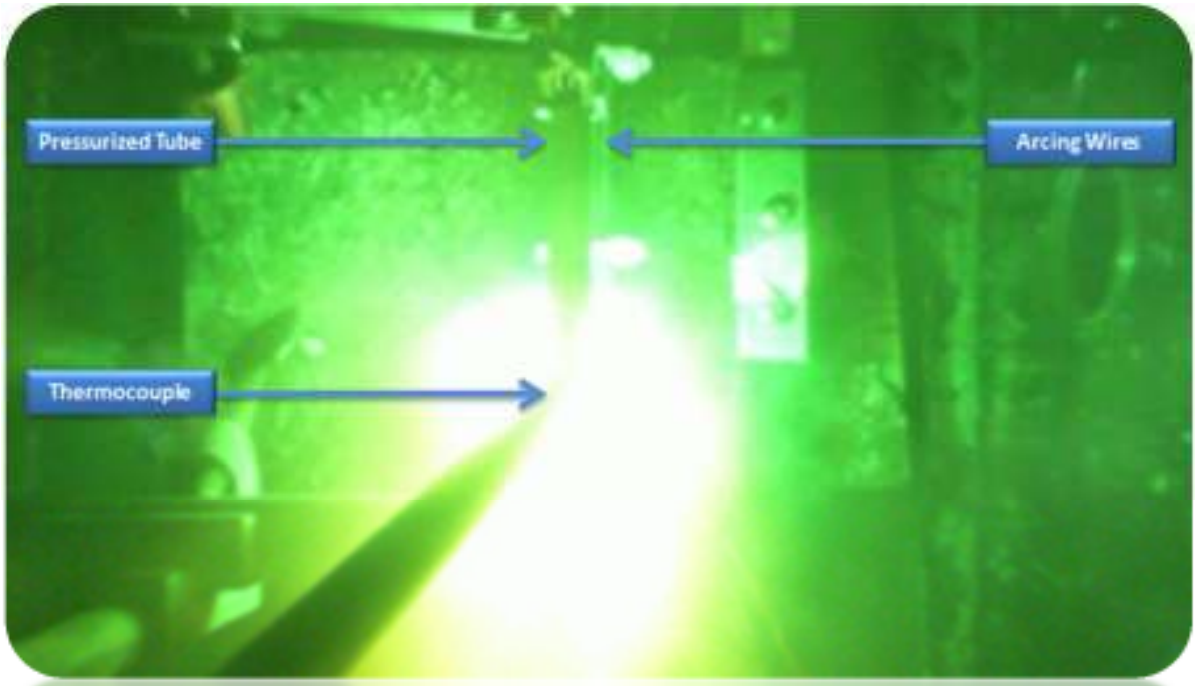


Pressurized Tube Test Video



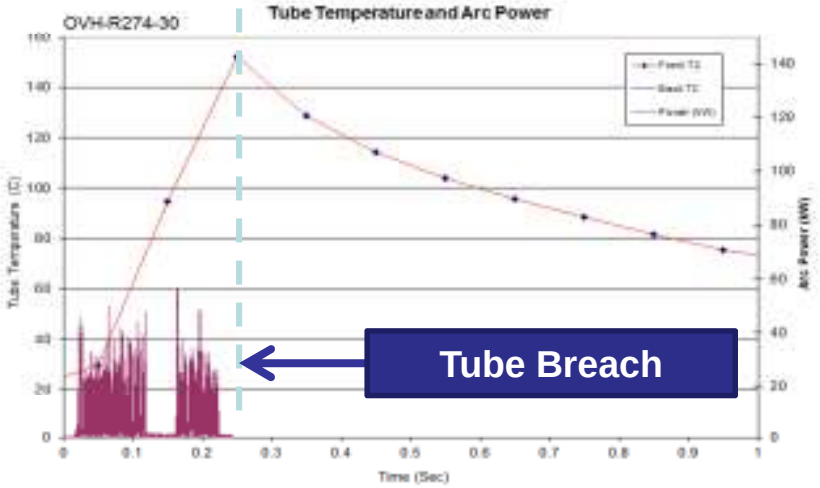
Overhead View of Arcing Event

- Camera placed over the experiment to monitor the direction of the arc plume
- Experimentation has shown that the arc can vary more that 45º from vertical for the same configuration
- Image shows an example of the UV filtered arc plume



Tube Breach Analysis

- The tube rupture was 1mm x 1.5mm.
- Noticeable pitting around the rupture location.
- Thermocouple was 1cm away from the tube breach. Measured temperature was not at the center of arc.
- Tube ruptured *after arc had stopped*.

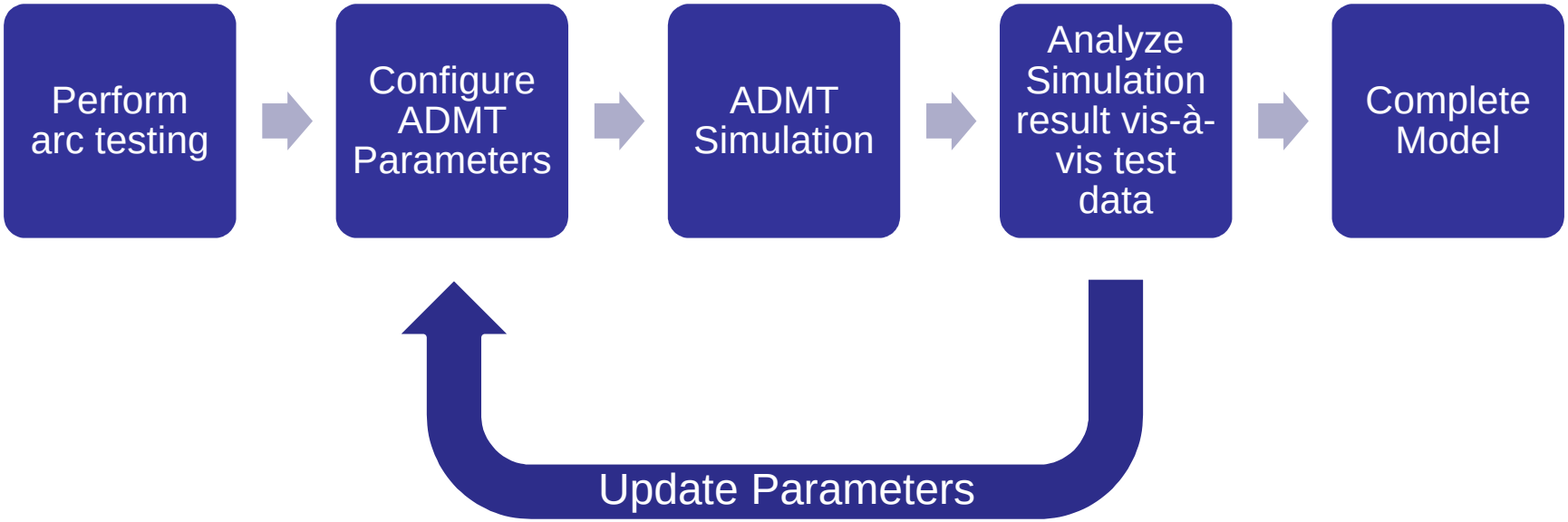


Simulating Breach with ADMT

- What is the Arc Damage Modeling Tool ?
  - Arc Damage Modeling Tool is a finite element tool based on the damage profiles, waveforms, and analysis on thousands of arc tests.
  - Originally developed with the FAA Tech Center
  - Capable of modeling damage from both direct contact and arcing at a distance

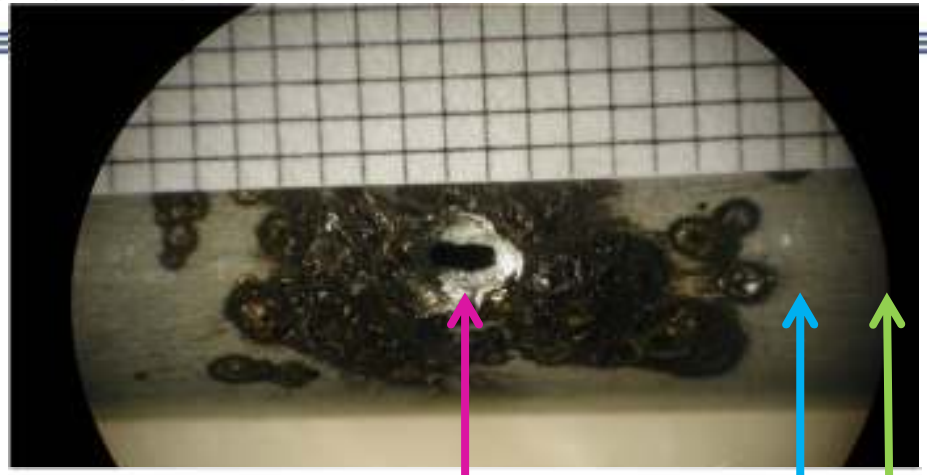
Arc Damage Simulation Process

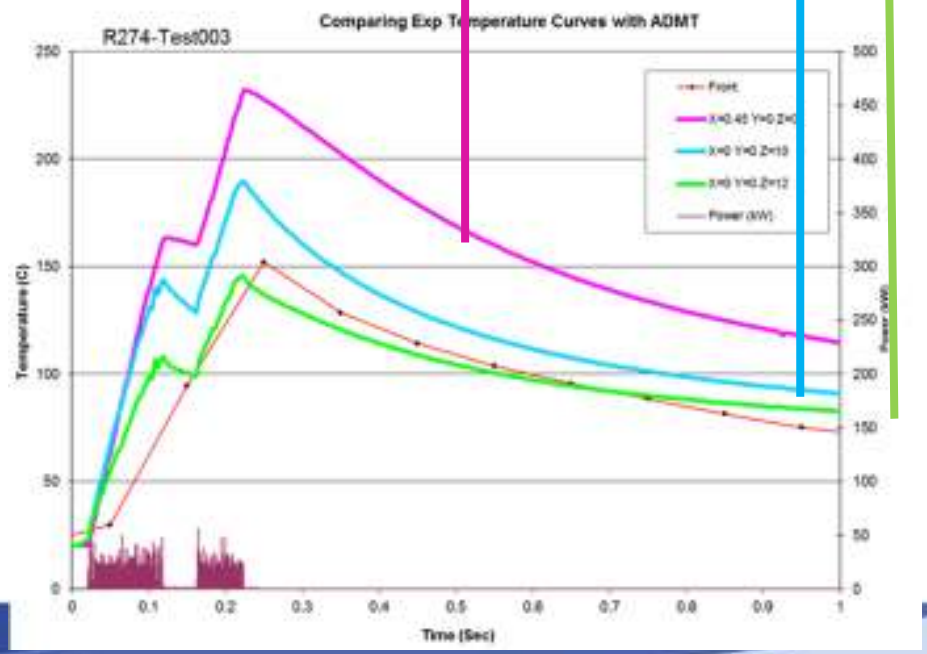
- Some parameters (such as fluid-tube thermal transfer coefficient) had to be gathered through progressive updates to simulation parameters
- Data was necessary to validate pressurized tube model



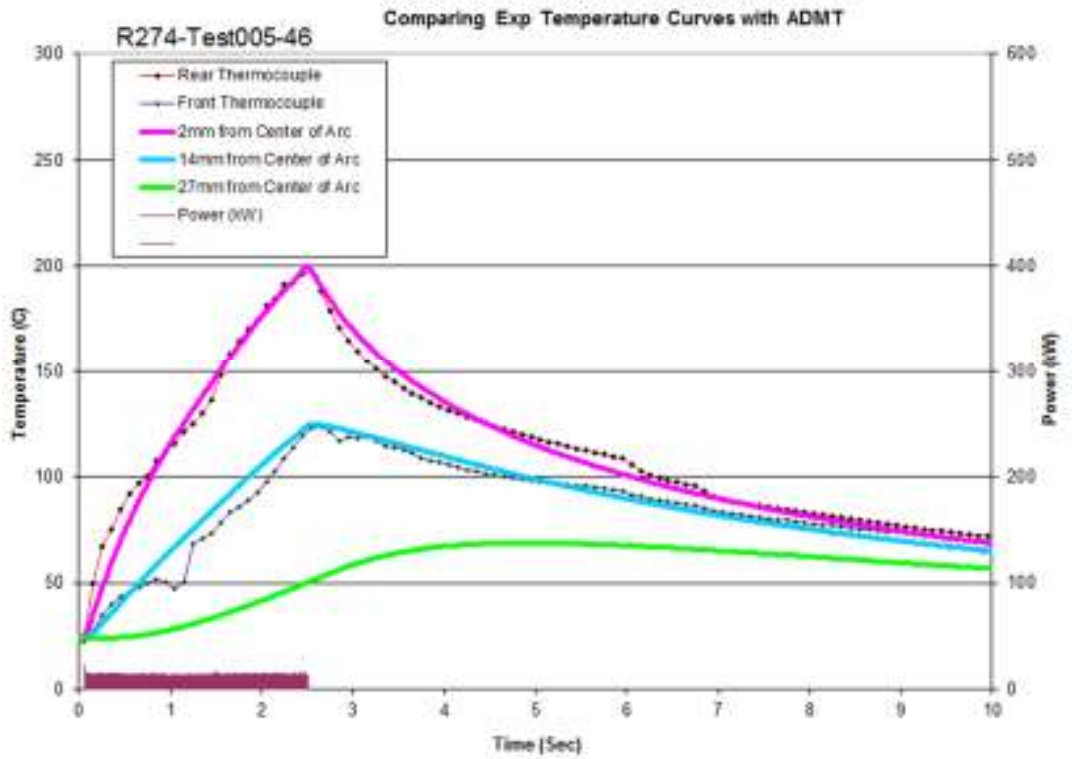
Comparison against ADMT Results

- Simulation used arcing waveform from test as seed data
- Temperature at center of arc area was approximately 235°C.
- Temperature does not match at 1s because ADMT does not yet model energy loss during breach.
- Simulation results are close to temperature measurements.





Simulation of Unbreached Tube



- The arc plume did not fully consume the target tube.
- The simulation showed excellent correlation with the laboratory results.

Additional Considerations

#1: These tests were done with the tube at room temperature. Operating temperatures are higher. Hydraulic lines are more susceptible to breach from arc events.

#2: Tube material properties matter. Tubes made of material with lower thermal conductivity (e.g. Titanium) are more susceptible, because they cannot conduct the heat from arc event.

Conclusion

- The tube pressurization makes a significant difference in the amount of energy necessary to create a breach in the tube wall.
- Even without direct contact, it is possible to transfer sufficient energy to cause a breach of a pressurized line. The effects of hydraulic fluids should be considered in any analysis to determine safe separation distances.
- Simulations showed excellent alignment with the laboratory data and have been presented in this paper. Further testing is necessary to ensure validation of the simulation results.

THANK YOU

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