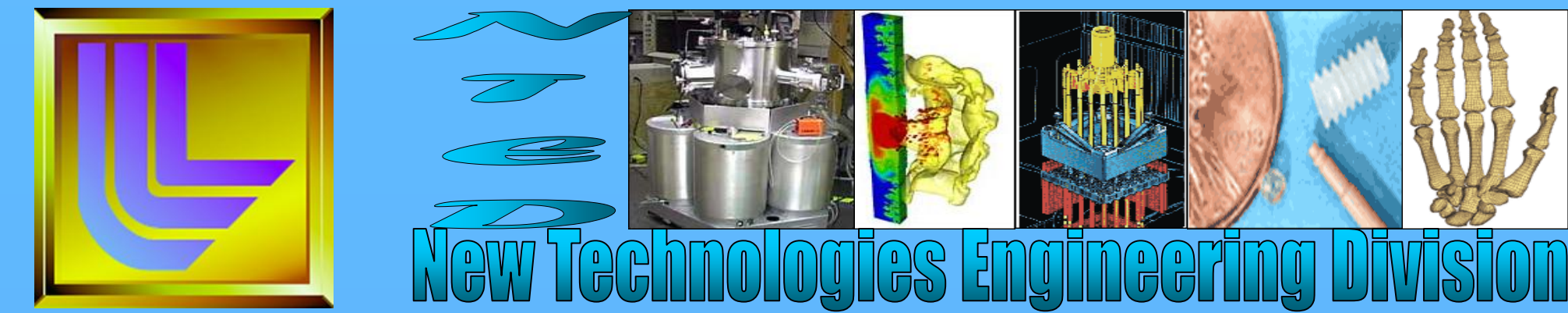


Thermal Endurance of a Cryogenic Capable Pressure Vessel for a (L)H₂ Fueled Toyota Prius

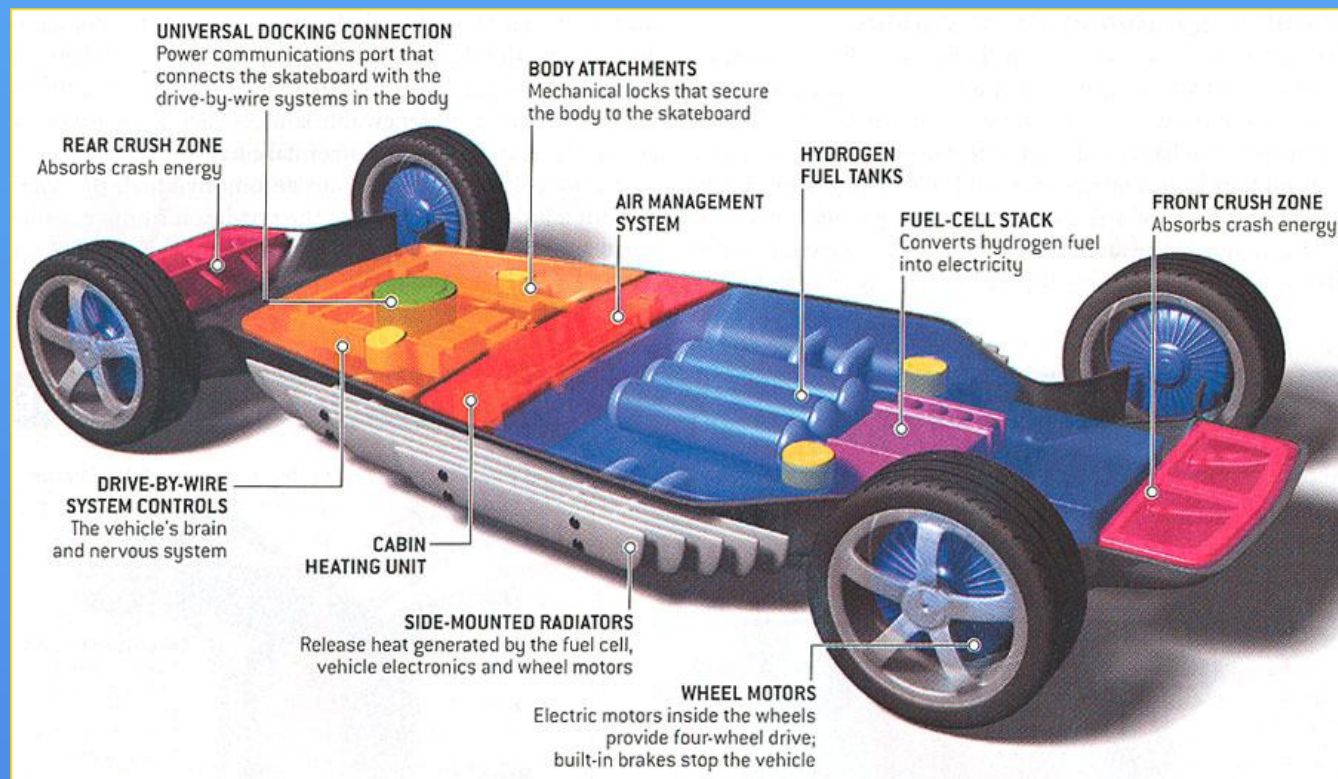
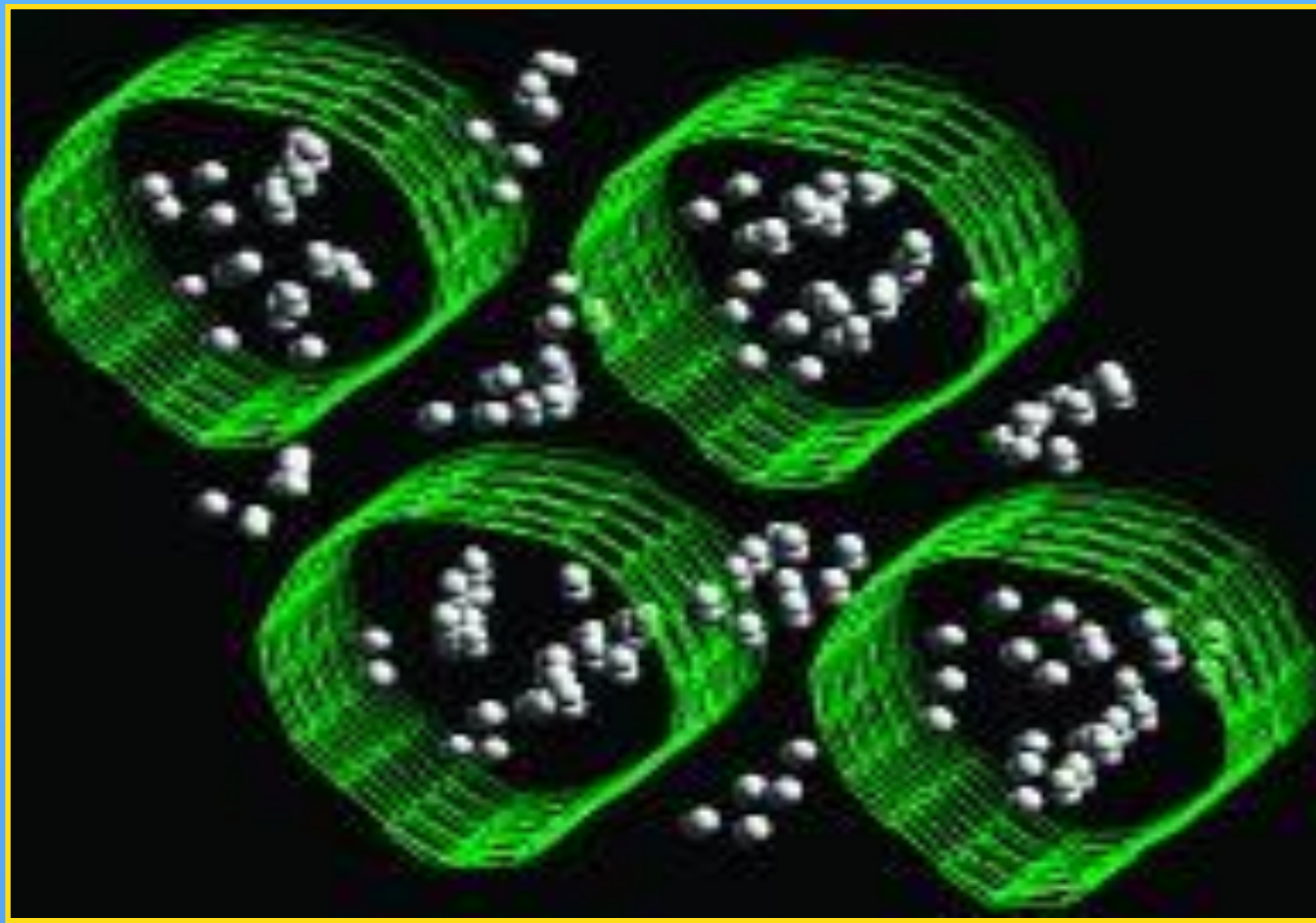


Ryan Shelby, University of California at Berkeley

Supervisor: Jeffery Haslam Mentor: Salvador Aceves

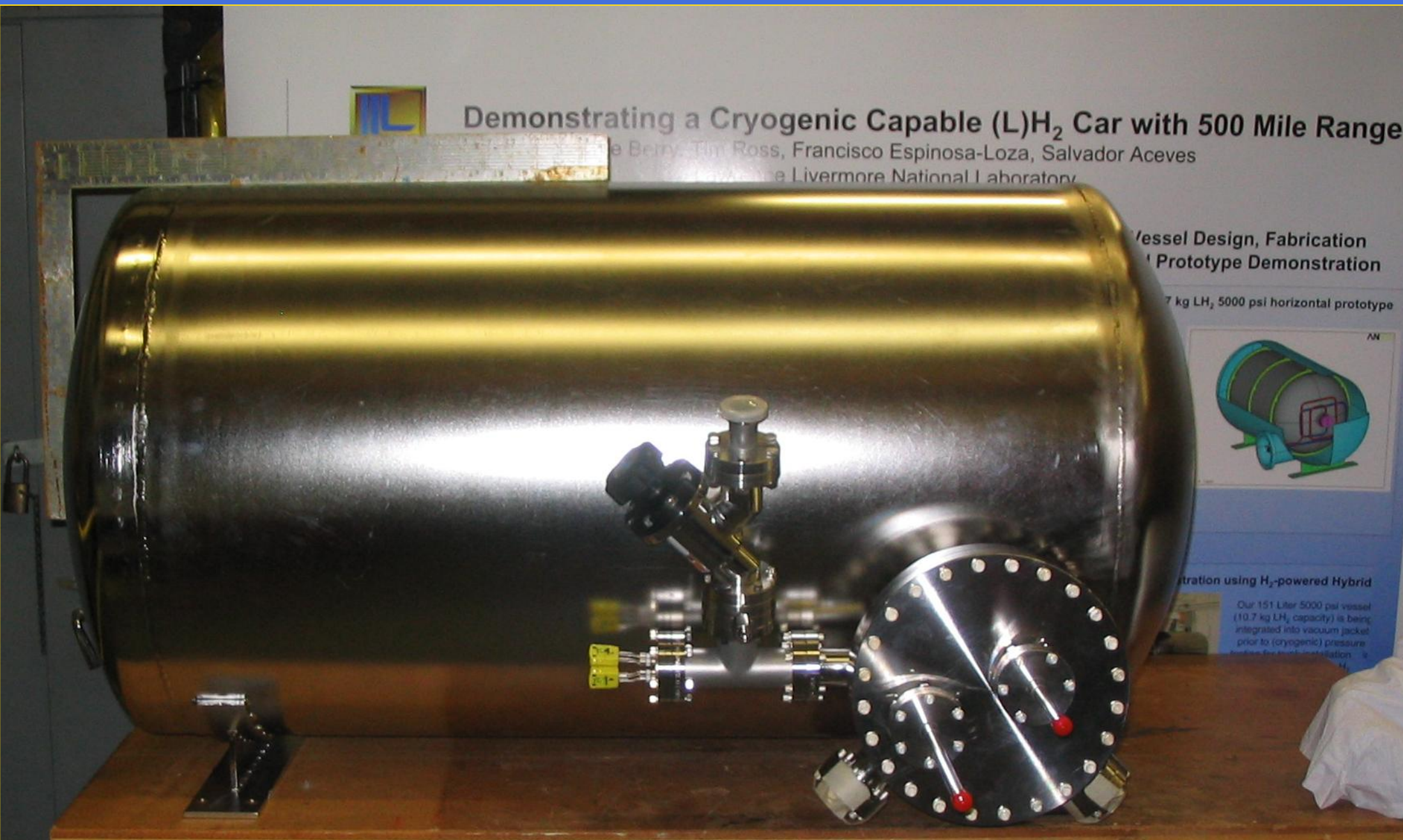
New Technologies Engineering Division, Energy and Environment Directorate, Lawrence Livermore National Laboratory

Introduction:



1. H₂ storage options

- There are four automotive H₂ storage technologies: compressed gas, metal hydride materials, carbon-based materials, and cryogenic liquid
- Each technology has its fundamental limitation: weight, volume, evaporation, or adsorption thermodynamics

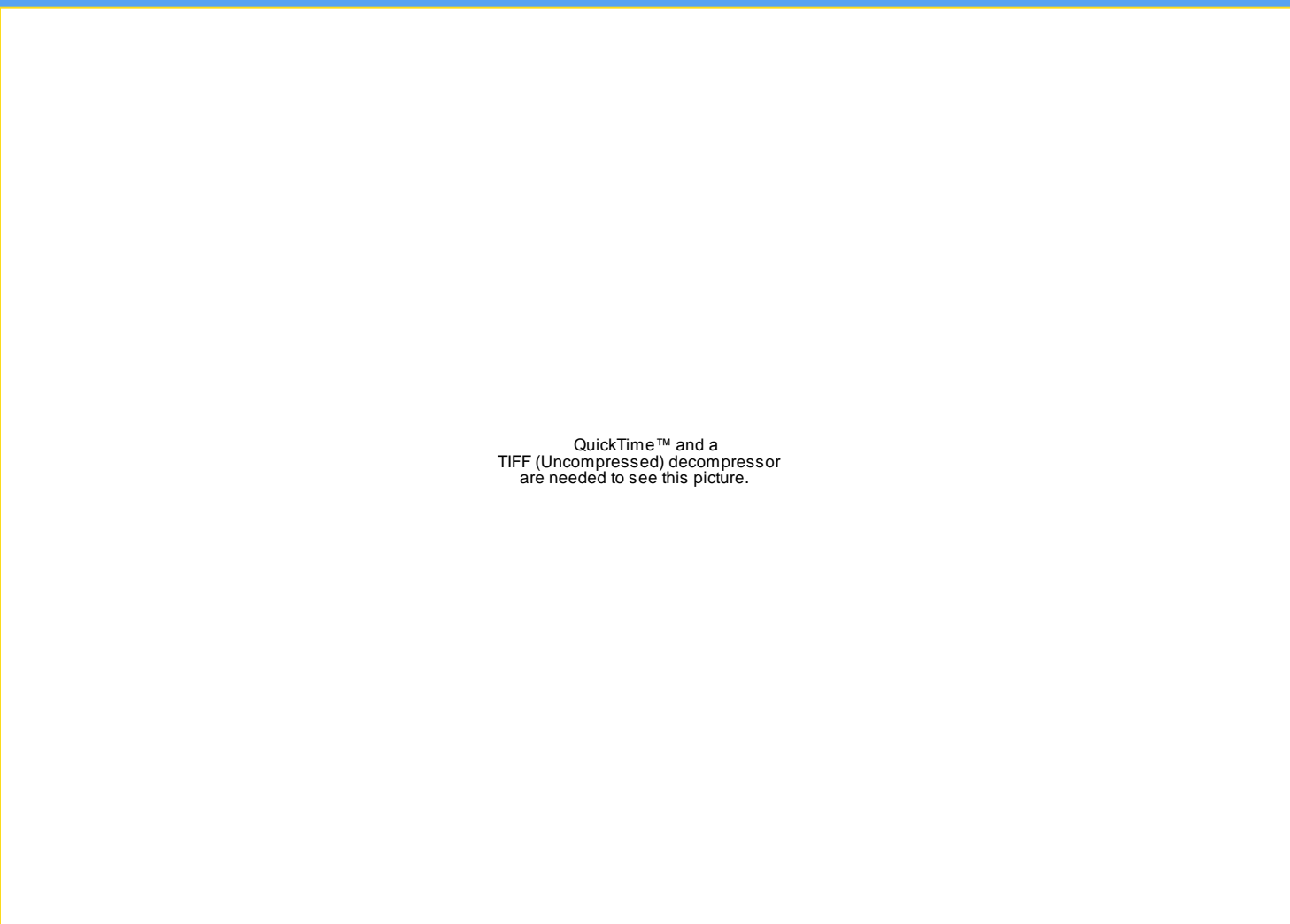


2. CCPV

- LLNL's cryogenic capable pressure vessel can store compressed H₂ or LH₂
- CCPV Advantages: long range, compact, eliminates LH₂ evaporation, flexible refueling

Methodology:

- A cryogenic dormancy test (1 week) of 151 liter CCPV was performed using LN₂
- From the test, equations were used to describe the measured vessel pressure and temperature during the test
- Utilizing those equations, a thermodynamic model of the CCPV was created to simulate the test results
- The model estimates the total heat transferred to the CCPV due to both radiation and conduction



3. Dormancy test results

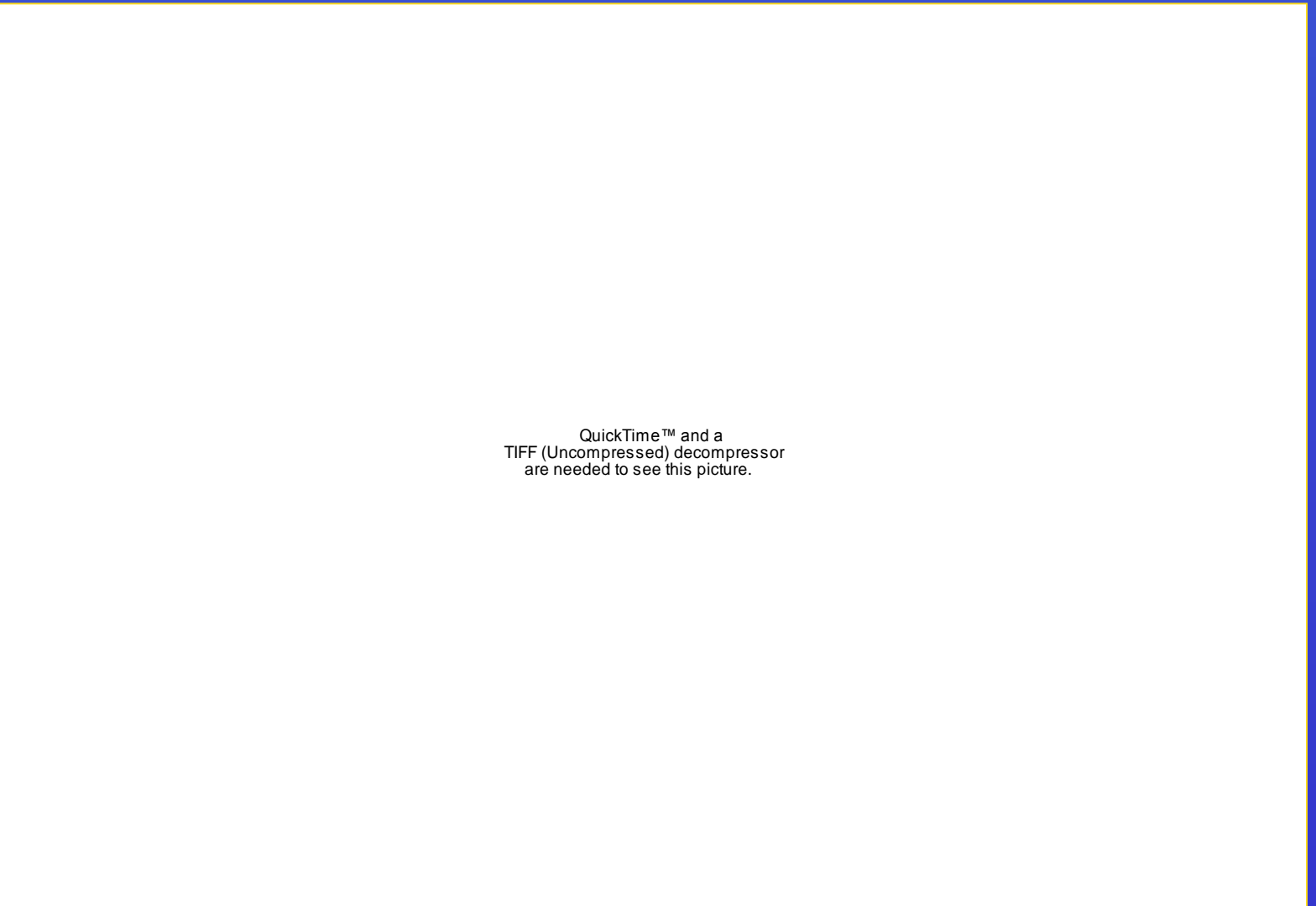


4. Dormancy test

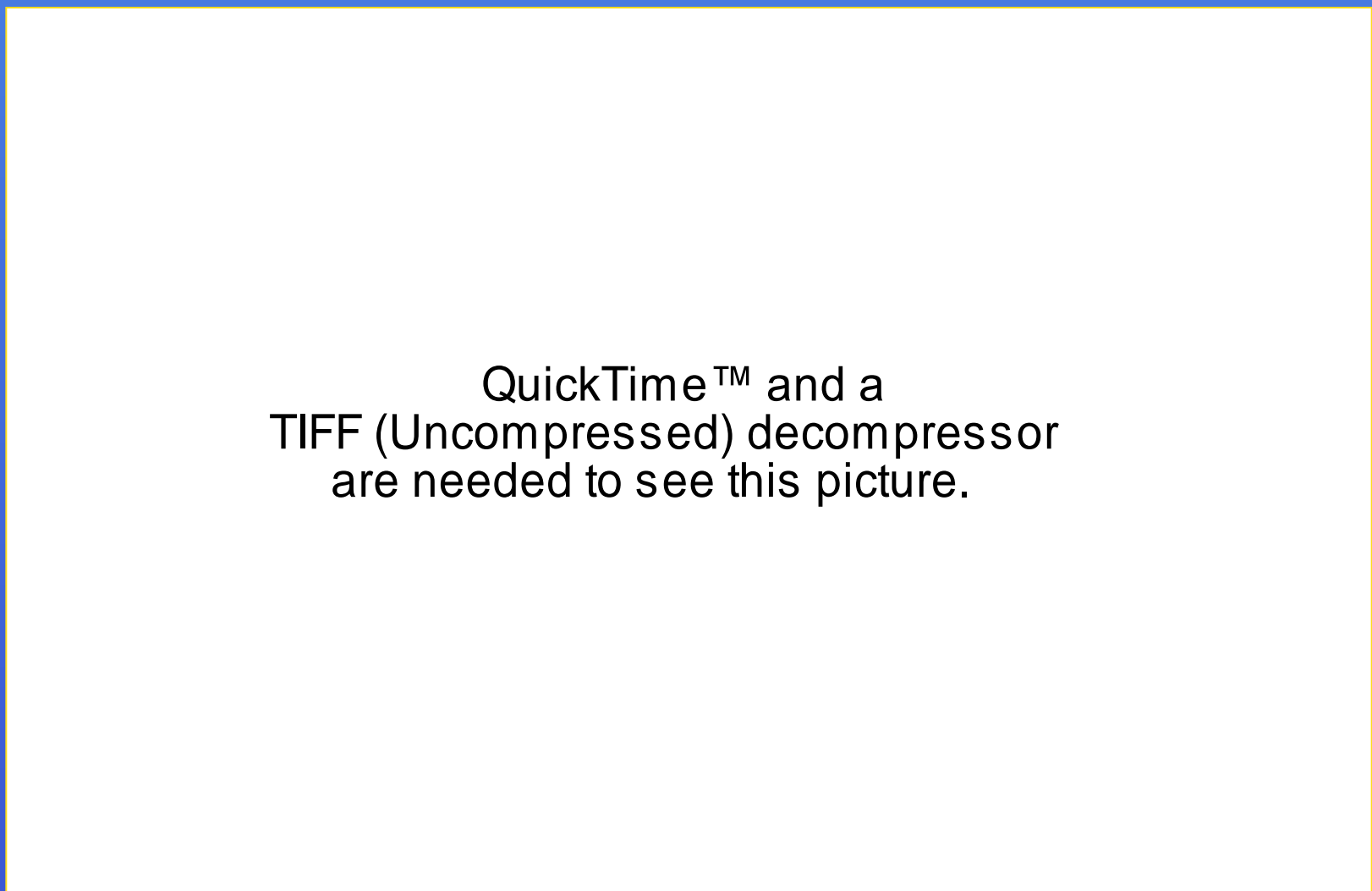
Thermodynamic Analysis



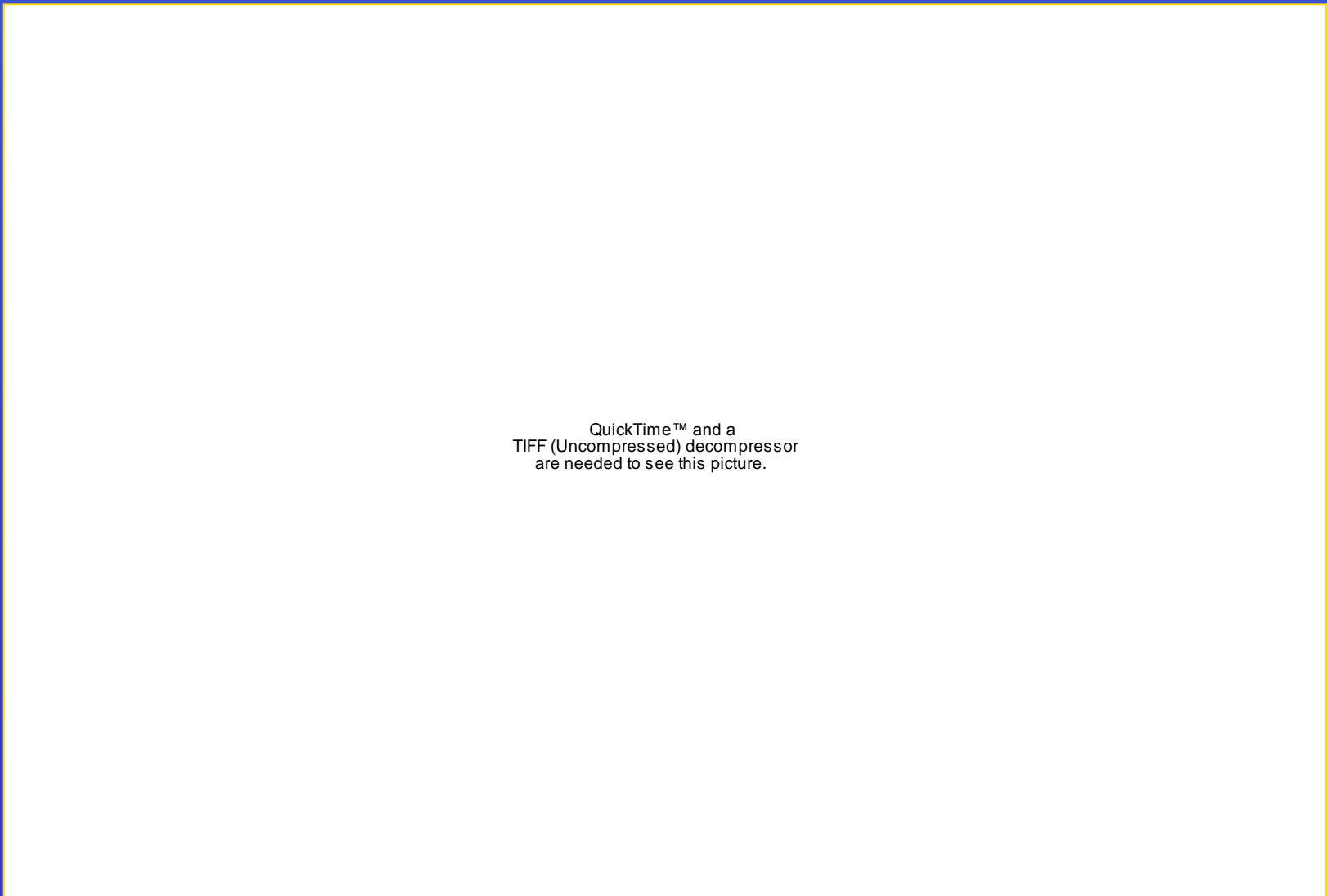
5. Nitrogen chart



7. Experimental Temperature



6. Heat leak Equations



8. Experimental Pressure

Results:



9. Simulated temperature



10. Heat leak

- The final test pressure and temperature was used to verify the amount of LN₂ in the CCPV: 13 kg
- The temperature values from the simulation are comparable to the experimental data
- Radiation is responsible for ~90% of the CCPV heat leak.
- The average amount of heat transferal rate to the CCPV during the dormancy test was 5.5 Watts

Discussion:

- Radiation is the main source of heat into the CCPV
- The length of the steel pipes can be reduced and the thermal isolation rings maybe shrunk dramatically
- It is predicted that at 5.5 Watts the CCPV will be sufficient to store 10.7 kg of LH₂ for 10 days before boiloff begins
- Future plans are to conduct fuel economy, range performance, and boiloff analysis of a Toyota Prius that is powered by a (L)H₂ filled CCPV. A 500-mile range is projected.



11. Insulation and rings



12. Toyota Prius