UV-T-RH COMBINED ENVIRONMENTAL TESTING

JET PROPULSION LABORATORY

C. C. Gonzalez

Objectives

- To determine the combined effects of controlled amounts of UV radiation, heat and humidity upon the mechanical properties of module cover materials and the electrical properties of a-Si cells
- To develop the relationships required to relate experimental results obtained in accelerated and controlled-environment tests to field observations

Approach

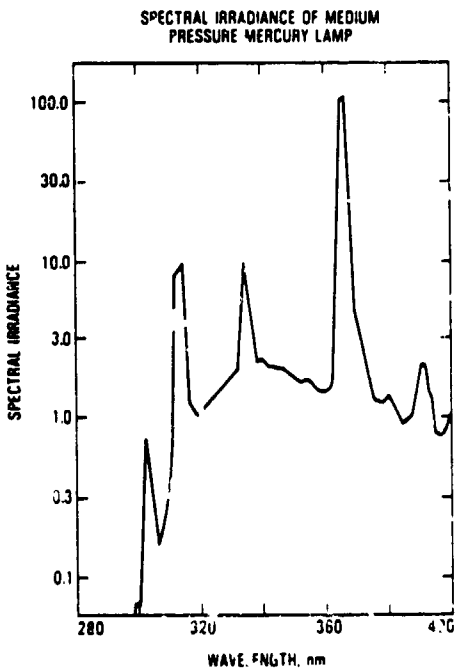
- Use controlled environment for given period of time
  - Initial calibration of oven with lower-limit environments
    - 85 deg C, 10% RH, 1-2 suns UV
  - Use of increased levels for subsequent tests
- Monitor changes in selected key chemical and physical properties that are expected to control long-term performance
- Correlate controlled-environment test results with outdoor exposure

Description of Test Equipment

- **Environmental chamber**
  - **Air-interchange, heat-and-refrigeration unit (-40 deg C to 175 deg C)**
  - **Varying humidity (10-100% (up to 90 deg C))**
- **UV lamp system**
  - **2000 W UV (1-2 suns)**
  - **Water cooled**
  - **Dry-nitrogen purge**

Ultraviolet Radiation Source

- **Manufacturer: Canrad-Hanovia**
- **Type: Medium pressure mercury vapor lamp**
- **Lamp power consumption: 2100 W**
- **Lamp power output prior to filtering by cooling jacket: 1100 W**



Environmental Parameter Measurements

- UV lamp
  - Integrated measurements
    - Actinometers
    - Radiometer
  - Spectral-radiometric measurements
    - Monochrometer
  - Lamp output vs time (qualitative)
- Oven temperature (continuous)
- Relative humidity (periodic)
- Selected sample temperatures

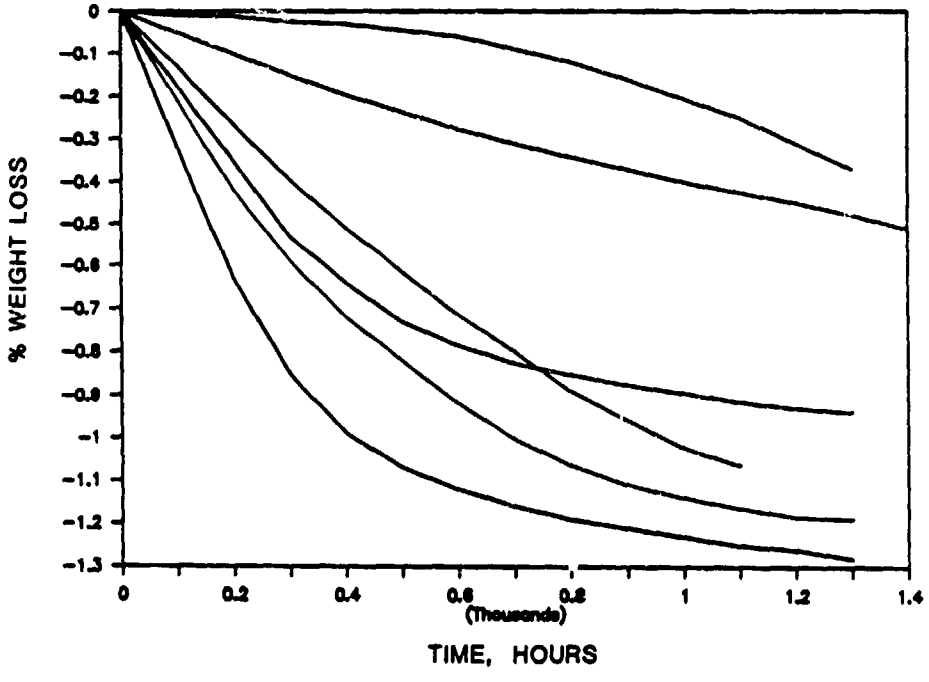
Sample Types

- Module encapsulant & cover materials
  - Material types
    - Tedlar
      - Varying amounts of additives
      - Clear and opaque
    - EVA
  - Size and configuration
    - 3/4" x 4" bare strips
    - 4" x 4" laminated tedlar-EVA-glass coupons
    - 4" x 4" submodules with tedlar front cover
- Amorphous-silicon 4" x 4" submodules

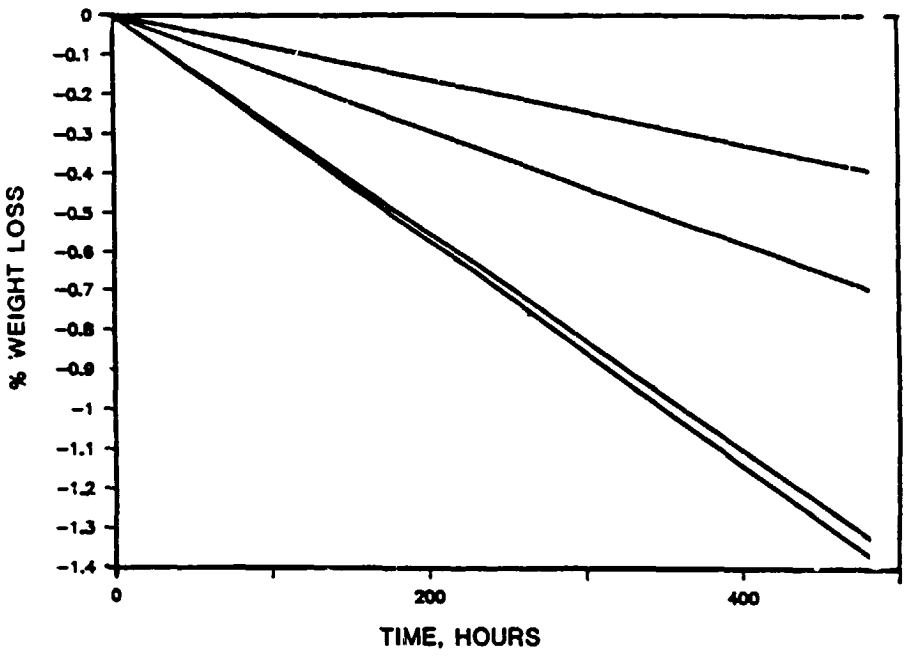
Material Parameters Measured (Cover and Encapsulation Materials)

- **Weight loss**
  - **Monitor loss of additives and volatiles**
  - **Correlate with shrinkage**
- **Changes in absorbance/transmission**
  - **Related to loss of absorbers and to chemical degradation (loss of transmission at 400nm related to yellowing)**
- **Tensile Modulus**
  - **May not establish rate and trend of photothermal degradation in early stages**
- **Visual inspection**
  - **Determine pliability of material by depressing laminated material**

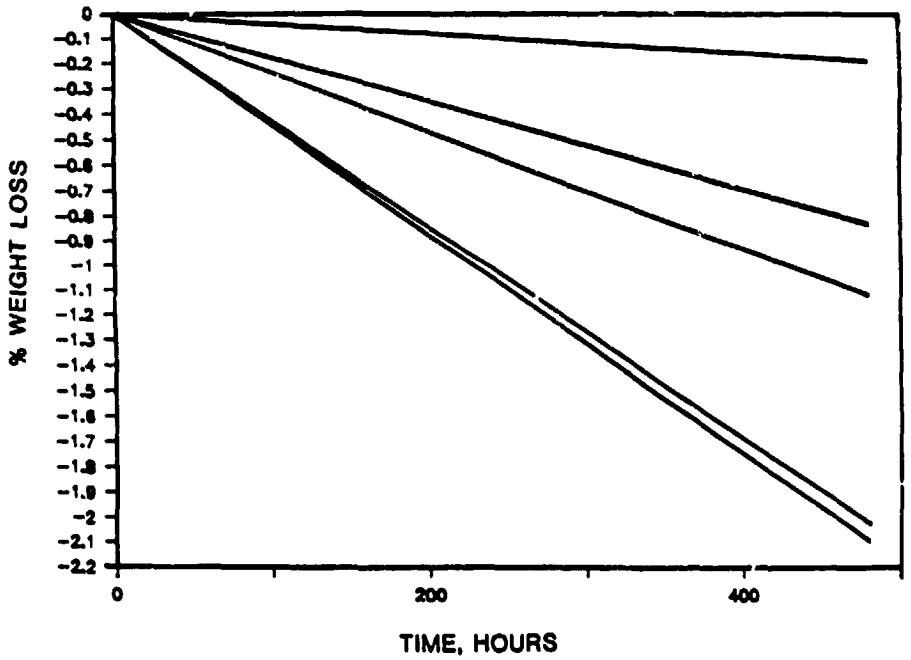
Tedlar: Percent Weight Loss Versus Time



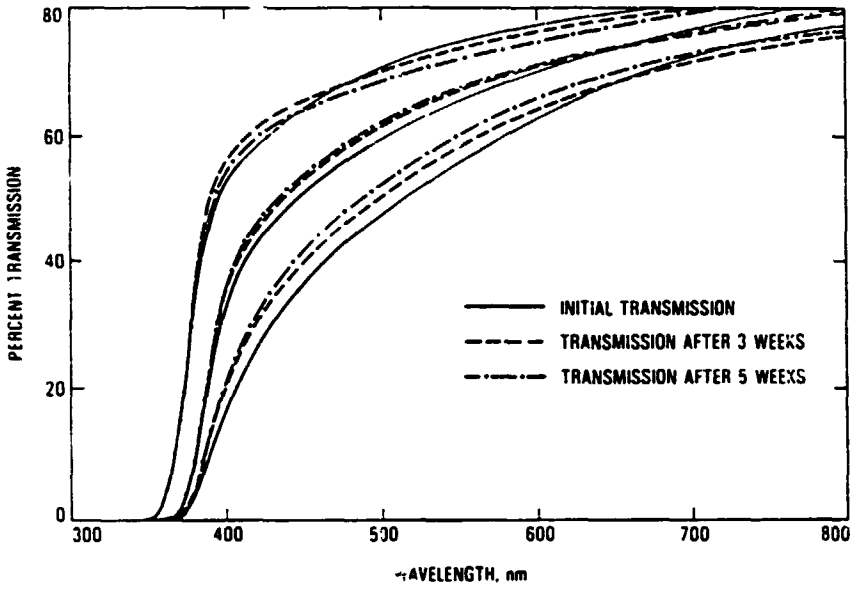
Tedlar (Dry Oven): Percent Weight Loss Versus Time



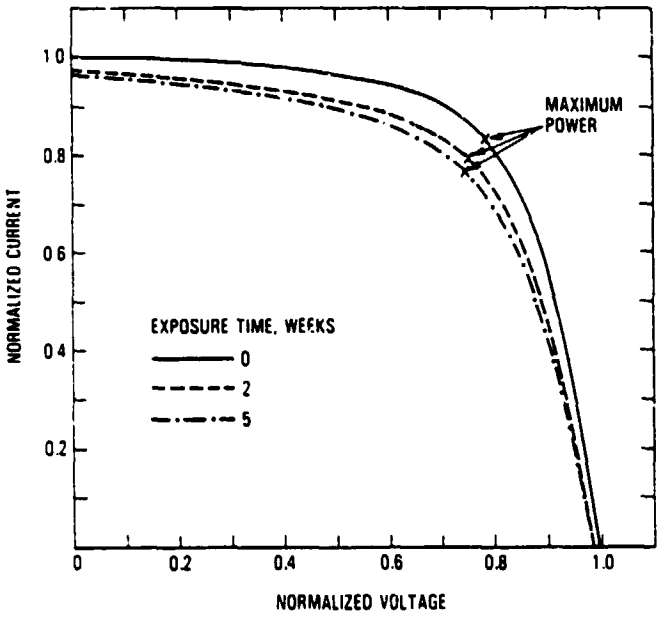
Tedlar (Vacuum Oven): Percent Weight Loss Versus Time



Module Front Cover Material: Percent Transmission Versus Exposure Time



Changes in I-V Curves of Amorphous Silicon Cells Versus Oven Exposure



Test Results Summary

- Cover materials
  - Weight loss
    - ≤1.35% after 7-weeks exposure
  - Changes in absorbance/transmission
    - Results ranged from no change to about 15% gain after 5 weeks
  - Mechanical properties
    - Visual observations reveal no significant changes except for one case
- Amorphous-silicon cells
  - IV-curve changes
    - Average max-power loss of 10-15% after 3-5 weeks exposure

Future Work

- Refine existing test and sample measurement procedures (Develop new ones, if required)
- Use high-humidity environment and increased temperature levels
- Vary UV levels by adding/removing screens and changing sample distance to lamp
- Perform parallel sample exposures in dry-heat and vacuum ovens