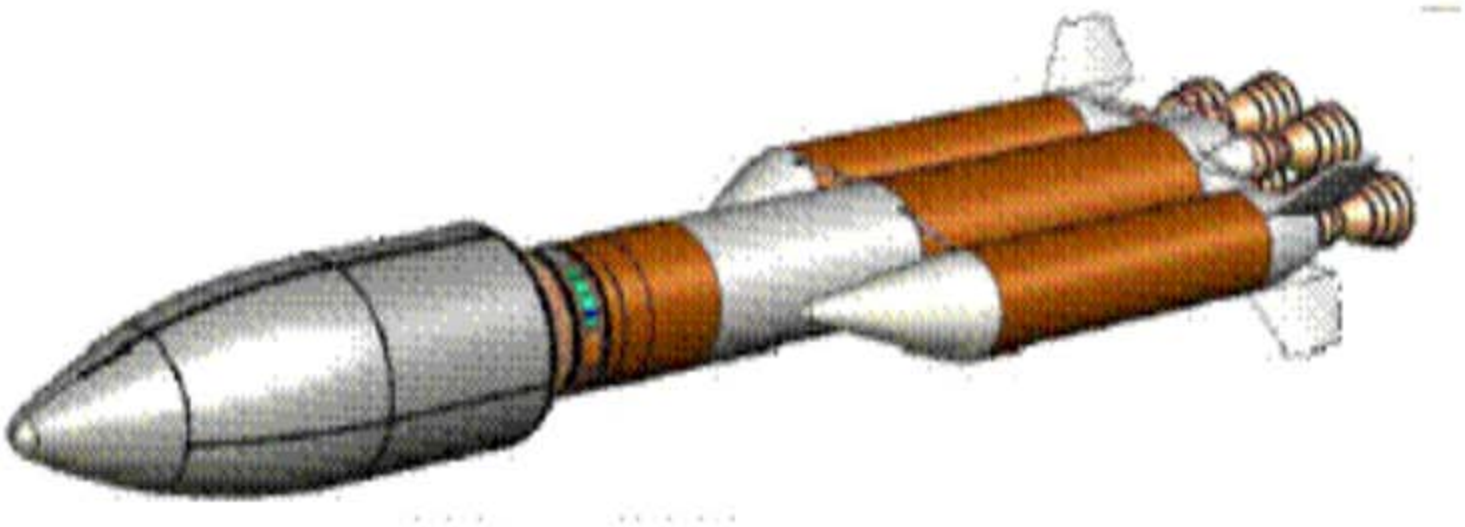
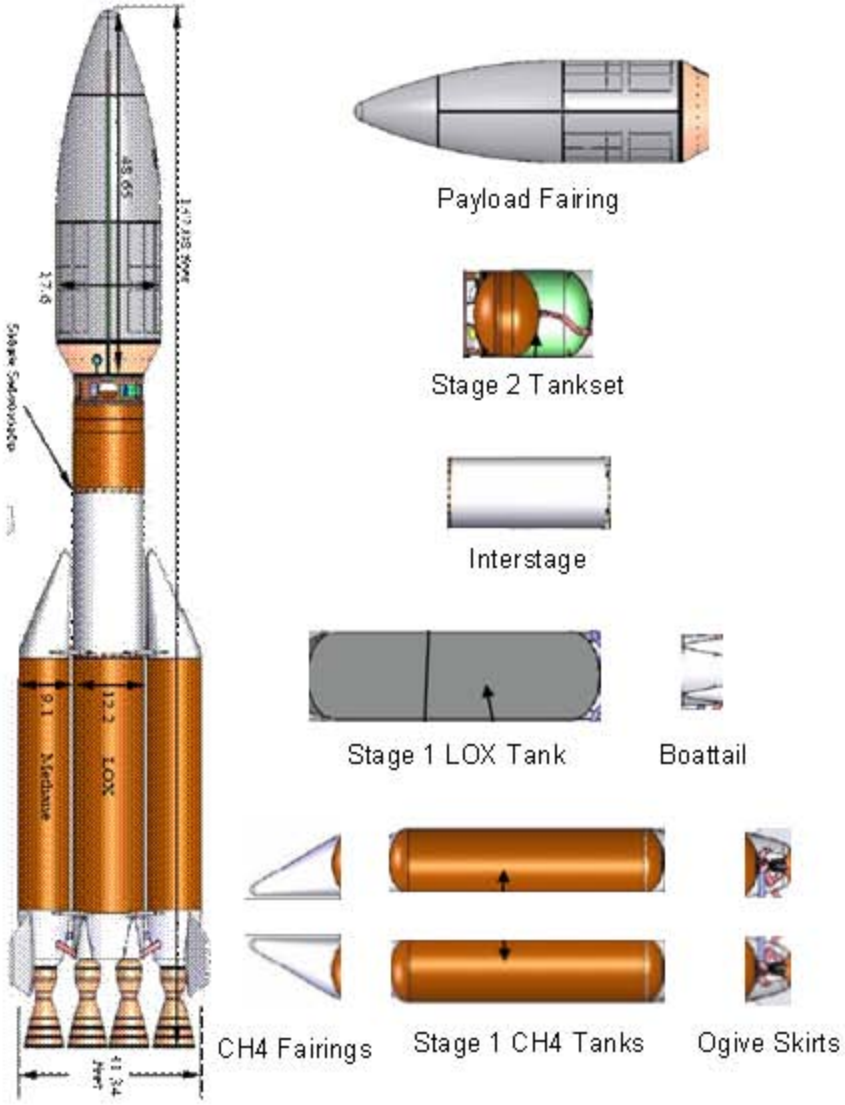
AL PLP Heating Analysis Results



AirLaunch PLP

AL PLP Heating Analysis Results



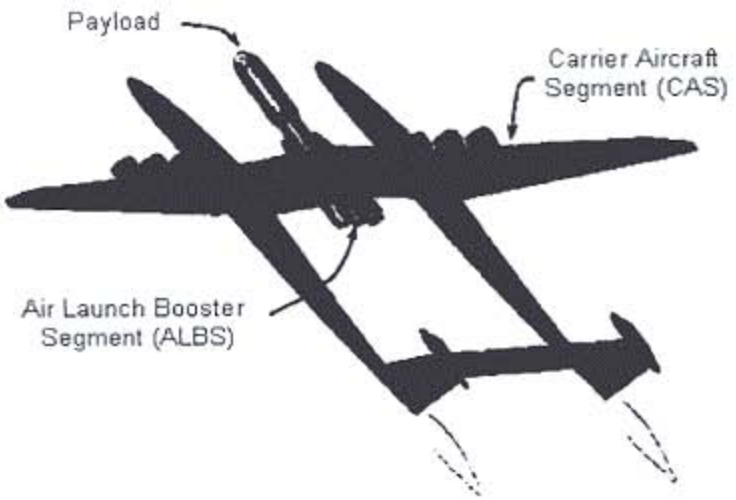
Launch Description

Objective:

- Develop and flight test an innovative new capability to transport medium class (12,000 Lbs minimum) payloads to low earth orbit

Requirements:

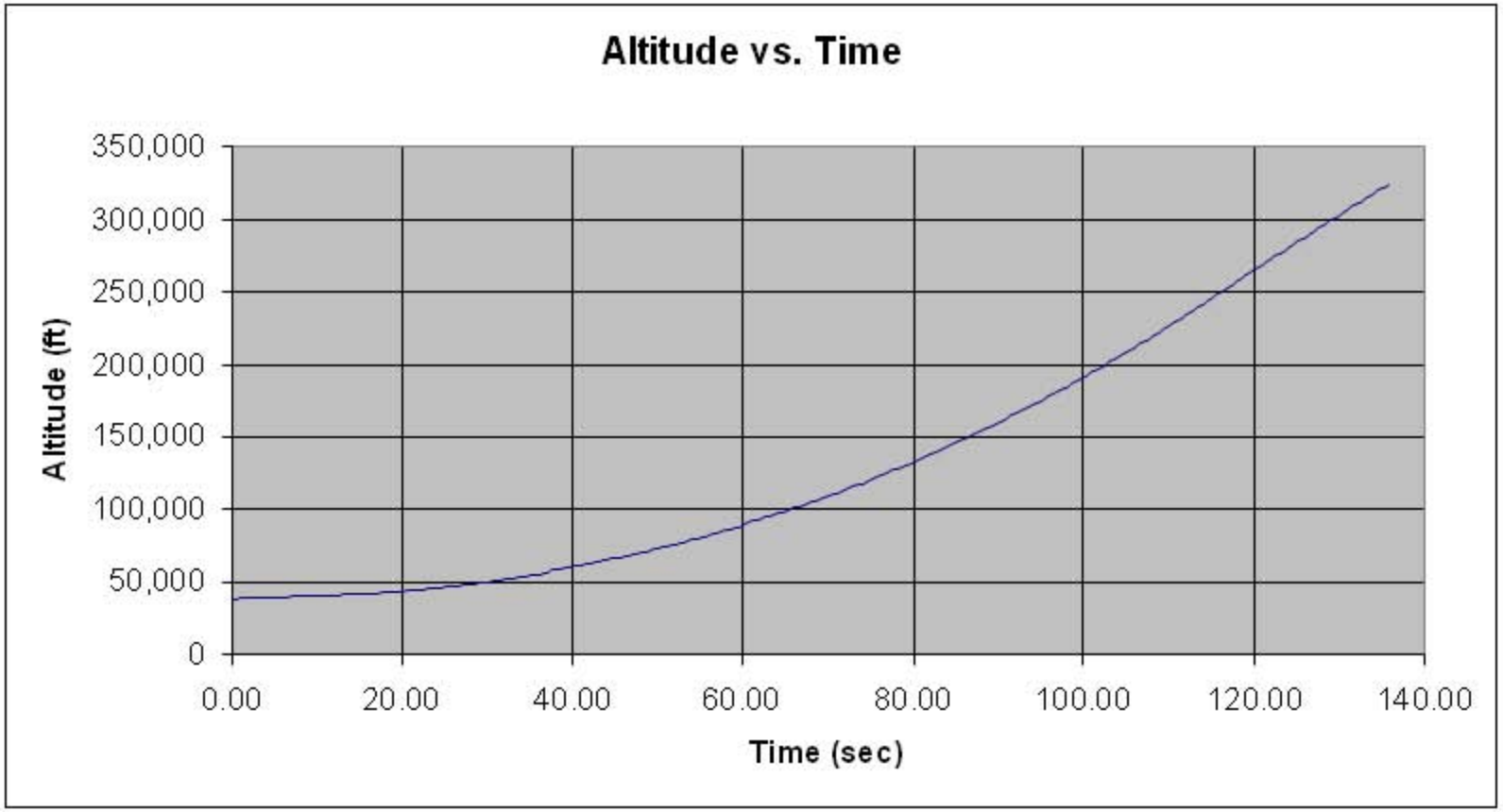
- 12,000 Payload
- 550,000 LB GLOW (ALBS and ASE)
- Orbit Insertion 250 NM / 60 degree inclination
- Mated Duration: 3 Week with multiple launch attempts without demating
- Launch 14 Days After Payload Delivery
- Mate and launch within 4 days of Carrier Aircraft availability
- Abort and Recover with ALBS with next launch attempt within 24 hours



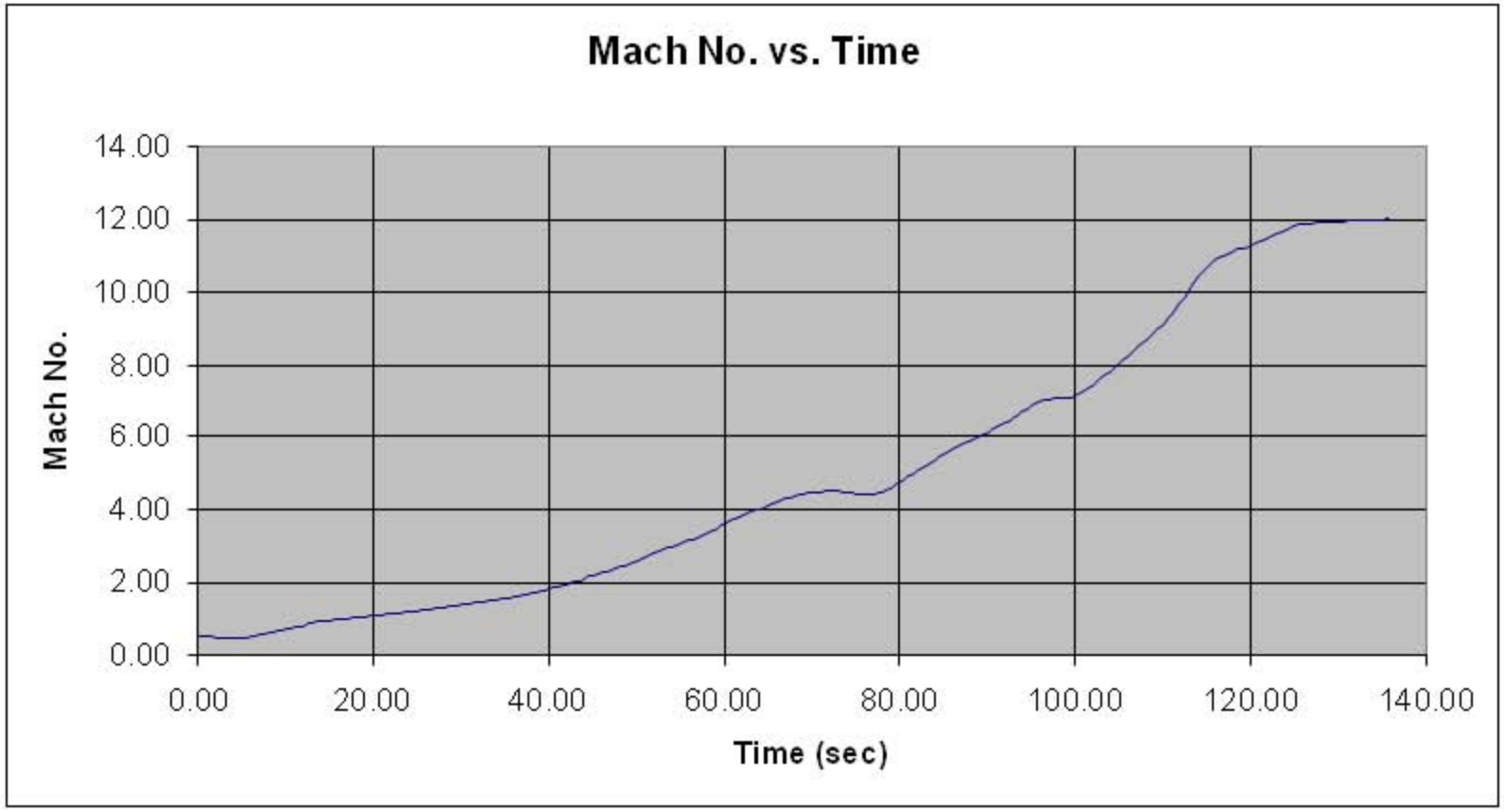
Example Release Conditions

- 450K lb booster
- 33K ft Maneuver Start Altitude
- 43 Degrees Gamma (Nose Up)
- Mach 0.55 to 0.65
- 42,000 Ft

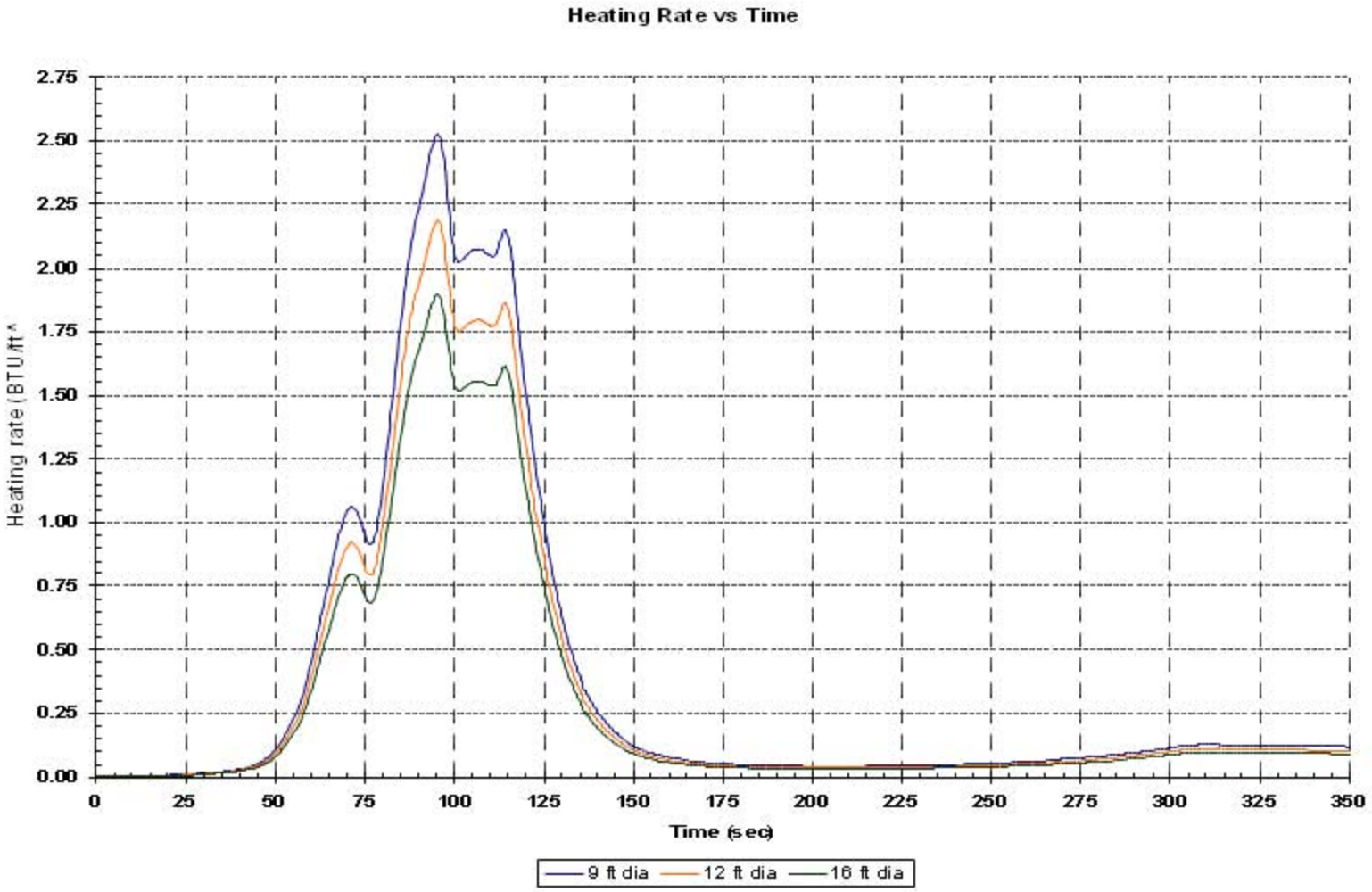
AL PLP Heating Analysis Results



AL PLP Heating Analysis Results



AL PLP Heating Analysis Results



AL PLP Heating Analysis Results

- Cross Section:
  - Outer Skin: 0.078" Graphite Epoxy
  - Core: 1" Vacuum Purged, Perforated Aramid Honeycomb
  - Inner Skin: 0.078" Graphite Epoxy
- No Exterior Coating (Emissivity: 0.80 @ -460 degF to 0.90 @ 4000 degF)
- Tank Interior Boundary Conditions:
  - LOX: -234 degF @ 200 psia to -245 degF at 140 psia (70% P_i_LOX)
  - CH4: -178 degF @ 200 psia to -193 degF at 140 psia (70% P_i_CH4)
- Pre-condition w/ Exterior Convection Prior to Launch (h = 20 btu/hr-ft2-F, 1962 Standard Day Atmospheric Model)
- Post-Launch:
  - Applied Exterior Aero-Thermal B.C.
  - No Additional Exterior Convection
  - Radiation to T_sky as Function of Altitude
  - Radiation to T_earth as Function of Altitude
  - Solar Load as Function of Altitude

AL PLP Heating Analysis Results
Mission Time: 0 to 135 sec.

- 9 Ft. Dia. CH4 Tank:
  - T_max Outer Skin: 555 F / Core: 137 F / Inner Skin: -114 F
  - T_min Outer Skin: -51 F / Core: -90 F / Inner Skin: -144 F
- 12 Ft. Dia. CH4 Tank:
  - T_max Outer Skin: 507 F / Core: 110 F / Inner Skin: -117 F
  - T_min Outer Skin: -51 F / Core: -90 F / Inner Skin: -144 F
- 9 Ft. Dia. LOX Tank:
  - T_max Outer Skin: 554 F / Core: 127 F / Inner Skin: -155 F
  - T_min Outer Skin: -53 F / Core: -106 F / Inner Skin: -188 F
- 12 Ft. Dia. LOX Tank:
  - T_max Outer Skin: 505 F / Core: 100 F / Inner Skin: -159 F
  - T_min Outer Skin: -53 F / Core: -107 F / Inner Skin: -188 F
- 16 Ft. Dia. Fairing (Adiabatic Interior Surface):
  - T_max Outer Skin: 468 F / Core: 125 F / Inner Skin: -10 F
  - T_min Outer Skin: -46 F / Core: -45 F / Inner Skin: -44 F

AL PLP Heating Analysis Results

CONCLUSIONS:

- Outer Skin Exceeds Desired 250 degF Maximum Subsequent to t = 85 sec. (i.e. T_max = 555 degF)
- Inner Skin Does Not Exceed 250 degF Maximum (i.e. T_max = 137 degF)

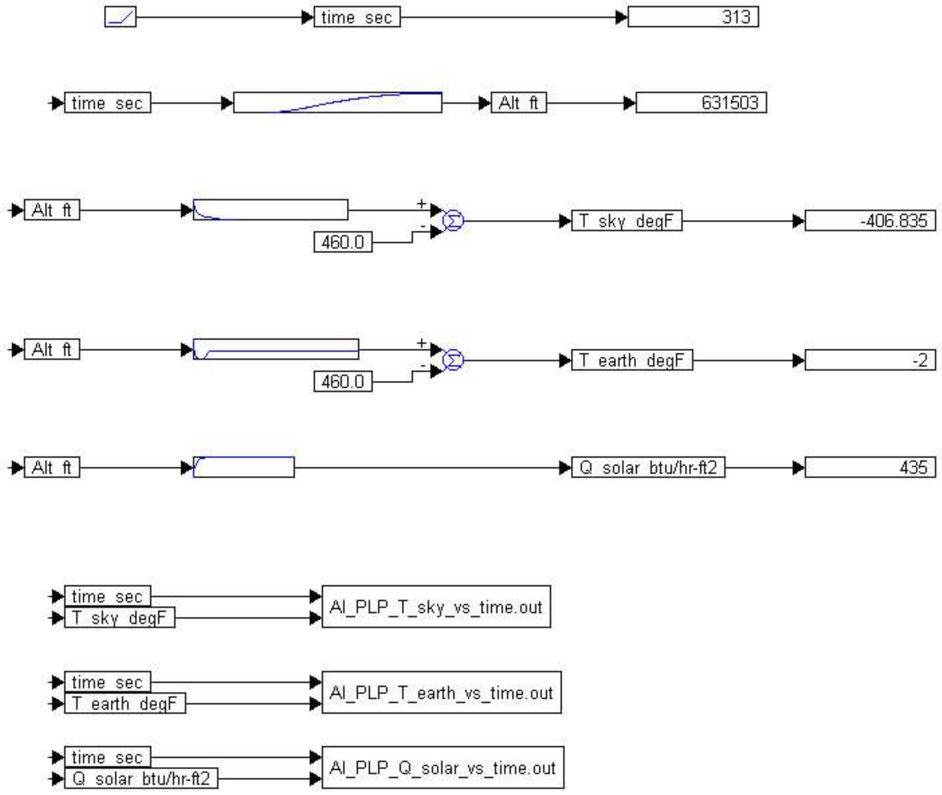
SUGGESTION:

- Employ an Asymmetric Cross Section:
  - Outer Skin + Core + Inner Skin Sized to Provide Structural Margins During Handling and Transport Loads (i.e. –Infinity < t < 85 sec.)
  - Inner Skin Alone Sized to Provide Structural Margins Subsequent to Launch (i.e. t > 85 sec.)
- Currently Looking at Various Thermal Barrier Coatings

VisSim - [T_sky_T_earth_Q_solar_vs_alt.vsm]

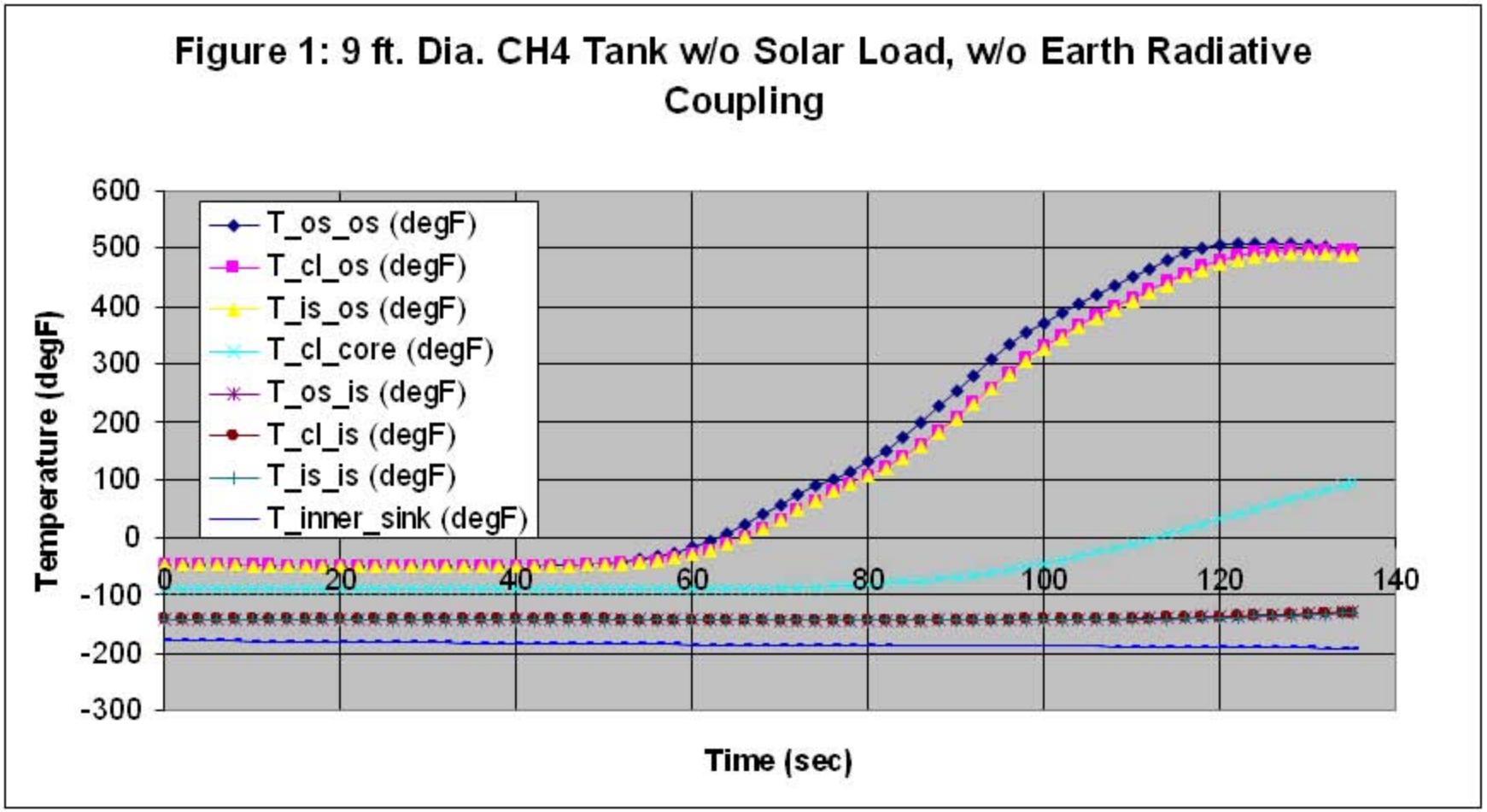
File Edit View Simulate Analyze Blocks Tools Window Help

C:\0_afc_work\

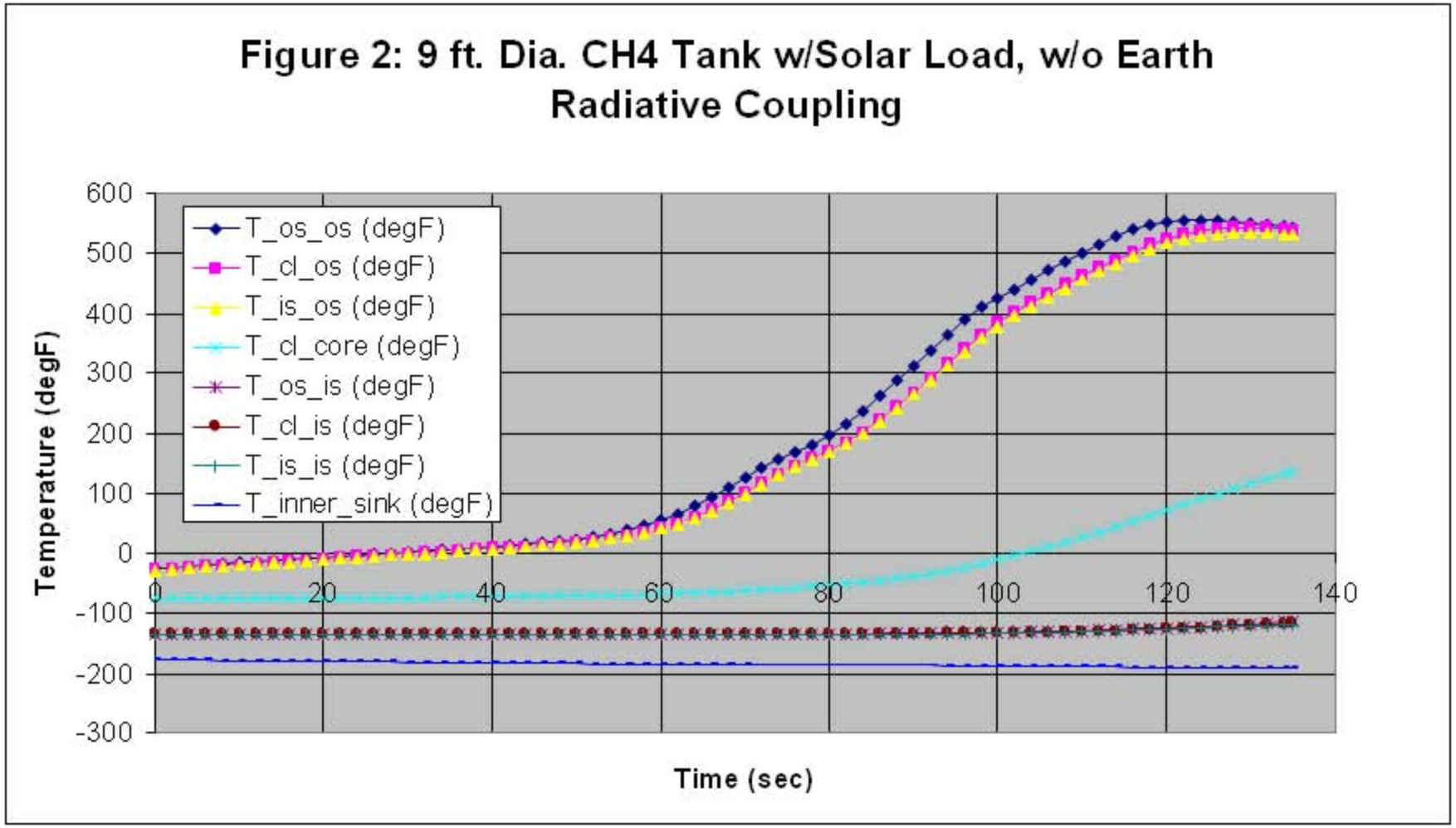


Blks 32 Rng 0 : 313 Step 1 T 313 RK2

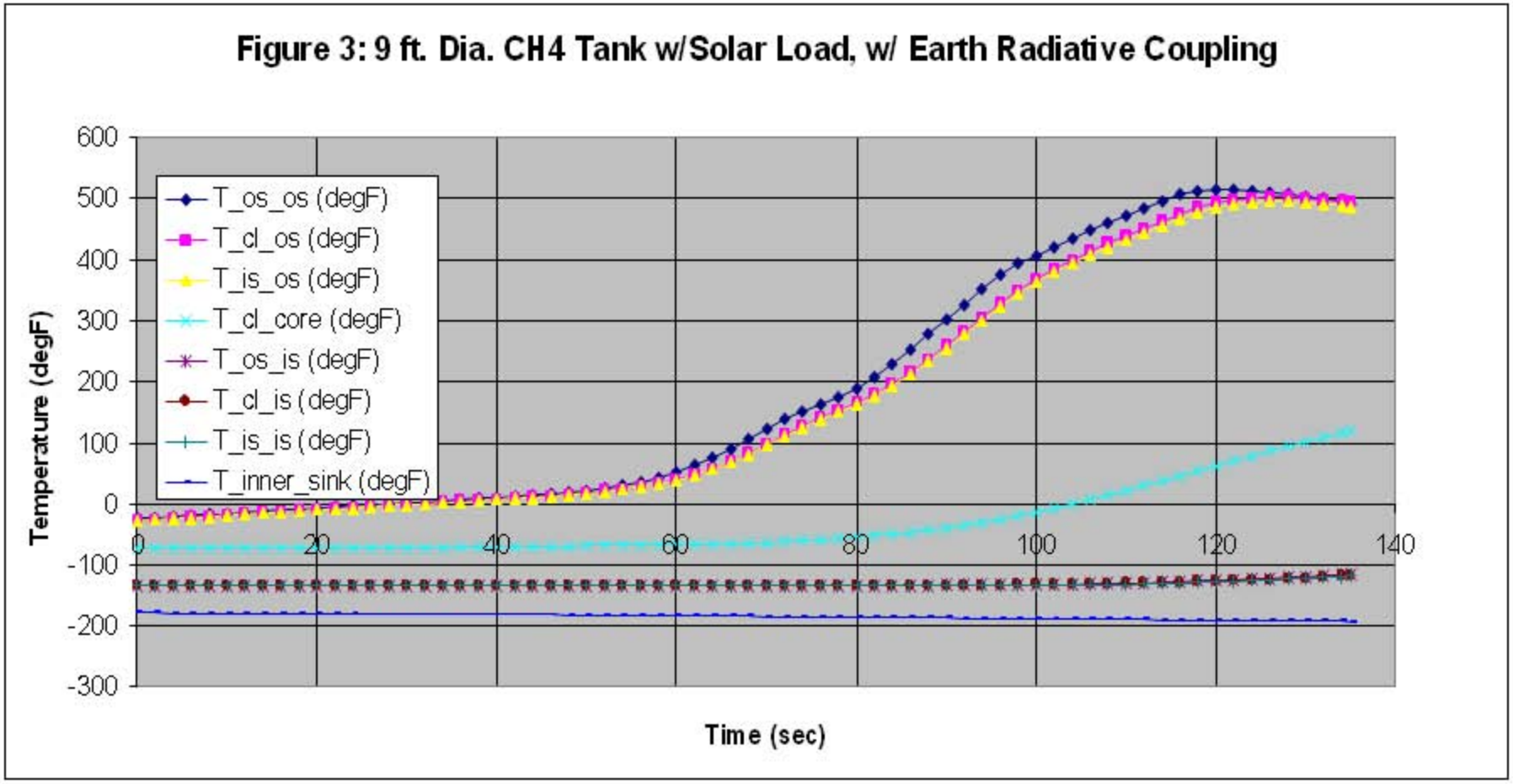
AL PLP Heating Analysis Results



AL PLP Heating Analysis Results

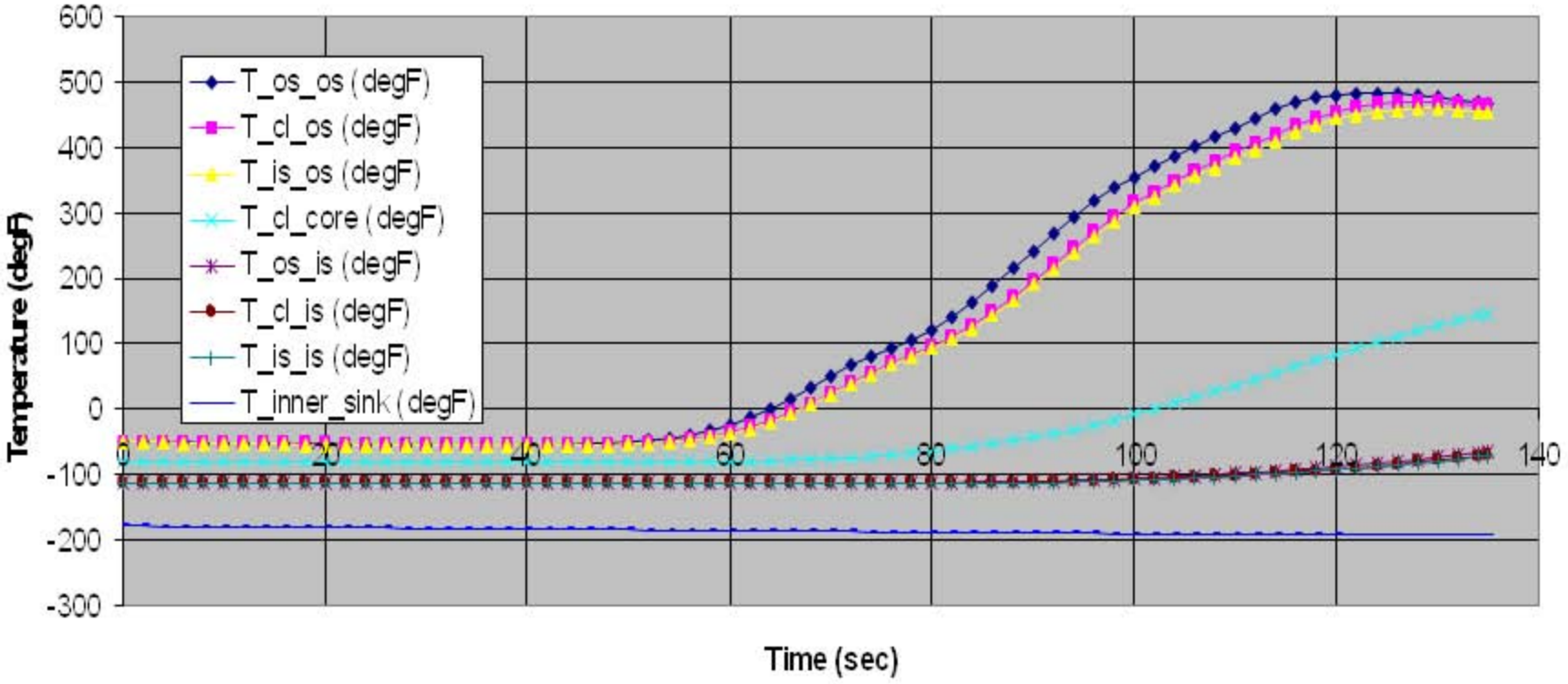


AL PLP Heating Analysis Results

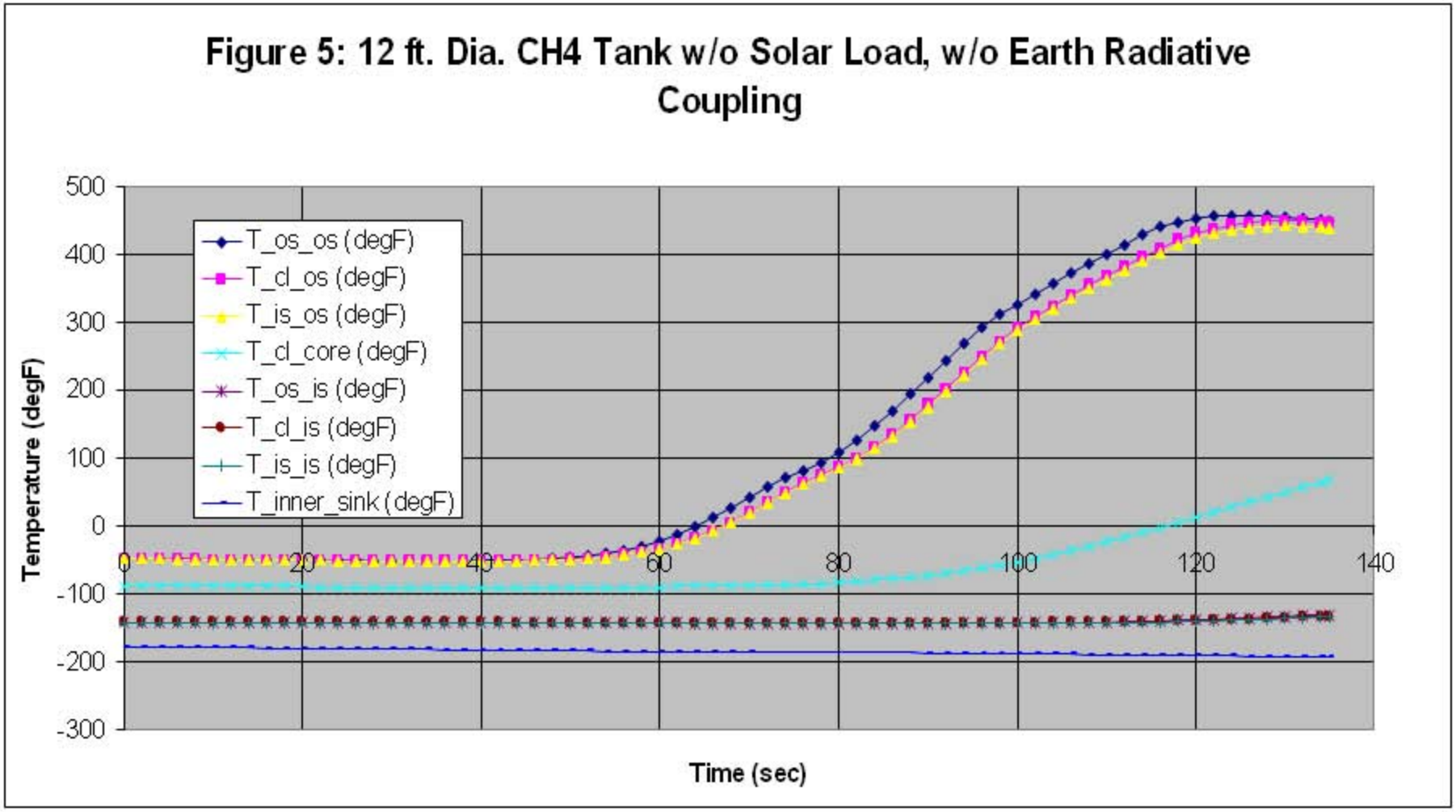


AL PLP Heating Analysis Results

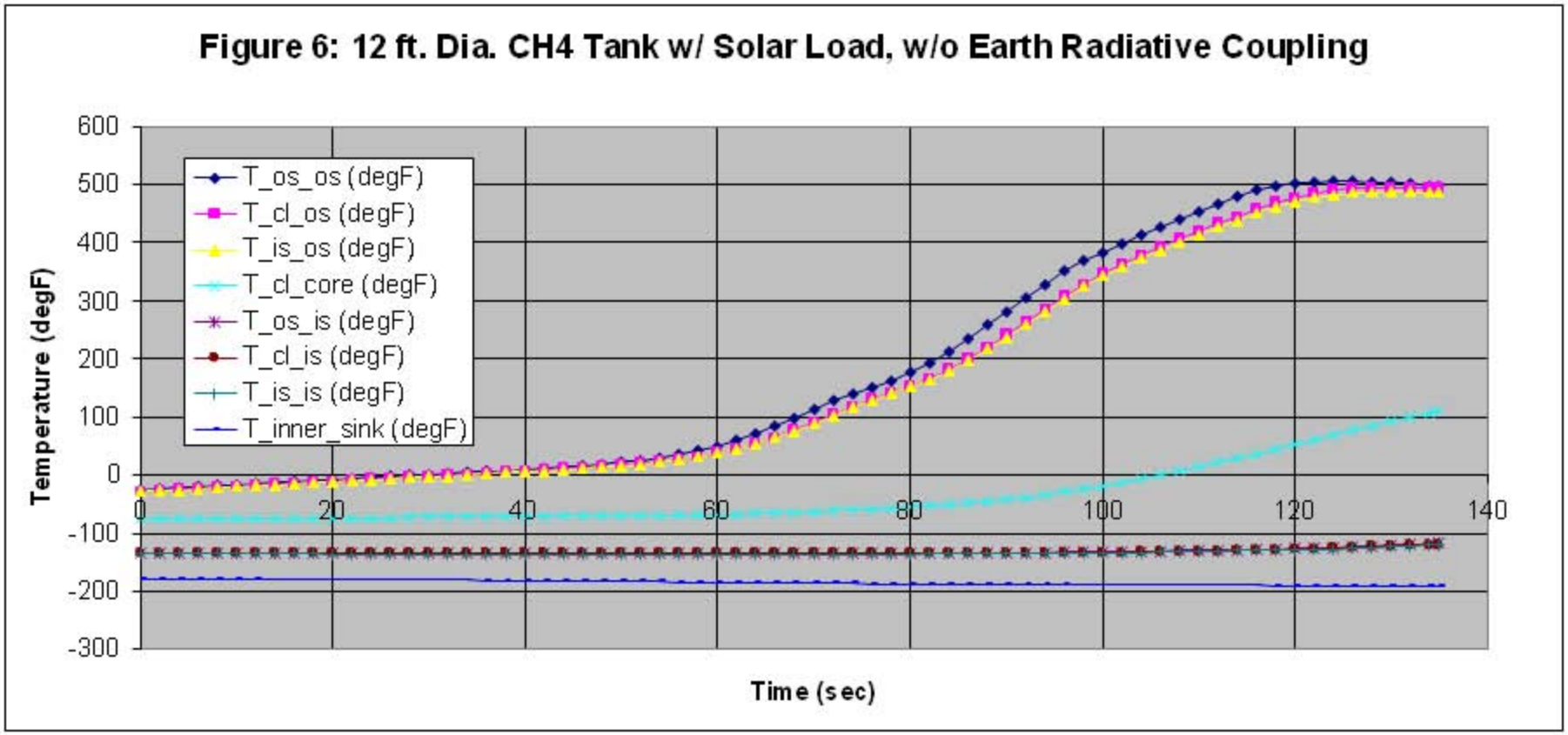
Figure 4: 9 ft. Dia. CH4 Tank w/o Solar Load, w/o Earth Radiative Coupling
(Core Material Conductivity Increased by approximate factor of 10)



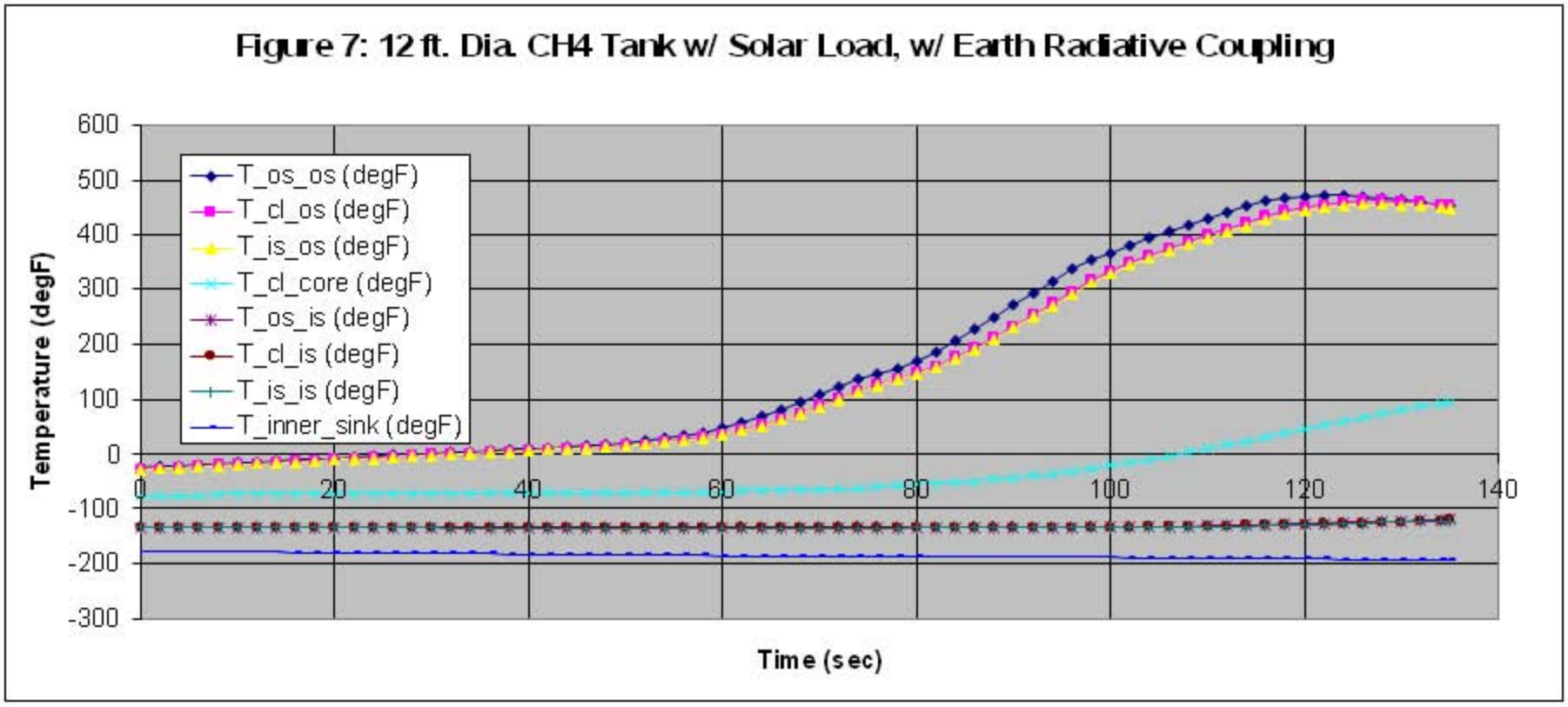
AL PLP Heating Analysis Results



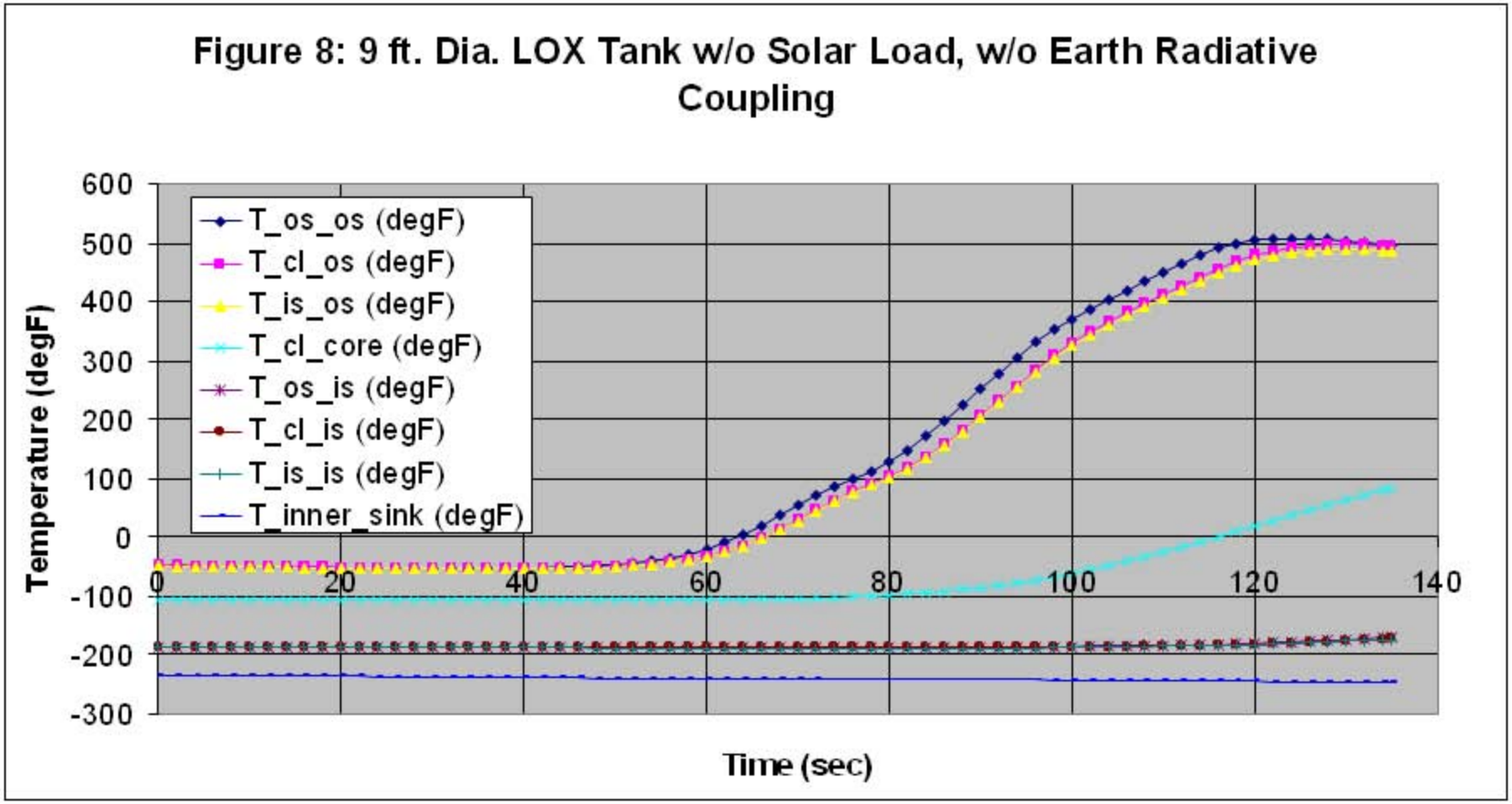
AL PLP Heating Analysis Results



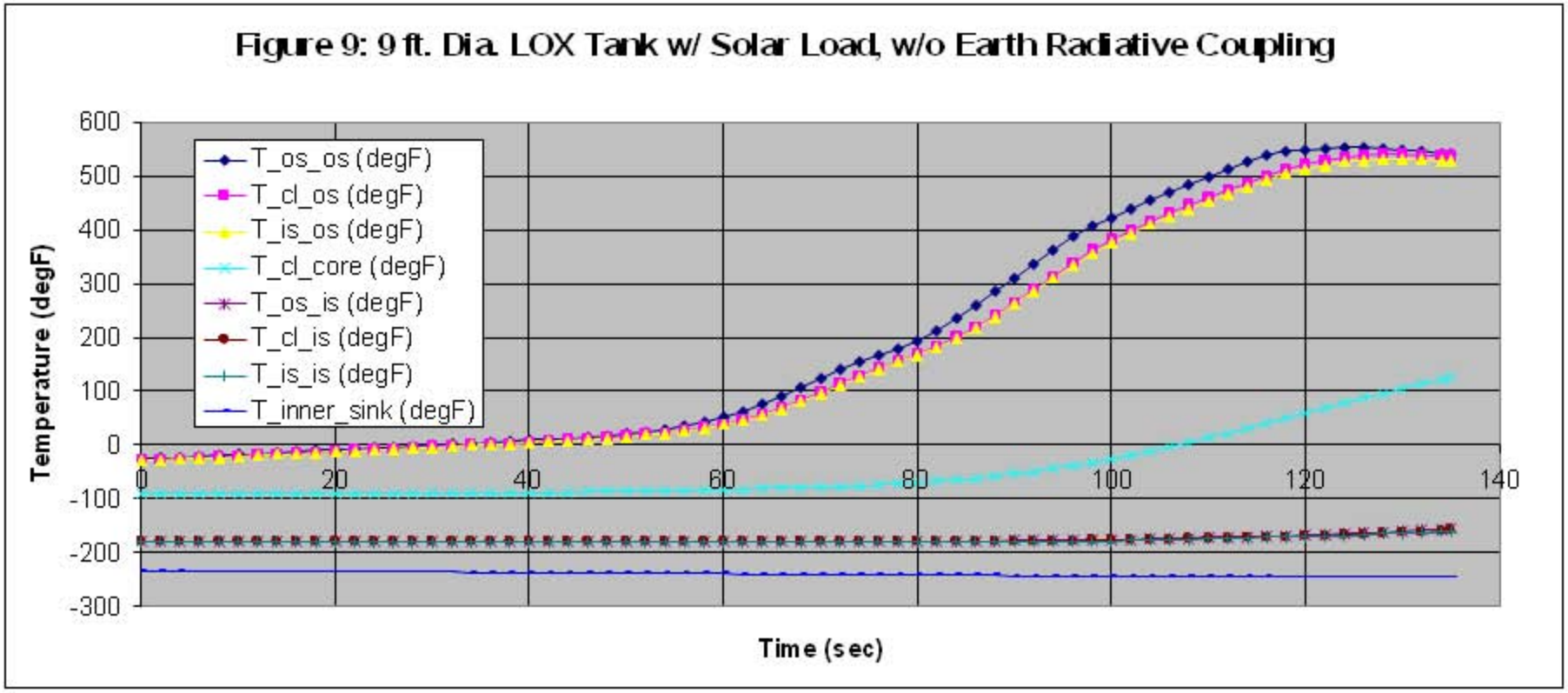
AL PLP Heating Analysis Results



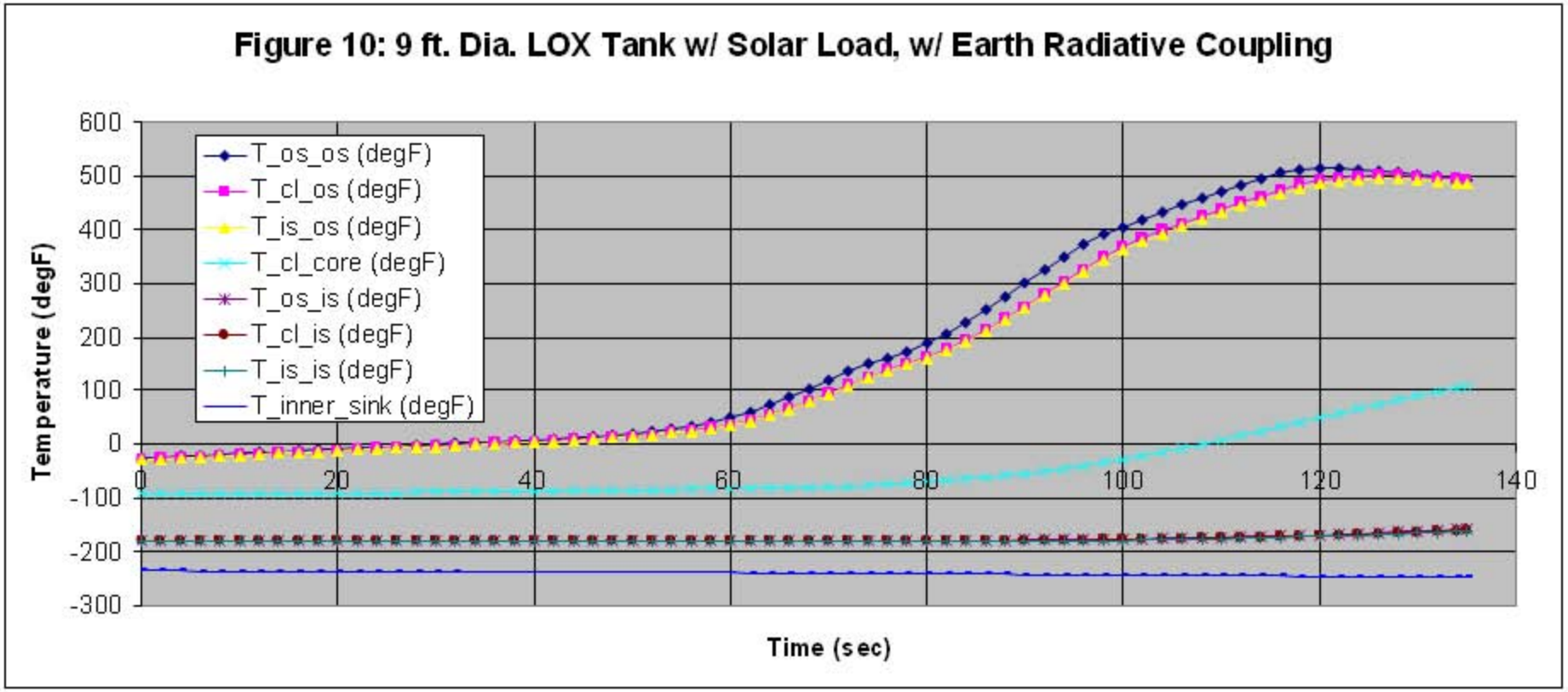
AL PLP Heating Analysis Results



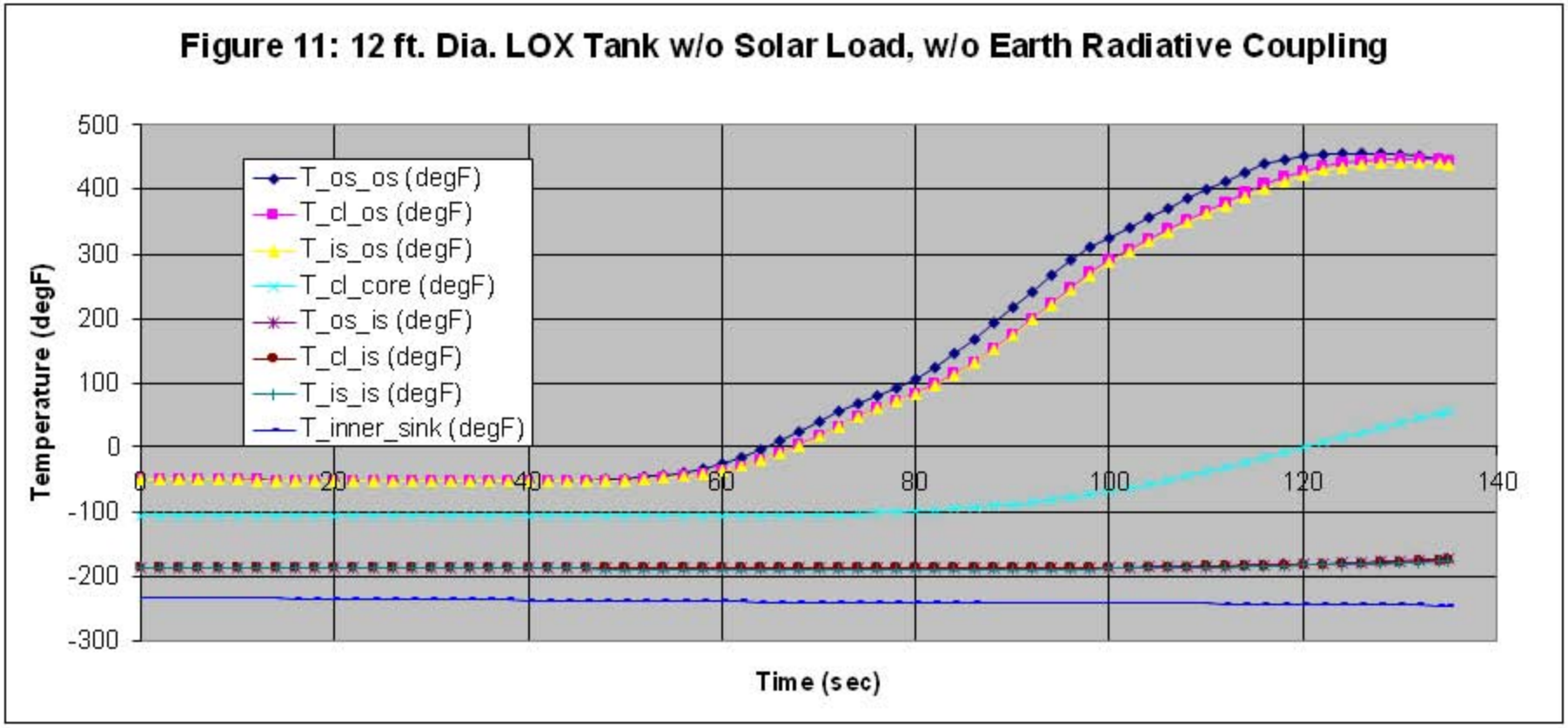
AL PLP Heating Analysis Results



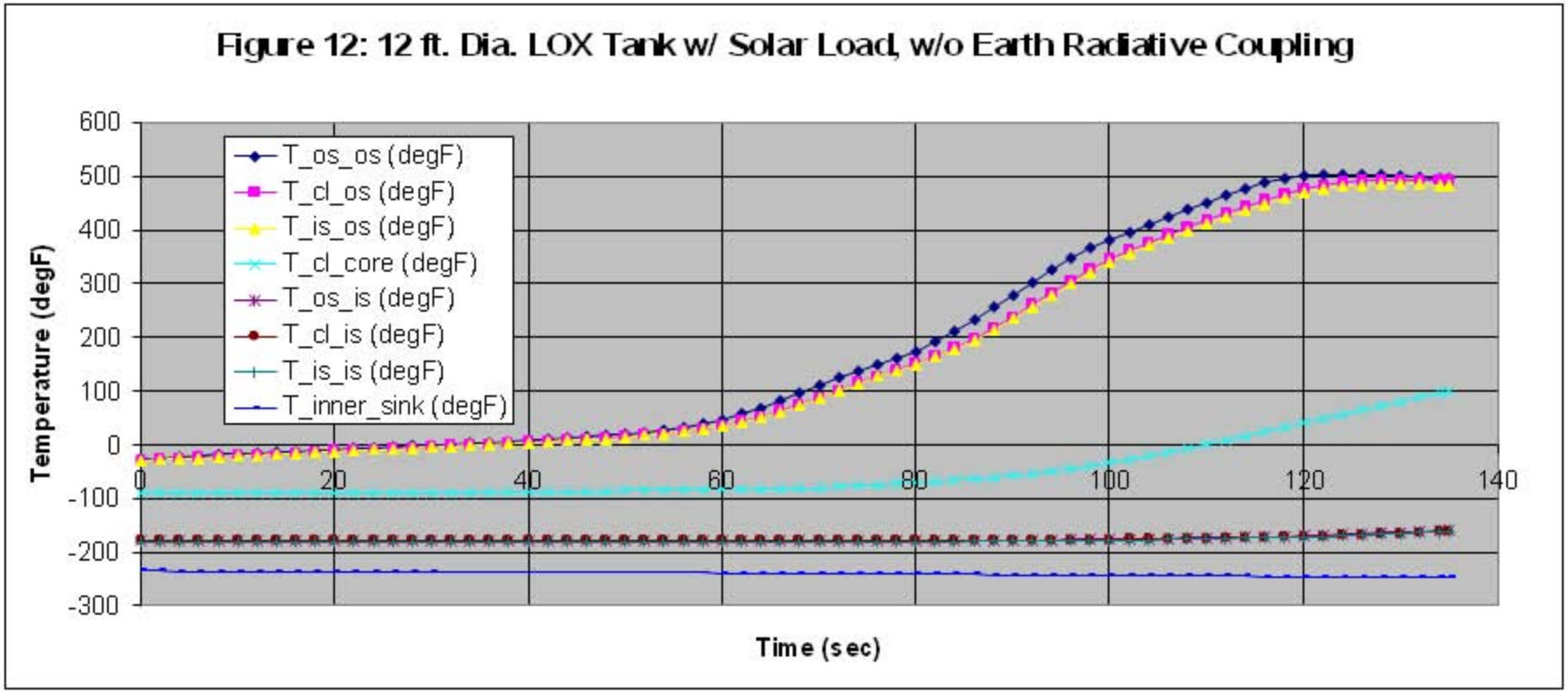
AL PLP Heating Analysis Results



AL PLP Heating Analysis Results

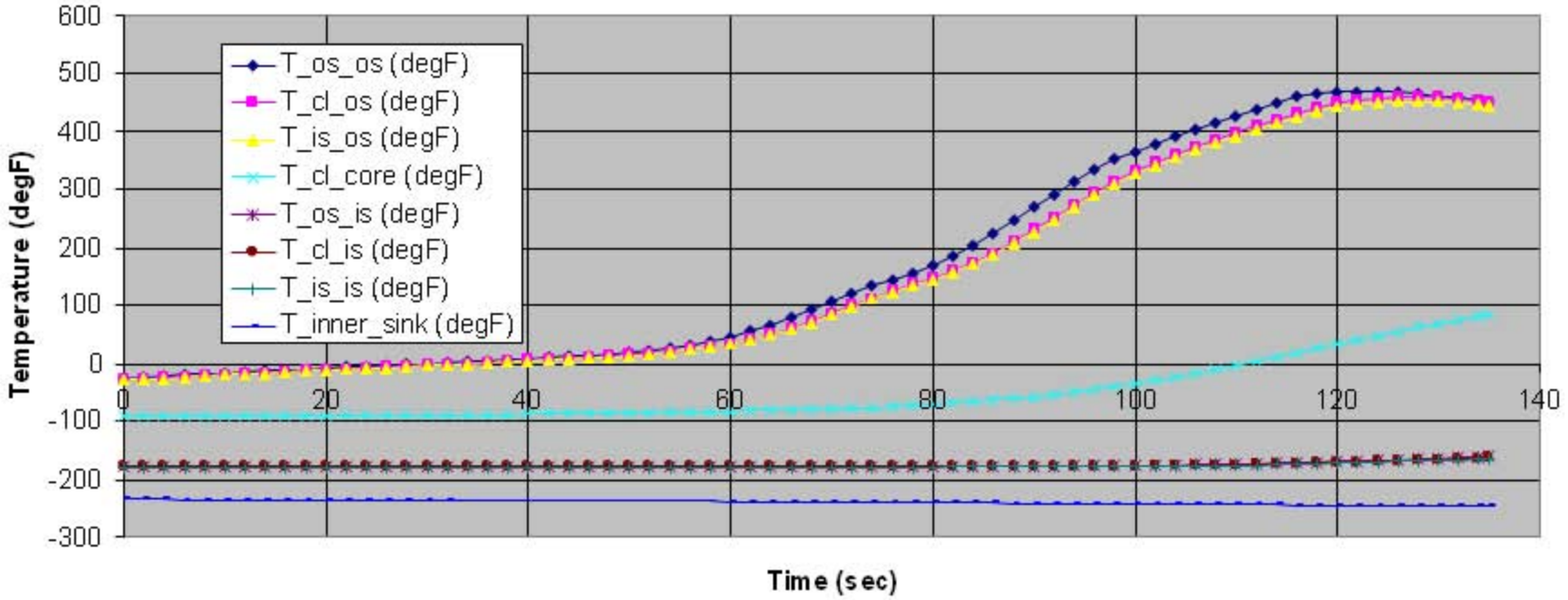


AL PLP Heating Analysis Results

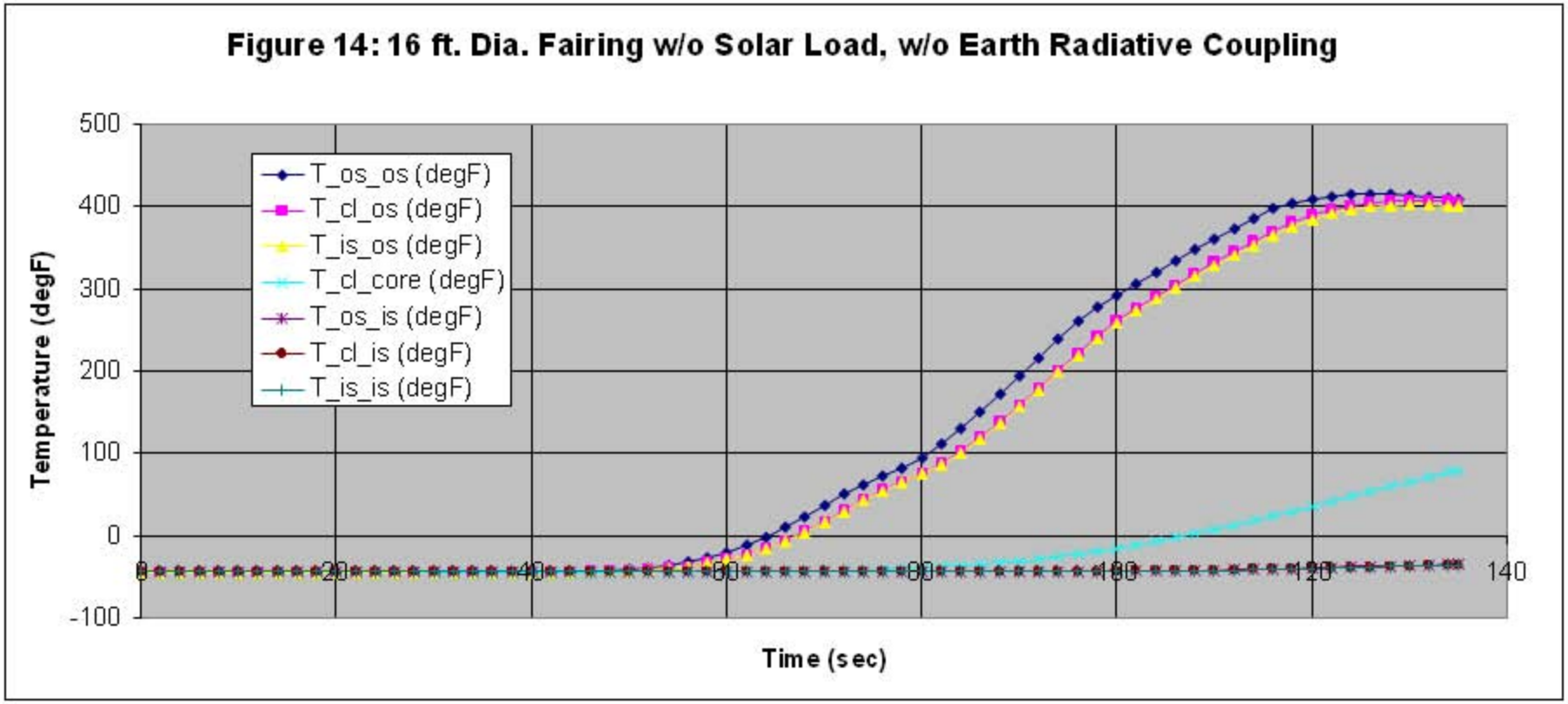


AL PLP Heating Analysis Results

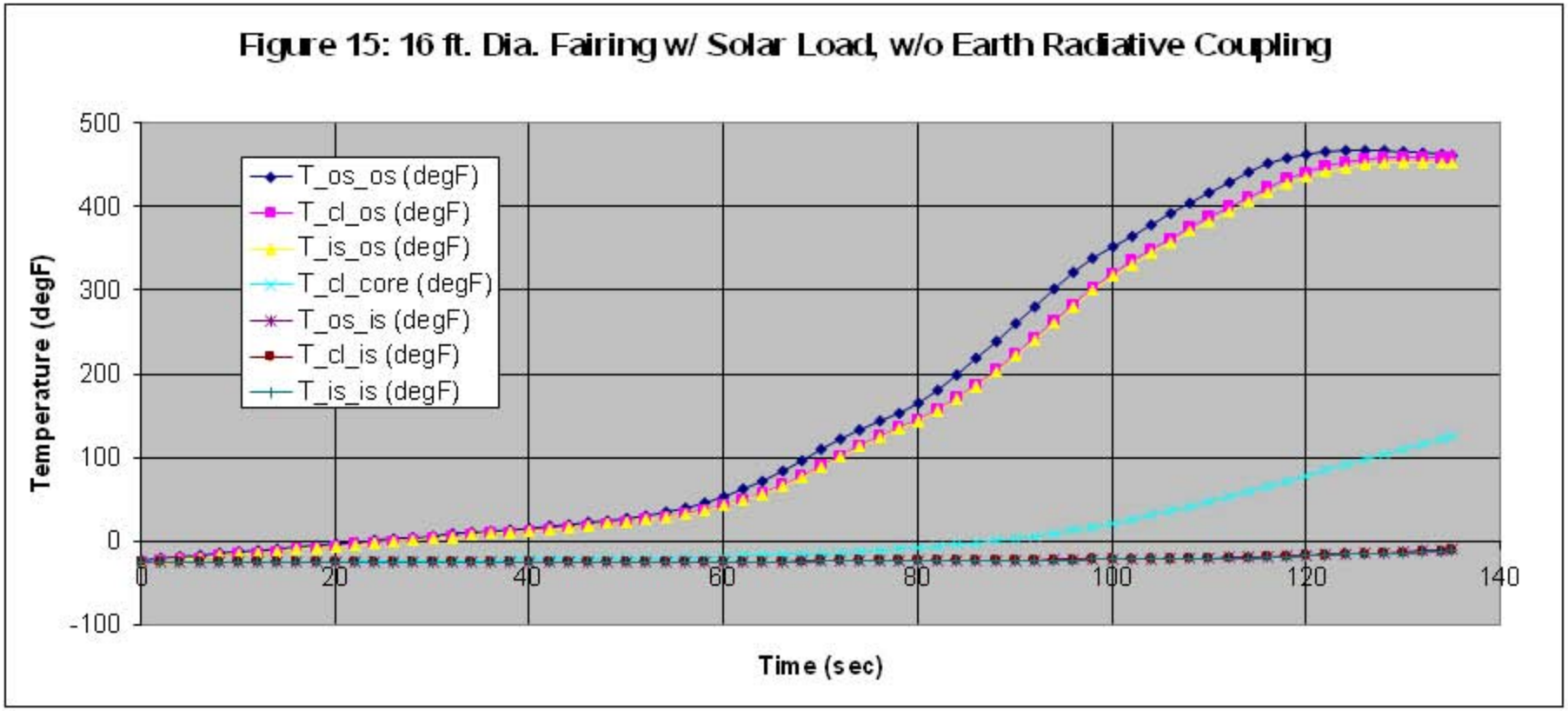
Figure 13: 12 ft. Dia. LOX Tank w/ Solar Load, w/ Earth Radiative Coupling



AL PLP Heating Analysis Results



AL PLP Heating Analysis Results



AL PLP Heating Analysis Results