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1-D Transient Thermal Modeling of an Ablative Material (MCC-1) Exposed to a Simulated Convective Titan IV Launch Environment

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Presented by
Thomas R. Reinarts, Ph. D.
Analytical Engineer

Pratt & Whitney
A United Technologies Company

P&W Space Propulsion
USBI Co.

OUTLINE

- Introduction
- Testing
- Transient Thermal Analysis
- Results
- Summary and Conclusions

INTRODUCTION

Purpose of work is to demonstrate flat test panel substrate temperatures consistent with analysis predictions

Testing performed in aerothermal facility

MCC-1 on aluminum substrate

Testing

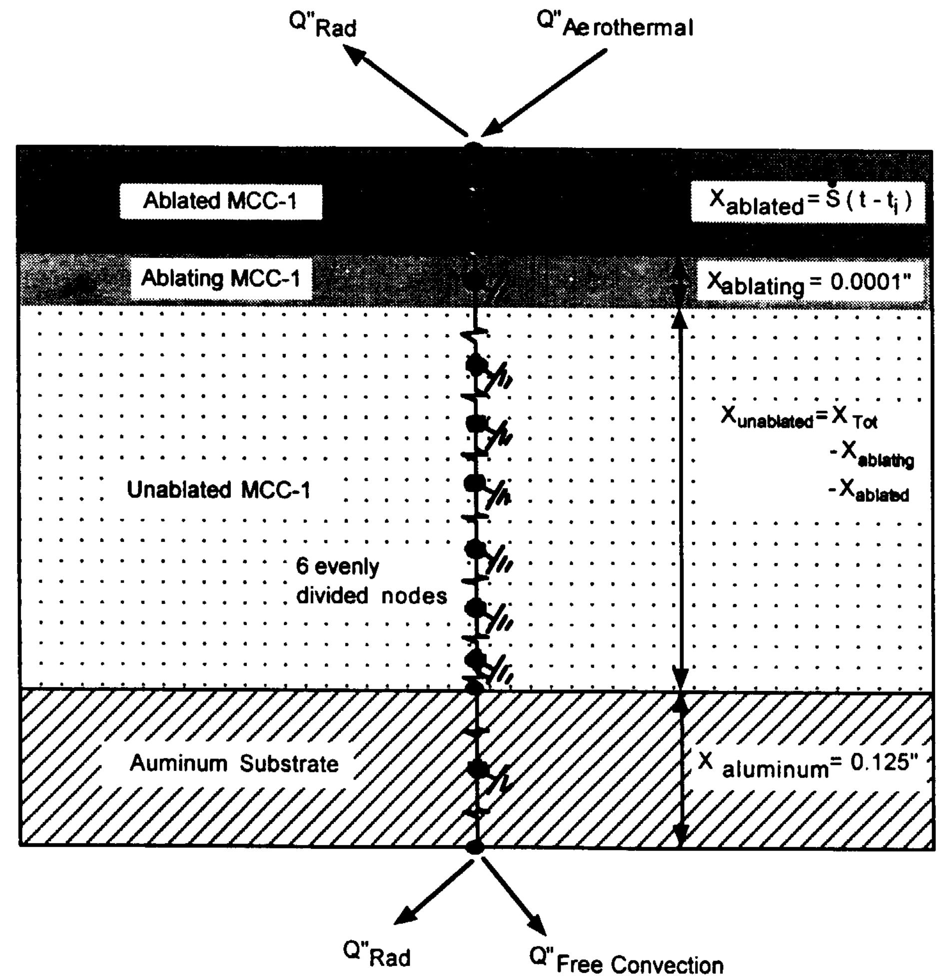
- Performed in IHGF facility
- Calibration runs define aerothermal heating environment
- Three different MCC-1 thicknesses tested

TESTING (Continued)

Bare MCC-1 Test Matrix

Test Series	Cold Wall Heat Flux ($Btu/s/ft^2$)	Test Run Length (s)	Aluminum Substrate Thickness (in)	MCC-1 Thickness (in)
T96-690	4.6	114	0.125	0.158
T96-693	4.6	114	0.125	0.158
T96-697	4.6	114	0.125	0.056
T96-699	4.6	114	0.125	0.056
T96-684	4.6	200	0.125	0.344
T96-686	4.6	200	0.125	0.343

TRANSIENT THERMAL MODEL



TRANSIENT THERMAL MODEL (Continued)

- Key assumptions

  ⇒ 1-D heat transfer
  ⇒ Constant ablation recession rate (determined from pre- and post-test measurements)
  ⇒ Ablation temperature 540°F
  ⇒ Char left behind ablation front
  ⇒ Temperature Jump Correction for Incident Heat Transfer Coefficient

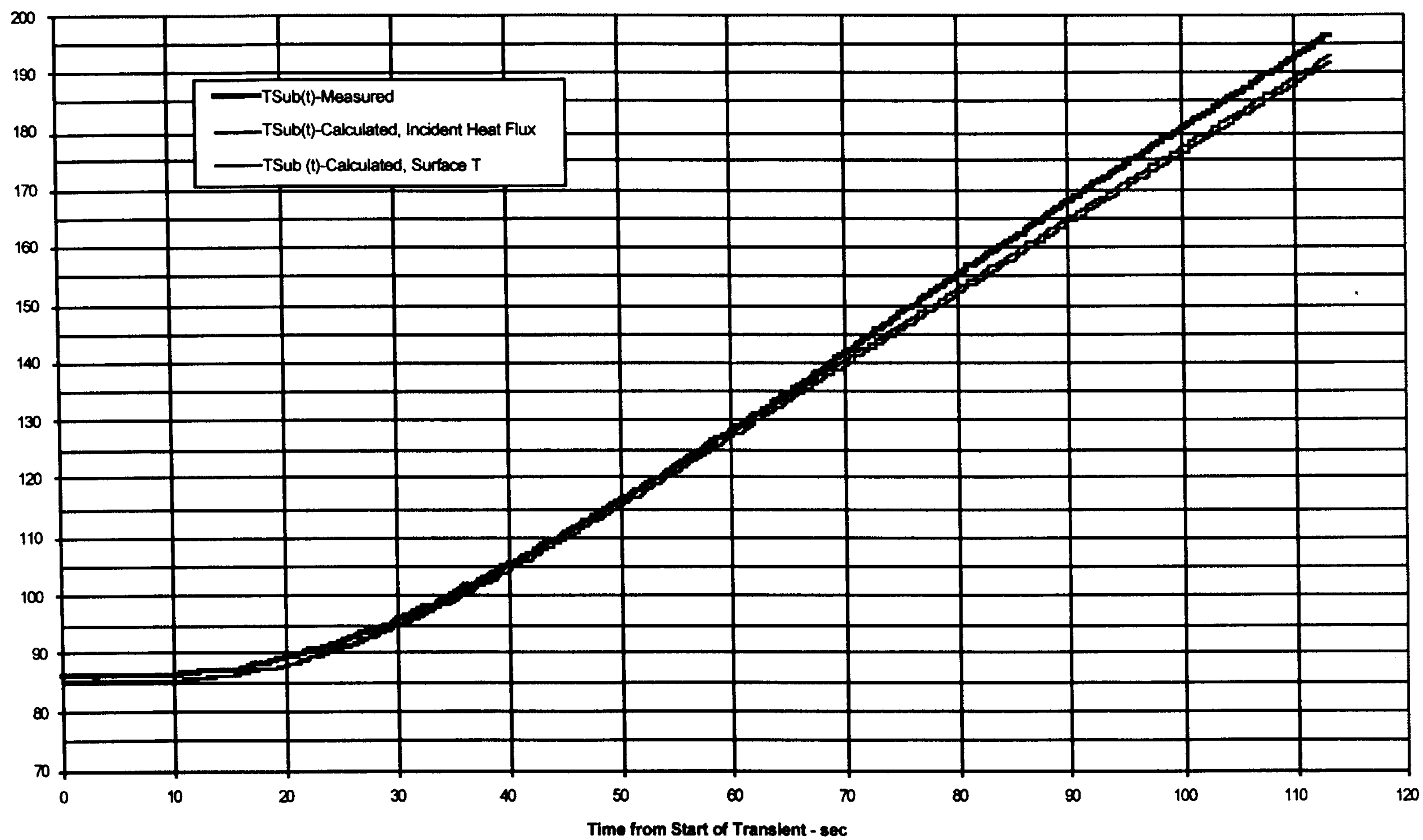
TRANSIENT THERMAL MODEL (Continued)

- Two Methods Used to Model Heating of Bare MCC-1

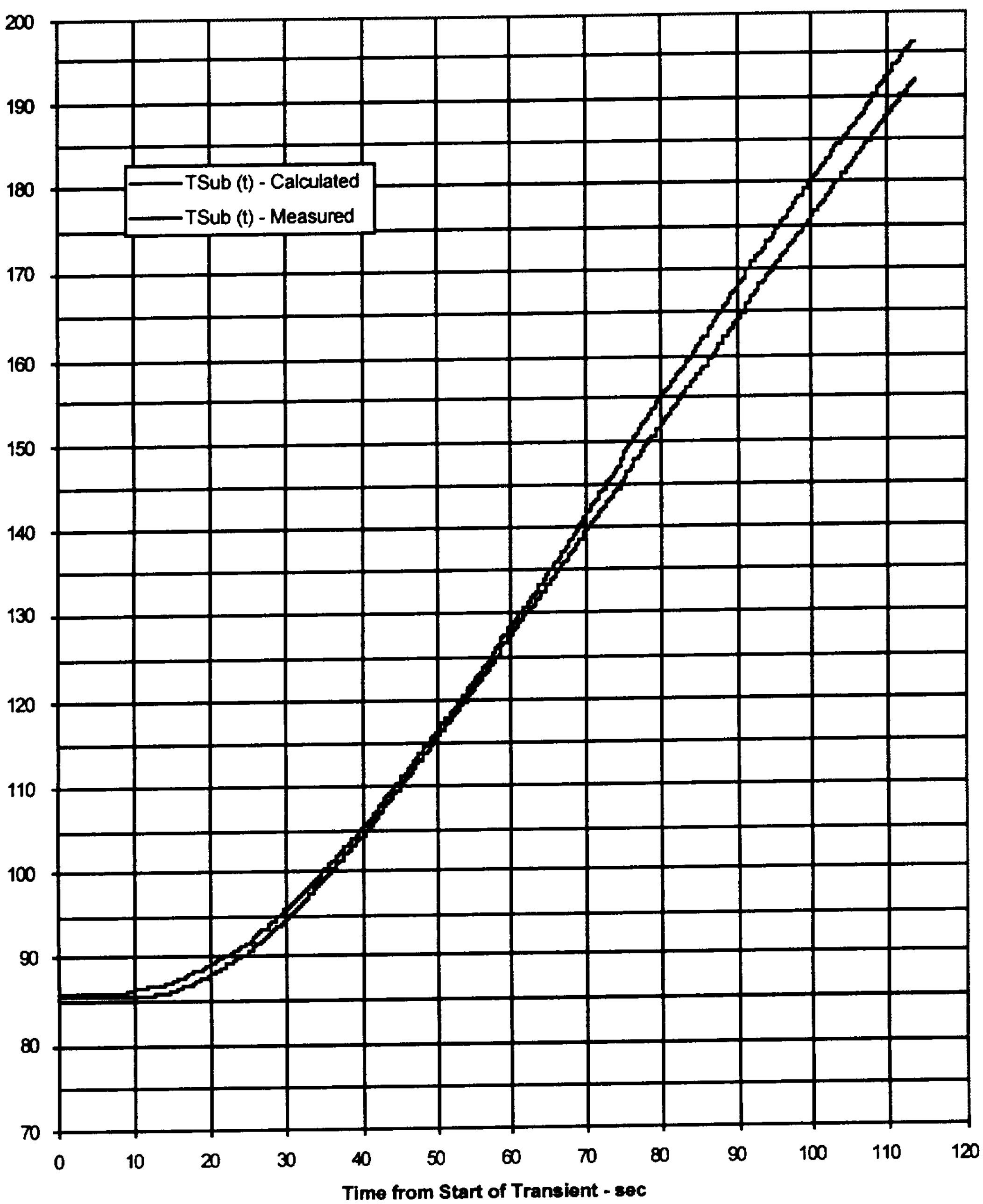
⇒ Directly Input Surface Temperature as a Function of Time, $T_S(t)$, from IR Measurement

⇒ Aerothermal Heating Using Calibration Plate Data, Subtracting Radiation Losses to Tunnel Walls

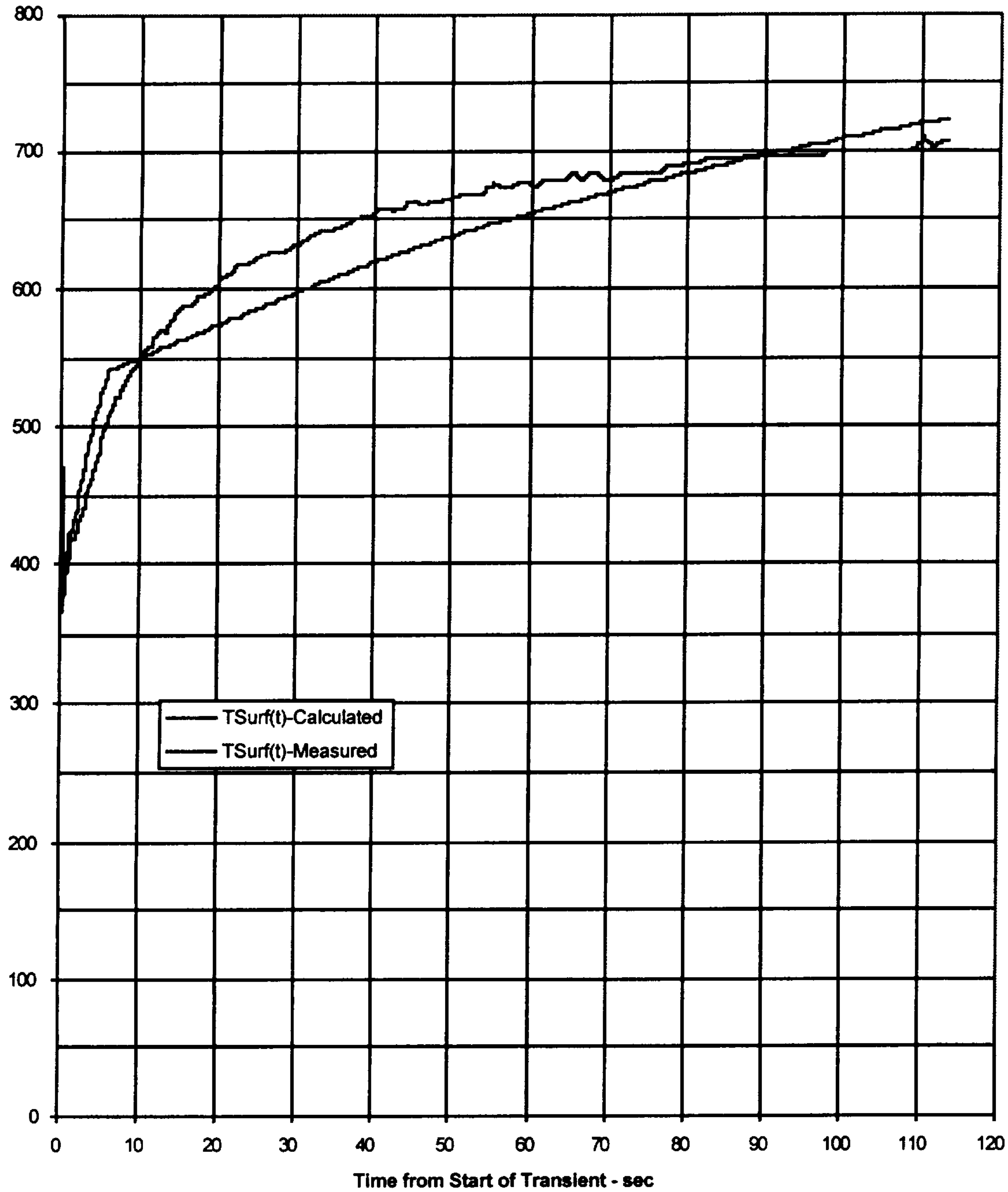
RESULTS



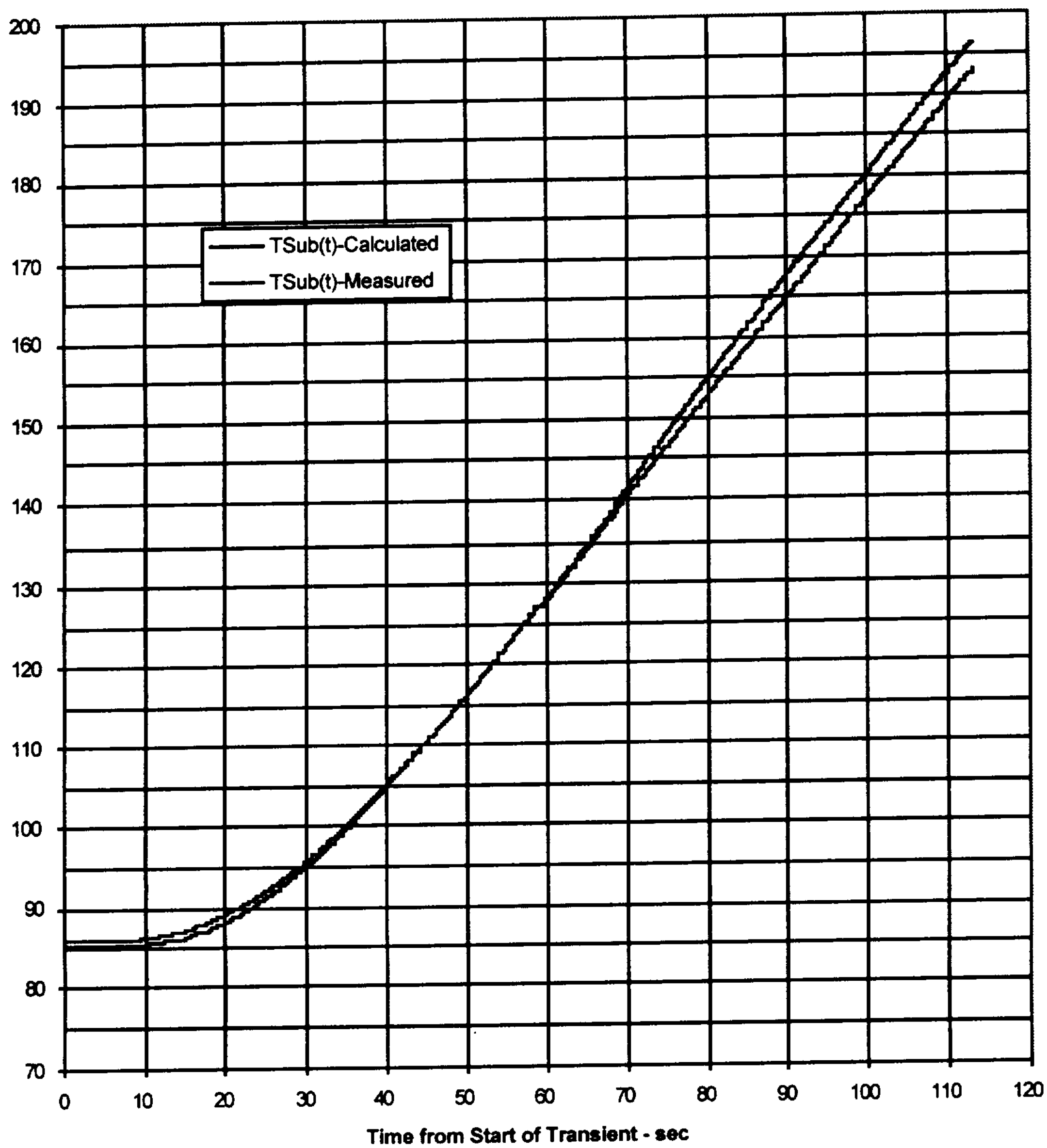
200
190
180
170
160
150
140
130
120
110
100
90
80
70
TSub(t)-Measured
TSub(t)-Calculated, Incident Heat Flux
TSub (t)-Calculated, Surface T
0
10
20
30
40
50
60
70
80
90
100
110
120
Time from Start of Transient - sec



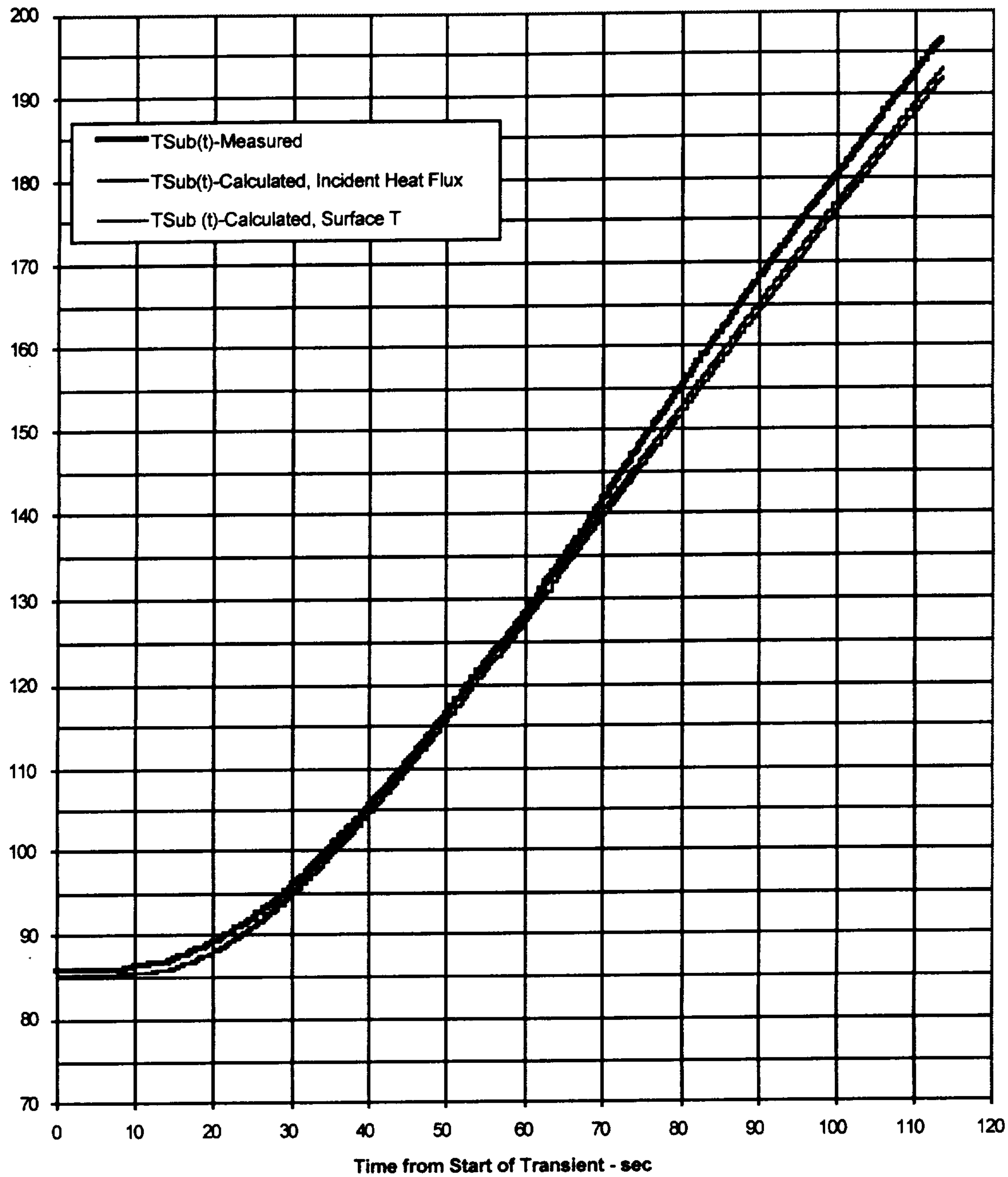
Comparison of T_{sub} (t) Measured and Predicted Values with Imposed T_{surf} (t) Boundary Conditions (q''_{CW} = 4.6 Btu/s/ft^2, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)



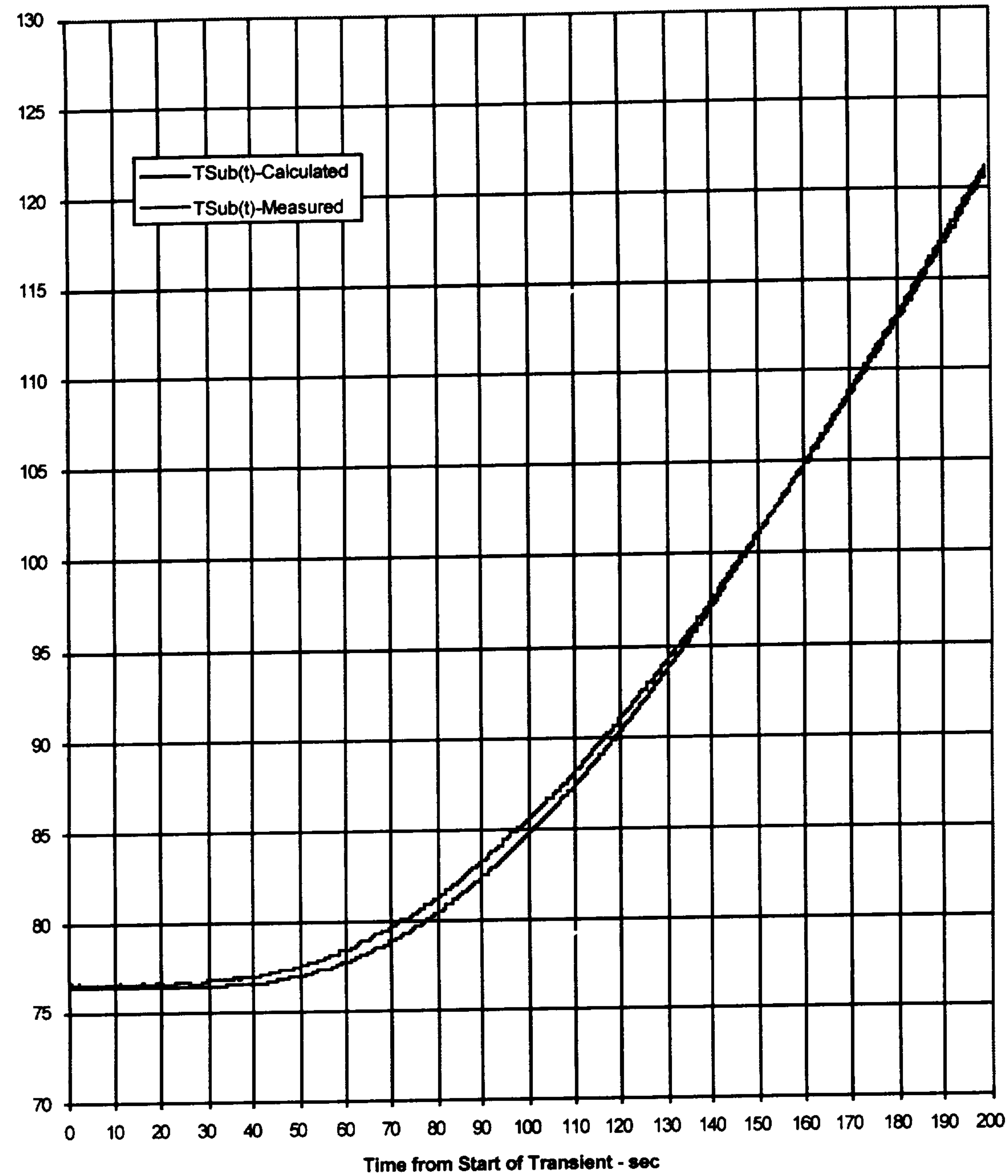
Comparison of T_{surf} (t) Measured and Calculated Values with Incident Heat Flux Conditions Specified from Calibration Testing
(q''_{CW} = 4.6 Btu/s/ft^2, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)



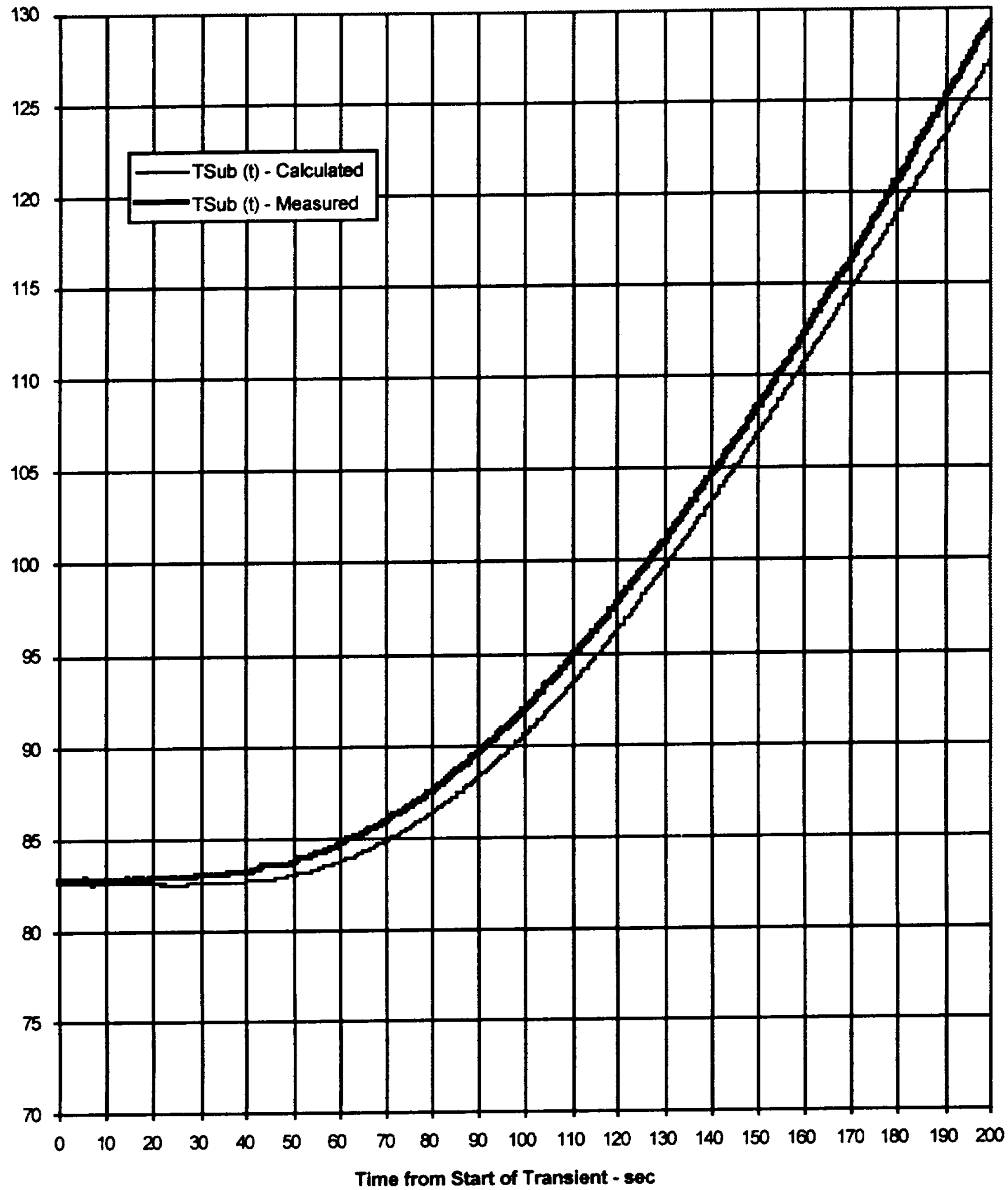
Comparison of T_{sub} (t) Measured and Calculated Values with Incident Heat Flux Conditions Specified from Calibration Testing (q''_{CW} = 4.6 Btu/s/ft^2, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)



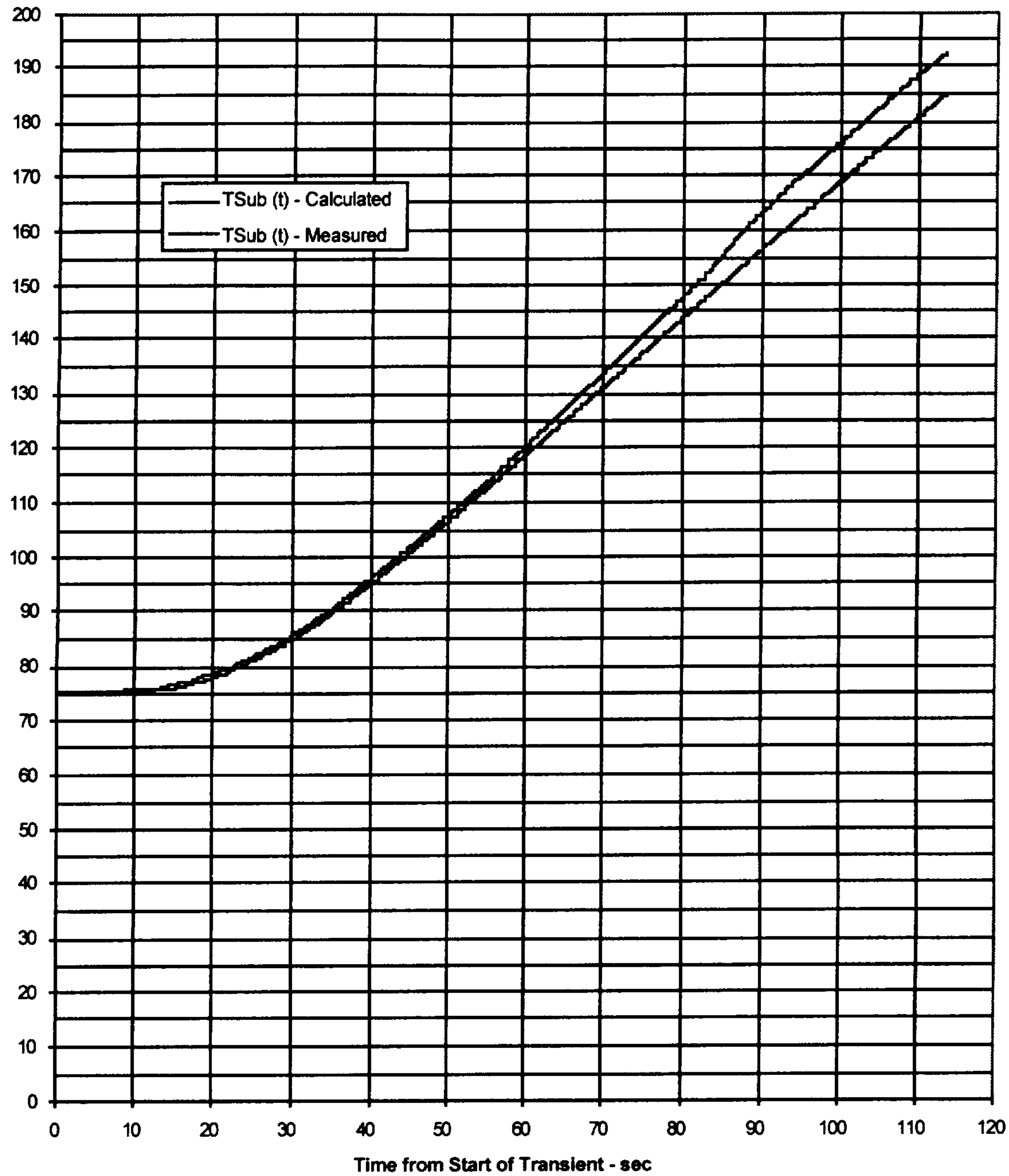
Comparison of Predicted Aluminum Substrate Temperatures Using Both the Imposed T_{Surf} (t) and the Incident Heat Flux Boundary Conditions
(q''_{CW} = 4.6 Btu/s/ft^2, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)



Comparison of T_{sub} (t) Measured and Calculated Values with Incident Heat Flux Conditions Specified from Calibration Testing
(q''_{CW} = 4.6 Btu/s/ft^2, Al thickness = 0.125 in., MCC-1 thickness =0.344 in.)



Comparison of T_{Sub} (t) Measured and Calculated Values for Incident Heat Flux Conditions Specified from Calibration Testing
(q''_{CW} = 4.6 Btu/s/ft^2, Al thickness = 0.125 in., MCC-1 thickness =0.343 in.)



Comparison of T_{Sub} (t) Measured and Calculated Values Incident Heat Flux Conditions Specified from Calibration Testing (q''_{CW} = 4.6 Btu/s/ft^2, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)