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# Effective Thermal Coefficient of Expansion in ANSYS

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Febuary 2000

**CSI ANSYS Tip of the Week**

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# Effective Thermal Coefficient of Expansion

- Thermal Strain Calculation May be Performed Using 2 Different Kinds of Thermal Coefficient of Expansion (CTE)
  - Instantaneous CTE
    - » Vendor-Supplied Data Often in this Form
    - ≈ $\varepsilon(T) = \alpha_{ins}(T)dT$
  - Secant or Average CTE
    - » Used by ANSYS
    - ≈ $\varepsilon(T) = \alpha_o(T)*(T - TREF)$
      - TREF = Temperature at Which Thermal Strain is Zero

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# Effective Thermal Coefficient of Expansion

- In ANSYS, TREF May Be Assigned in 2 Different Ways:
  1. "Globally" - TREF is Same for All Parts of Model
     - » Cannot Change Between Load Steps
     - » [TREF, *reference temperature*] (Default: 0)
  2. As a Material Property:
     - » Different Materials May Have Different Values
     - » [MP, #, REFT, *reference temperature*]
     - » Values Specified as Material Properties Take Precedence Over Global Setting, All Others Default to Global Setting

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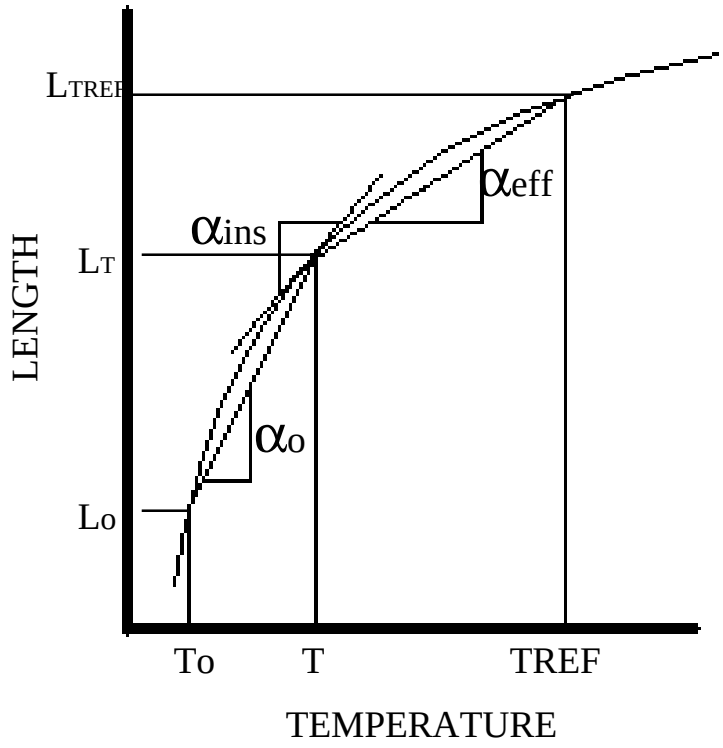
# Effective Thermal Coefficient of Expansion.

- Clearly, if Vendor-Supplied Data is in Instantaneous Form, it Must be Converted to Secant Form Before Using in ANSYS Analysis
- Even if Vendor-Supplied Data is Already in Secant form, the Values Probably Still Require Conversion to Those of **Effective Thermal Coefficient** of **Expansion**

# Differences Between Instantaneous ($\alpha_{ins}$), Secant ($\alpha_o$), and Effective ($\alpha_{eff}$) CTE




- A Test is Performed with a Specimen Starting at Length Lo at Temperature To
- $L_T$ = Length @ Temperature T
- $L_{TREF}$ = Length @ TREF
- If Lo = 1.0, then:
- $\alpha o$ = Secant CTE at Temperature T from Test
- $\alpha ins$ = Instantaneous CTE at Temperature T from Test
- $\alpha eff$ = Effective CTE Based on Stress-Free Temp (TREF) at Temperature T (Use in ANSYS Analyses)
  - **Note that $\alpha eff \neq \alpha o$**

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# Effective Thermal Coefficient of Expansion

- Vendor-Supplied Values Must be Modified if:
  - Data is Secant (or Average) and Data is Temperature Dependent and Reference Temperature NOT EQUAL to Component Strain Free Temperature, or if
  - Data is “Instantaneous”

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# Effective Thermal Coefficient of Expansion

- Modifying Secant (Average) Values Based on a Temperature (To) Other Than the Desired Stress-Free Temperature (TREF)
  - Use [MPAMOD,*MAT*,*DEFTEMP*]
    - » *MAT*: Identification Number Material to be Modified
    - » *DEFTEMP*: "Defining" Temperature (To) Corresponding to Test Specimen Length Lo (Temperature at Which Thermal Strain from Test Data is Zero)
    - » Must Define TREF Prior to Using Command:
      - [MP,#,REFT,stress-free temperature]

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# Effective Thermal Coefficient of Expansion

- Converting Instantaneous Data to Secant Data
  - Requires Evaluation of Integral

    $\approx \varepsilon(T) = \alpha_{ins}(T)dT$
  - No Convenient Command Exists in ANSYS, but One Can Perform Operations Between Single Column Array Parameters with [*VOPER] Command